Assessment of Auditory Skills Following Cochlear Implant in Children in Abu Dhabi (UAE)

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Abstract

Background: Cochlear implants are now firmly established as the treatment of choice in the rehabilitation of children with bilateral profound sensori-neural hearing impairment.

Objective: To track the development of auditory skills in children following cochlear implantation.

Subjects and Methods: The study included 48 children attending the phoniatric clinic, Mafraq hospital, Abu Dhabi (UAE). Their age ranged between 2-4 years. The study lasted for 15 months from September 2010 to November 2011. All children had bilateral sensorineural hearing loss since birth. None of the subjects had prior Cochlear implant, but all had tried conventional hearing aid. All subjects were implanted unilaterally and bilaterally, sequential/simultaneous with CI devices including MED EL and Nucleus. All met the criteria of cochlear implant.

Results: All items of the studied auditory skills improved significantly by time. There is significant improvement between 3-6 months in the scores of detection, discrimination, identification and comprehension skills. Significant improvement in comprehension is also found between 6 and 9 months; and between 9 and 12 months interval. PAS score had weak negative correlation with age.

Conclusion: Children fitted with cochlear implants showed significant improvement in acquisition of auditory skills over a period of 12 months. The age and the side of the implant are the most significant factors.

Key Words: Cochlear implantation – Hearing impairment – Auditory skills – Children – Variables.

Introduction

COCHLEAR implants are now firmly established as the first treatment of choice in the rehabilitation of individuals with bilateral, profound sensori-neural hearing impairment. There is a growing evidence that early application of cochlear implant is of great importance for the development of adequate auditory performance and language skills [1].

Auditory thresholds of the cochlear implanted children allow access to the auditory information beyond that available to the deaf child who routinely use the conventional amplification that offer a critical substrate for auditory therapy [2].

Meinzen-Derr et al. [3] mentioned that the clinicians need to be familiar with the sequence and time scales of listening and language development following Cochlear implant. Early intervention providers should monitor the child progress to determine whether the intervention is yielding the anticipated progress.

The amount of communicative benefit following cochlear implant varies among individuals and appears to depend on several factors. These factors include demographic and hearing characteristics of the child, as well as features of the implant device. Blamey et al. [4] reported that age of implantation, amount of residual hearing, socio-economic status, mode of communication, nonverbal intelligence and family support are potential predictors of the outcome.

Objectively evaluating the auditory skill development of very young children is challenging due to their limited response capabilities with traditional assessments of development. Some studies have elected to use questionnaires or rating scales of auditory development, such as the Category of Auditory Performance (CAP) [1] or the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) [8] and the Auditory Skills Checklist

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Subjects and Methods

Forty-eight children were included in this study. Their age ranged between 24-48 months old with a mean age of 34.2±7.0 months. The children were attenant to the phoniatric clinic, Mafraq hospital, Abu Dhabi (UAE). The study lasted for 15 months from September 2010 to November 2011. All children had prelingual onset of bilateral sensorineural hearing loss. None of the subjects had prior Cochlear implant, but all had tried conventional hearing aid. Range of duration of hearing loss was since birth and duration of implants is 15 months on average. All subjects were implanted either unilaterally, or bilaterally, sequential and simultaneous with CI devices including MED EL and Nucleus. All met the criteria of cochlear implant. None of the children has any retrocochlear pathology or cochlear anomalies. All children have average IQ and good physical fitness.

A- Preoperative:

All subjects were subjected to the following:

- Audiological assessment to determine the degree of hearing loss and residual hearing as well as to exclude auditory neuropathy.
- Radiological investigations: CT scan and MRI to determine the state of cochlea and to exclude any retro cochlear pathology.

B- Operative:

- All surgeries were done under general anesthesia and under facial nerve monitoring. The ear was approached through a small postauricular incision. The implant was placed in bony bed and fixed with a non-absorbable suture. The middle ear was approached through mastoidectomy/posterior tympanotomy approach. Electrodes were inserted either through the round window membrane or cochleostomy. Cochleostomy was done inferior and slightly anterior to the round window membrane.
- Intraoperative neural response telemetry (NRT) to test device integrity and objective auditory reaction for cochlear implant patients intraoperatively.

C- Postoperative:

- Follow-up with audiology for mapping of speech processor.
- Rehabilitation therapy: Postoperative rehabilitation started after completing the first mapping session (1 month postoperatively). All subjects were enrolled in an aural rehabilitation program applied in Cochlear Implant Unit, Kasr Al-Aini Hospital, as individual sessions 3 times per week, the duration of each session is 30 minutes. The parents were involved in this rehabilitation program.

A checklist was applied to track the child’s progress [Post-cochlear Auditory Skills (PAS)] acquired to monitor the effectiveness of therapy at regular intervals at 3, 6, 9 and 12 months postoperatively. The checklist (Appendix 1) consisted of 38 items representing 4 skills; detection (10 items), discrimination (7 items), identification (8 items) and comprehension (13 items). Each item was scored (0) if no response, (1) if inconsistent response and (2) if consistent response.

Statistical analysis:

Data were described as mean±SD for numeric data, frequency (number and per cent) for non-numeric data or as scatter plot chart or staked bar chart. They were compared using t-test. Correlation was done using Pearson correlation coefficient for numeric data and Chi-square test for non-numeric data. Two tailed significant values were considered when \( p < 0.05 \). Data were analyzed using SPSS for windows version 11.

Results

As stown in (Table 2), during the progression of the habilitation program (12 months) there was a significant increase of all components of PAS score as well as the total score by time. Values at 6 months were significantly higher than 3 months \(( p < 0.001 \). Also, values at 9 months were significantly higher than 6 months \(( p < 0.001 \) and values at 12 months were significantly higher than 9 months \(( p < 0.001 \).
Results showed that there was a significant negative correlation between the age of the patient and the development of post-operative auditory skills (PAS).

Results obtained in (Table 4) demonstrated that there were insignificant relations between the sex, type of implant in the patient PAS scores. On the other hand there was significant relation between the side of implant (unilateral, bilateral) and the patient’s PAS score.

Table (1): Characteristics of the studied sample.

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in months (mean±SD)</td>
<td>34.3±7.2</td>
</tr>
<tr>
<td>Range in Month</td>
<td>24-48</td>
</tr>
<tr>
<td>Sex:</td>
<td></td>
</tr>
<tr>
<td>Males N (%)</td>
<td>29 (60.4%)</td>
</tr>
<tr>
<td>Females N (%)</td>
<td>19 (39.6%)</td>
</tr>
<tr>
<td>Implant Side:</td>
<td></td>
</tr>
<tr>
<td>Unilateral N (%)</td>
<td>30 (62.5%)</td>
</tr>
<tr>
<td>Bilateral N (%)</td>
<td>18 (37.5%)</td>
</tr>
<tr>
<td>Type:</td>
<td></td>
</tr>
<tr>
<td>Med El N (%)</td>
<td>21 (43.7%)</td>
</tr>
<tr>
<td>Nucleus N (%)</td>
<td>27 (56.3%)</td>
</tr>
</tbody>
</table>

Table (2): Mean±SD Post cochlear Auditory Skills (PAS) scores during the follow-up period.

<table>
<thead>
<tr>
<th>(PAS) Scores</th>
<th>3 Months</th>
<th>6 Months</th>
<th>9 Months</th>
<th>1 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection (/20):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>14.52±0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>(14-16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cases got max score</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Discrimination (/12):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>1.81±2.150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>(0.0-6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cases got max score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification (/16):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>12.50±7.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>(12-14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cases got max score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension (/26):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>3.37±4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>(3-4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cases got max score</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total (/74):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>16.25±2.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>(14-22)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

* Date are presented as mean and SD values.
** Total ranges are in parenthesis.

Table (3): Pearson correlation coefficient of age of patients with PAS scores.

<table>
<thead>
<tr>
<th>Age</th>
<th>PAS scores</th>
<th>Correlation (r) value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.286</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

Fig. (1): Changes of PAS score during follow-up period after cochlear implant.

Fig. (2): Distribution of PAS development over time.
Discussion

Cochlear implants provide an improved auditory signal and enhance the development of speech-perception and production skills for profoundly deaf children. However exactly when these early speech skills begin to develop remains unclear [1].

The present study aimed at evaluating. Development of auditory skills in children fitted with cochlear implant over a period of 12 month.

The results revealed significant improvement in all items of the studied auditory skills. There was significant improvement between 3-6 months interval in the scores of the following skills detection, discrimination, identification and comprehension. Significant improvement in comprehension is also found between 6 and 9 months; and between 9 and 12 months interval (Table 2), (Figs. 1, 2).

Comparison between results reflects an obvious and dramatic change in the development of auditory skill in the initial period following implantation. The pattern of these present findings was expected, acquisition of auditory skills is sequential, and development of one skill depends upon the acquisition of earlier skills. This finding was proved by other researchers [7-9].

Rapid improvement in auditory skills during the first year of device use was also found in the study done by McConkey-Robbins et al. [10]. In their study they found that the largest increase in the skills occurred within the first 6 months after implantation. Immediate results after initial tuning were also found in other studies [11-12].

Limited progress after 3-6 months of intense therapy may be an indication that the child should be considered for alternative therapeutic methods that include more visual information for communication i.e. sign language [3].

However difference in progress does exist with different variables of children under study. Blamey et al. [4] reported that there are several factors that account for individual differences in outcomes following implant.

In our study we assessed the possible effects of three basic variables: (Age, sex, side and type of implant), on the development of the auditory skills. We found that there was a significant correlation of the outcome with the age and the side of the implant. On the otherhand, in-significant correlation with the type of implant and the sex of the child (Tables 3,4).

Regarding the age, our data revealed that children who were implanted at a younger age were more likely to achieve better results (Table 3). Possible explanation might be related to neural plasticity, early implantation, increase the access to sound during this sensitive period of development (the first 2 years of life).

Tomblin et al. [13] suggested that early implantation can benefit long term development in two ways; first it shorten the duration of deafness with its association with poorer rate of language acquisition and development, secondly it can provide language development by altering the rate after initial stimulation. In accordance with our findings several researchers found similar findings [8,13-16].

In the present study we found insignificant correlation with the type of implant and the outcome (Table 4). Similar finding was reported by [18,19] they mentioned that cochlear implant outcomes are similar across different types of devices.

There is a wide range of patient outcomes within each group of individuals using a given device. Some people obtain substantial auditory-only speech understanding whereas others use the input from their cochlear implant as an aid to speech reading. Tyler et al. [17] in their study concluded that the development rate of children's auditory skills and the speech perception abilities following implantation improve with increased device experience.

Regarding the effect of the side of implant, a significant correlation of the outcome in bilaterally implanted children was shown (Table 4). Our findings might reflect that sequential bilateral cochlear implantation has the potential to improve speech perception abilities in the secondary implanted ear. Possible explanation was also provided by [18].

Ramsden et al. [18] suggested that bilateral implant provide access to the use of binaural mechanisms such as the head shadow effect, they reported better localization, discrimination, better sound quality in bilateral implantation, better understanding speech in noise and less listening effort. However the improvement unfolds over time and continues to grow during the 6 to 12 months after activation of the second implant.

In agreement was the present finding Litovsky et al. [19] and Vermeire et al. [20] similarly reported that bilateral simultaneous implantation can significantly improve the child ability to interact socially and to hear incidental sounds.
Conclusion:

Children fitted with cochlear implants showed significant improvement in acquisition of auditory skills over a period of 12 months. Present data revealed significant correlation of the outcome with the age of the child, side of implant (unilateral or bilateral) and insignificant correlation with the type of implant and children's sex.

Recommendations:

- An assessment protocol for auditory skills program should be formulated in Arabic language.
- Determining the long-term impact in implanted children requires additional study with larger groups of subjects, different age groups and more prolonged monitoring.
- Progress of the therapy (for early intervention providers) needs to be monitored to determine whether the intervention are yielding the anticipated progress and to evaluate areas of strength and weakness of children during aural rehabilitation.
- Rehabilitation course should be increased and be more intensive for those who show slow progress.
- Parent written report is recommended to describe auditory skills progress.

Acknowledgement:

The authors would thank Dr. Omneya Mohamed, MD, for her help in monitoring the audiological aspects of this study.

Conflict of interest:

The authors declare that they have no conflict of interest.

Appendix 1

Auditory Skills Checklist (ASC)

Auditory skills:

A- Detection:

1- Bonding and wearing cochlear implant.
2- Child realize independently if the system stop working.
3- Aware of speech sounds.
4- Respond to music and noise making toys.
5- Aware of soft environmental soundss e.g. Clock ticking.
6- Aware of loud environmental sounds e.g. Dog barking.
7- Consistently moves to music out of eyeline.
8- Respond to all ling sound.
9- Ignore background noise and focus on speech signals.
10- Definite turn to locate interesting sounds.

B- Discrimination:

11- Discriminate environmental sounds.
12- Discriminate between speech sounds.
13- Discriminate between soft and loud voices.
14- Discriminate between environmental versus speech sounds.
15- Discriminate family members voices.
16- Discriminate musical versus speech sounds.
17- Discriminate rhyming words.

C- Identification:

18- Identify the ling sounds.
19- Recognises the voices of a number of familiar people heared out of eyeline.
20- Can pick one object from a set of familiar objects.
21- Identify her/his name when called.
22- Identify an item with an associated sound.
23- Identify commonly used words.
24- Consistently imitates fragments of what they hear.
25- Identify monosyllabic word versus bisyllabic words.

D- Comprehension:

26- Range of one word understanding.
27- Understand simple one step direction.
28- Range or 2 word sentence understanding.
29- Responds to simple questions.
30- Understand frequently heared phrases / sentences.
31- Understand 2 step directions.
32- Understand the use of negatives in phrases.
33- Understand object function.
34- Understand concepts in phrase-sentence.
35- Understand familiar' expressions.
36- Understand most of what is said through audition alone.
37- Development of auditory closure.
38- Learns from incidentally heared information e.g T.V.

Scoring:

0- Means no response.
1- Means inconsistent response.
2- Means consistent response.
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References


