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No changes in cochlear implant mapping and audiometric parameters in adolescence

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Abstract

Objective: Audiologists mapping in the clinic report that many cochlear implanted teenagers and their parents complain of deterioration in hearing capabilities. The aim of the study was to compare the mapping parameters measured over the years and determine whether more changes occurred throughout adolescence than during childhood.

Methods: The files of 23 cochlear-implanted teenagers were studied retrospectively. Data were collected for each individual at several points in time between the ages of 6:06-18:03 years. Typical data collected from the mapping sessions included: behaviorally measured T values, impedance results, audiogram thresholds in free field with the implant, speech reception threshold and speech perception of VCV syllables.

Results: No changes were found in either the behavioral or the objective parameters, over the years.

Conclusions: The stability in mapping and audiometric measurements found in adolescence do not support an explanation based on hormonal and growth effects on implant function. Perhaps a more likely cause of the subjective sense of hearing deterioration is related to changes in social and educational requirements.

Keywords: adolescence, cochlear implant, mapping
Introduction

Cochlear implantation is a very common option for rehabilitation in cases of severe to profound sensorineural hearing loss. Electrodes are inserted into the cochlea during surgery. Later on, an outside speech processor is connected. The speech processor converts acoustic stimuli into electric stimulation, which ultimately reaches the electrodes in the inner ear. The electrodes stimulate the auditory nerve fibers electrically. In the audiology clinic the speech processor is programmed by "mapping", during which measurements are made to determine the minimum and maximum current units needed to evoke auditory responses. Impedance values of the electrodes are also measured. Mapping sessions take place in the clinic on a routine basis or if there is deterioration in everyday function.

In the course of mapping sessions in the clinic, audiologists report that more complaints of difficulties in hearing (in different everyday situations) are made by cochlear implanted adolescents than by other age groups. Adolescents and their parents frequently complain that there is greater difficulty than before, and wonder if something is wrong with the implant or map. Adolescence is known to be a period in which the individual experiences social, emotional, physical, and other changes. Martin et al (1) suggest that communication skills appropriate to younger children may no longer be adequate at later ages. There may be higher expectations of an adolescent compared to those in childhood, and more challenging hearing situations may be experienced, such as changing teachers for every class instead of having one teacher for the entire school day, or coping with increasing peer group size (2). This might explain the difficulties they experience. However, in addition to behavioral changes, physiological puberty, growth and hormonal changes take place at this time, and may also affect hearing. Although a search of the literature did not reveal results
linking hormonal changes in puberty to changes in hearing, it has been shown that hormonal changes can affect hearing, such as reported in menopause and in Turner's syndrome and attributed to changes in the levels of endogenous estrogen hormones (3, 4). Al Mana et al. (5) found that changes in hormonal level during menstrual cycle, pregnancy and menopause may modulate auditory acuity, although an understanding of the exact influence on auditory function remains limited.

Most of the studies on populations with cochlear implants found changes in mapping parameters during the earlier period after implantation and subsequently the mapping parameters remained fairly stable, both in children and in adults. Henkin et al. (6) measured T (minimum) and C (maximum) levels as well as impedance values and discovered large changes during the first 6 months after implantation. Lai et al (2004) (7) followed changes in ECAP measurements and reported similar results; ECAP threshold changed during the first year after implantation and then remained stable. Brown et al. (8) recorded ECAP responses at 3-6 months post implantation, and again 5-7 years later. They reported greater changes in ECAP threshold in children compared to adults. However, this was a long interval, and the timing of changes is unclear. Kaplan Neeman et al. (9) tracked mapping parameters in a group of five women during pregnancy and after delivery to see if the hormonal changes affected these values. They found elevation of the T levels during pregnancy in one woman. The T levels decreased back to baseline after cessation of nursing. They suggested that these changes were a result of temporary hormonal changes that reach equilibrium over time. A search of the literature did not reveal a paper that evaluated the constancy of mapping parameters or a longitudinal study of changes in adolescence.
The aim of the present study was to compare the mapping parameters measured over the years in individuals and to determine whether more changes occurred throughout adolescence than during childhood. Such changes would support an explanation based on hormonal and growth effects on implant functions, rather than changes in emotional or social requirements.

Methods

The files of 23 cochlear-implanted adolescents (13 females, 10 males) with no additional disabilities were studied retrospectively. Their age at the time of the study ranged from 11:10-18:06 years. Data were collected for each individual at several points in time between the ages of 6:06-18:03 years. Age at implantation was 1:11-7:06 years. Four were implanted with the Nucleus 22, ten with Nucleus 24 (Cochlear Corporation) and an additional nine were implanted with the CII (AB Advanced Bionics), all at the Hadassah University Medical Center and they continued their mapping sessions at the hospital's Audiology Clinic. All children were prelingually deaf, consistently used their cochlear implant daily and most were mainstreamed in various school settings. The study was approved by the Hadassah University Medical Center Ethics Committee.

Minimum age for data collection was from 6.5 years and at least three years after implantation, when mapping parameters had stabilized and the children were old enough to cooperate and provide reliable behavioral measures.

Time points from which data were collected retrospectively were typically a year apart and intervals between time points collected for each individual ranged from 9-27 months. The number of time points per individual ranged from 3-11 points.
Data collected at the mapping sessions varied depending on time and diagnostic concerns. Typical data included: behaviorally measured T values, impedance results for all 22 or 16 electrodes (according to the implant model), behavioral audiogram thresholds for the warble pure tones 250-4000 Hz in sound field with the implant, speech reception threshold (SRT) in sound field, and speech perception measured by the number of VCV (Vowel Consonant Vowel) syllables repeated accurately out of 19 VCVs in Hebrew or Arabic.

Data analysis

The analysis of the data was done using paired samples t-test. Two analyses were carried out. In the first analysis, the first point of data collection was compared to the last point with no reference to the age at which these measurements took place. This analysis was carried out on 23 participants. In the second analysis, the data collected between age 6.5 yrs and 10.5 yrs was compared to the data collected between age 11.5 yrs and 18.0 yrs. For those who had several points of data collection in each age group, the first point was included in the younger age group and the last point in the older age group. Participants who had points of data collection at ages included in only one of the age groups were excluded from the analysis. Therefore, this analysis was carried out on 16 participants.

Results

The values of the different measured parameters over time in the same individuals showed no increase or decrease over time, and the changes were within accepted test retest values in the clinic (for example 5dB changes for PTA and SRT). Examples of data for two individuals are presented in Figures 1 and 2.
Table 1 presents descriptive and inferential statistics of the parameters analyzed in the study, in the two analyses. Due to lack of data at some of the data collection points, some of the participants were excluded from the analysis.

In Analysis 1, a comparison between first and last points of data collection was performed. A significant difference was found between age at the first point of data collection (mean age=8.86, s.d.=2.13) and the age at the last point (mean age=13.36, s.d.=2.45, t(22)=-10.05, p<.001). No differences were found in either the behavioral or the objective parameters measured.

Analysis 2 presents the comparison between age 6.5 yrs–10.5 yrs and age 11.5 yrs–18.0 yrs. Mean age was found to be significantly different between the young (mean age=8.31, s.d.=0.95) and the older age group (mean age=13.69, s.d.=1.62, t(15)=-10.6, p<.001). No differences were found in the behavioral or the objective parameters measured. However, the difference in the impedance results was found to be marginally significant (p=0.062).

Discussion

Adolescence is characterized by physiological, psychological, and social development. Audiologists mapping in the clinic had the impression that in this particular age group, recipients have more complaints about the function of their cochlear implant. One hypothesis was that the physiological maturation and hormonal changes can cause changes in the cochlea or nerve and consequently affect the mapping parameters. However, in the present study, no significant changes in mapping or audiometric parameters were found in adolescence; all the parameters studied were found to be stable during adolescence in individuals who had been implanted earlier, in childhood. Al Mana et al. (5) report that changes in estrogen
level cause significant but very small alterations in the auditory system, both at the level of the cochlea and brainstem. However, in the present study, results revealed no significant changes in adolescence compared to childhood for audiological parameters. It is possible that small differences may exist but were not detected in the present study because the measurement procedure could not make fine distinctions in parameters such as lack of control for varying hormonal states and levels of secretion.

An alternative explanation might be suggested. Transition from childhood to adolescence presents all children with challenges in the physiological, psychological, academic and social areas. However, teenagers with a hearing loss face even greater challenges.

Geers et al. (10) conducted a longitudinal study that examined speech, language, and reading skills as well as attitudes in a group of cochlear implanted high school teenagers compared to themselves several years earlier in elementary school. They found an increase in mainstreaming from elementary school to high school. Similar results were reported by Thoutenhoofd (11). However, reading skills, which were very similar to those of age mates with normal hearing in elementary grades, fell further behind hearing peers by their high school years (12). Harris and Terlektsi (13) conclude that even with the considerable advances in hearing technology, many deaf adolescents continue to find literacy and other academic tasks challenging. Dammeyer (14) found that cochlear-implanted children, aged 6–19 years, had more psychosocial difficulties than normative hearing children in the same age group.

Furthermore, Wheeler et al. (15) found teenagers mentioned difficulty with the use of the implant in situations in which there was a lot of background noise. It may be concluded that although cochlear-implanted children experienced positive psychosocial development, as teenagers these individuals have to cope with changes
in everyday situations in the classroom as well as with leisure and other activities, entailing more communication within groups and multiple participant contexts. The adolescent faces higher requirements that can lead to difficulties that were not experienced at younger ages.

Furthermore, adolescence is the stage at which the teenager explores and builds his self-image and identity through social interactions and experiences. Several reports found that self-esteem of cochlear-implanted adolescents was not different than normal hearing peers (16, 17). Dammeyer (14) found that the score on the Strengths and Difficulties Questionnaire SDQ was not significantly different between cochlear-implanted and normal hearing peers aged 6-19 years.

Leigh et al. (18) found that students in higher grades had more of a deaf identity, while students in lower grades had more of a hearing identity. A possible explanation is that students in higher grades increasingly experience communication difficulties with hearing peers in the classroom and in other social situations.

Moog et al. (19) report that the majority of the cochlear implanted high school students exhibited high levels of self-esteem. However, when self-esteem ratings were compared with self-ratings obtained from these same students at 8 or 9 yrs old, adolescent self-ratings were lower than at the younger age. A similar finding was reported by Loy et al. (20). They measured Quality of Life in cochlear-implanted children and found that the overall QoL score was similar to that in normal hearing children. However, the cochlear-implanted teenagers rated QoL lower than the younger group, suggesting that these differences may be related to the pressures and difficulties that adolescents experience. Schorr (2) used reports of cochlear implanted children and found that while younger children aged 5-9 years experienced similar
levels of peer acceptance as normal hearing children, older children aged 9-14 years reported greater loneliness compared to normal hearing peers.

Punch and Hyde (21) interviewed parents, teachers and children. They found adolescence was a particularly difficult time for some as they struggled with feelings of self-consciousness about their hearing, friendships, sensitivity about their appearance, as well as worries concerning external cochlear implant equipment.

There is a need to design a study to test the theory of hormonal influence on the function of the cochlear implant more precisely. Nonetheless, existing research has shown that cochlear implanted adolescents find it harder to cope with the changes than hearing children, and since all the children in this study were mainstreamed at least part of the day, they may compare their functioning to their hearing peers. Teenagers experience difficulty when confronted with new situations in everyday life (e.g. background noise, simultaneous talkers), especially when involving people who do not understand or pay attention to the needs of the cochlear implant user. It may very well be that unconsciously they chose to explain the difficulties they experience and the gap in performance between themselves and their hearing peers by "blaming" the function of the cochlear implant. Therefore, it is recommended that teenagers be counseled about the development and changes in the adolescent stage in general, how it may affect their hearing with the cochlear implant, and thus help them overcome the difficulties and cope with new situations.

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References


19. Moog JS, Geers AE, Gustus CH, Brenner CA. Psychosocial adjustment in adolescents who have used cochlear implants since preschool. Ear Hear 2011;32;75S–83S


Figure 1. An example of a boy with congenital hearing loss implanted with a Cochlear Nucleus 24 at the age of 3:01. As can be seen between ages 7.8 to 13.6, no great changes in any of the measured parameters were seen.

Figure 2. An example of a girl with congenital hearing loss implanted with Advanced Bionics CII at the age of 5:03. As can be seen between ages 8.5 to 15.2, no great changes in any of the measured parameters were seen.
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