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Acquisition of early auditory milestones with a cochlear implant

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ABSTRACT

Objective: Speech acquisition after cochlear implant is a long process. Various studies have followed the auditory milestones in the early period after implantation. The aim of the present study was to track the development of hearing skills in the early period after cochlear implantation and evaluate which factors influence the process.

Methods: 195 records of children implanted in the Hadassah Medical Center were examined retrospectively. Data on etiology, age at implantation and type of implant were collected. In addition, information on the rate of progress was measured: the first time that there was detection and identification of Ling sounds, the first time it was possible to obtain SDT (speech detection threshold), SRT (speech reception threshold) and an audiogram, and the first accurate repetition of VCV (vowel consonant vowel) sounds.

Results: Results show a consistent pattern of auditory milestone acquisition similar to that of normal development, from milestones that do not require decoding beginning with SDT, detection of Ling sounds followed by an audiogram which requires cooperation, to tasks that involve decoding starting with SRT and repetition of Ling sounds and finally VCV repetition.

The children implanted before 24 months of age achieved the auditory milestones later than children implanted between 2 and 6 years, apparently since these tasks involve cognitive abilities which are not yet developed in the youngest children.

Previous hearing experience improved the rate of acquisition of the auditory milestones and progress was faster in the second implanted ear compared to the first implanted ear.

Conclusion: More research is needed to address the relationship between acquisition of early auditory milestones and performance with the cochlear implant later on in life.

1. Introduction

Speech and language acquisition after cochlear implantation is a long process that requires a rehabilitation program and intensive practice. Various studies have followed the development in the early period after implantation [e.g.[1–4]]. Several tools were developed such as parental questionnaires as well as auditory and speech perception tests that are performed to measure progress at the early period after implantation. Moon et al. [5] evaluated phonologic and phonetic development in young children following CI (cochlear implant) and discovered continuous improvement in stages that correlated with the CAP (categorical auditory performance) scores. Wu et al. [2] followed CI recipients' gradual auditory and speech development using SIR (speech intelligibility rating) and CAP scales. They found that the CAP score improved after 1 year of implantation and reached maximum three years after implantation. The SIR score improved in the first 2 years after implantation and reached maximum three years post implantation. Calmels et al. [6] found that closed-set perception of words develops within the first year post implantation, while open-sentence speech perception shows significant improvement between the second and fifth year post implantation. The SIR score improves from the first months up to 5 years post implantation. Zheng et al. [7] used a hierarchical outcome assessment battery built on questionnaires designed to measure early prelingual auditory and speech perception development. They describe a normal developmental trajectory in which, after eight months, pediatric CI recipients reached a score equivalent to 12 months of age in normal hearing peers. McConkey Robbins et al. [4] used the IT-MAIS (infant-toddler meaningful auditory integration scale) assessment and found rapid improvement in auditory skills over the first year post-implantation.

The aim of the present study was to track the development of hearing and speech skills in the early period after cochlear

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implantation by following the first acquisition of results for tests routinely used in the Audiology Clinic, for example the time at which an audiogram was first obtained or the first time Ling sounds were detected and recognized. Furthermore, we wanted to observe which factors influence these developments.

2. Methods

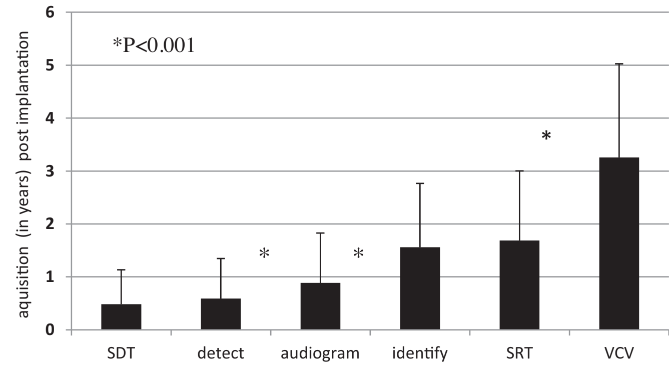
195 records of children (101 males, 94 females) implanted in the Hadassah Medical Center were examined retrospectively (117 Arabic speakers, 78 Hebrew speakers). These children with prelingual severe to profound bilateral sensorineural hearing loss without additional disabilities were implanted between the years 1995 and 2011. Their age at implantation ranged from 11 months to 6 years and ten months (average 3.32 years SD = 1.48). 174 were monaurally implanted and 21 were bilaterally implanted sequentially. In 8 cases a revision of implant had been performed. The study was approved by the Hadassah University Medical Center Ethics Committee.

The etiology of hearing loss was genetic in 82 (42%) children, in an additional 6 (3%) children hearing loss was part of a syndrome, an additional 36 (19%) cases resulted from environmental causes (congenital CMV, post-meningitis, asphyxia during birth, prematurity and ototoxicity), and 71 (36%) were of unknown origin. The overall prevalence of etiologies was similar to that described in the literature, although in the present study the genetic component was higher [8,9].

Type of implant was Cochlear Corp. in 155 recipients (23 with Nucleus 22, 76 Nucleus 24, 50 Freedom, and 6 with C5). 38 were implanted with Advanced Bionics (16 CII and 22 HiRes 90k) and 2 cases with Med-El.

CI recipients were in different educational and rehabilitation centers and came for mapping sessions at the hospital audiology clinic at a frequency of once a week initially that dropped to once a month and later to once in three months. After the first 2 years, they came for a mapping session once in 6 months. In the present study, information on the rate of progress in auditory milestone acquisition was recorded in the files and included: (1) the first time (in years) post-implantation that there was detection of Ling sounds (a, i, u, s, sh and m) in a quiet room, (2) the first time post-implantation that there was identification of the 6 Ling sounds in a quiet room, (3) the first time post-implantation that it was possible to obtain SDT (speech detection threshold) in a soundproof booth, (4) the first time post-implantation that it was possible to obtain closed- set SRT (speech reception threshold) in a soundproof booth, (5) the first time post-implantation an audiogram including threshold testing of 5 frequencies (250, 0.5 k, 1 k, 2 k and 4 kHz) was obtained in a soundproof booth, and (6) the first time post-implantation that there was accurate repetition of 70% of 19 VCV's (vowel consonant vowel) utterances in Hebrew and Arabic. Due to the retrospective design of the study, in some cases (as can be seen in Table 1) information on acquisition of certain auditory milestones was not documented in the file, and therefore not included in the analysis.

Data analyses: statistical analysis included *t*-tests and ANOVA for comparison between rate of acquisition of the different milestones, and the influence of age of implantation, first vs. second implant and etiology. Level of significance was set to 0.05.



Graph 1. Average age postimplantation for acquisitions of early milestones.

3. Results

Results show a constant pattern of auditory developmental milestone acquisition as can be seen in Table 1 and Graph 1. ANOVA showed milestones that do not require decoding (SDT, Ling detection and audiogram) were achieved significantly earlier than milestones requiring decoding (SRT, Ling identification and VCV repetition) ($F = 2.22$ $p < 0.001$). Post-hoc *T* tests revealed within the category not requiring decoding, audiograms were obtained significantly later than SDT and Ling detection ($t = 1.64$ $p < 0.001$). Within the decoding category, VCV repetition was achieved significantly later than SRT and Ling repetition ($t = 1.65$ $p < 0.001$).

For data analysis, subjects were divided into 2 groups based on age of implantation as done in previous studies [e.g. 4,10]: early implanted (up to 24 months) and late implanted (older than 24 months). Children implanted before 24 months of age achieved Ling detection and identification as well as audiogram later than children implanted after 24 months of age ($t = 1.65$ $p < 0.05$). We did not find a significant effect of implantation age for the other auditory milestones. Comparison of children implanted younger (before 24 months) to children implanted later after 24 months appears in Table 2 and Graph 2.

The progress was faster in the second compared to the first (sequentially) implanted ear for acquisition of the auditory milestones that involve speech and language: detection and identification of Ling sounds ($t = 1.94$ $p < 0.05$; $t = 2.13$ $p < 0.05$, respectively), SRT and VCV ($t = 1.94$ $p < 0.05$) as measured with paired *t* test. There was no significant difference between the first and second implant in rate of acquisition of the audiogram and SDT as can be seen in Table 3 and Graph 3.

Etiology had no significant effect on rate of acquisition of the different auditory milestones ($p = 0.55$ $F = 0.58$).

4. Discussion

In the present study we investigated tools that are widely used in the audiology clinic and tried to build a model of auditory milestone acquisition rate. The purpose was to learn more about

Table 1
Average and standard deviation of time of first documented acquisition of the different milestones (in years) postimplantation.

	SDT	Ling detection	Audiogram	Ling identification	SRT	VCV
No. of subjects	172	161	189	147	152	87
Average	0.48	0.59	0.88	1.55	1.68	3.25
S.D.	±0.65	±0.75	±0.94	±1.21	±1.31	±1.76