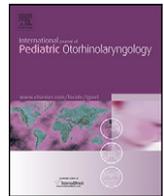




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## Cochlear implant outcomes in children with motor developmental delay

Susan Amirsalari<sup>a</sup>, Jaleh Yousefi<sup>a,\*</sup>, Shokofeh Radfar<sup>a</sup>, Amin Saburi<sup>b</sup>, Seyed Abbas Tavallaie<sup>a</sup>, Mohammad Javad Hosseini<sup>a</sup>, Sima Noohi<sup>a</sup>, Mahdieh Hassan Alifard<sup>a</sup>, Mohammad Ajallouyeen<sup>a</sup>

<sup>a</sup> Cochlear Implantation Research Center, Baqiyatallah University of Medical Sciences, Tehran, Islamic Republic of Iran

<sup>b</sup> Health research center, Baqiyatallah University of Medical Sciences, Tehran, Islamic Republic of Iran

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### ABSTRACT

**Introduction:** Multiple handicapped children and children with syndromes and conditions resulting additional disabilities such as cerebral palsy, global developmental delay and autistic spectrum disorder, are now not routinely precluded from receiving a cochlear implant. The primary focus of this study was to determine the effect of cochlear implants on the speech perception and intelligibility of deaf children with and without motor developmental delay.

**Method:** In a cohort study, we compared cochlear implant outcomes in two groups of deaf children with or without motor developmental delay (MDD). Among 262 children with pre-lingual profound hearing loss, 28 (10%) had a motor delay based on Gross Motor Function Classification (GMFC). Children with severe motor delays (classification scale levels 4 and 5) and cognitive delays were excluded. All children completed the Categories of Auditory Perception Scales (CAP) and Speech Intelligibility Rating (SIR) prior to surgery and 24 months after the device was activated.

**Result:** The mean age for the study population was  $4.09 \pm 1.86$  years. In all 262 patients the mean CAP score after surgery ( $5.38 \pm 0.043$ ) had a marked difference in comparison with the mean score before surgery ( $0.482 \pm 0.018$ ) ( $P = 0.001$ ). The mean CAP score after surgery for MDD children was 5.03, and was 5.77 for normal motor development children (NMD). The mean SIR score after surgery for MDD children was 2.53, and was 2.66 for NMD children. The final results of CAP and SIR did not have significant difference between NMD children versus MDD children ( $P > 0.05$ ).

**Conclusion:** Regarding to the result, we concluded that children with hearing loss and concomitant MDD as an additional disabilities can benefit from cochlear implantation similar to those of NMD.

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### 1. Introduction

Recently, treatment of children with severe-to-profound sensorineural hearing loss has been influenced by diagnostic improvements and technological treatment advances, specifically new cochlear implant prospects. These advances have changed cochlear implantation into a burgeoning common procedure in the treatment of these children. Moreover, these screening and treatment advances have established a huge population of cochlear implant candidates. On the other hand, one of the public health application and outreach goals from healthy people 2010, objective 28:13b [1], is to decrease the number people who are deaf or very hard-of-hearing by the means of cochlear implants. This goal was established in an attempt to address the fact that, despite the substantial benefit

the procedure can provide recipients, cochlear implantation is an underutilized service.

Specifically, the National Institute on Deafness and Other Communication Disorders (NIDCDs) report notes that in 1999 only 2 of every 1000 deaf or very hard-of-hearing adults received a cochlear implant. Statistics for cochlear implant utilization in children are not provided, but similar underutilization is implied [2].

Multiple handicapped children and children with syndromes and conditions resulting disabilities such as dual sensory loss, cerebral palsy, global developmental delay and autistic spectrum disorder, are now not routinely precluded from receiving a cochlear implant. However, regarding to the fact that children with motor and/or cognitive delays are significantly slower than other children in their development of speech perception skills after implantation, the anticipated outcomes in these children are likely to differ markedly from those of their peers without additional sensory, motor or cognitive disabilities, suggesting that these types of delays were a better predictor of outcome than etiological factors per se [3].

There are controversies around the results of cochlear implantation in children with concomitant developmental delay.

\* Corresponding author at: Cochlear implantation Research Center, Baqiyatallah University of medical sciences, Baqiyatallah Hospital, Vanak Sq, Mollasadra St, Tehran, Islamic Republic of Iran.

Tel.: +98 21 8860006; fax: +98 21 8860006.

E-mail address: [bcic\\_bcic@yahoo.com](mailto:bcic_bcic@yahoo.com) (J. Yousefi).

Although, it seems that the disability type and severity are potentially more predictive than an etiology of delay or hearing loss. This is likely an important concept to convey as we expand our comfort level with specialized populations. Holt and Kirk evaluated a group of 19 cochlear implanted children with additional developmental delay (mild cognitive delays) concluding that these children do benefit from cochlear implantation in terms of speech perception and receptive and expressive language [4]. In contrary, Donaldson et al. assessed the progress of six children with autistic spectrum disorder, and reported small gains compared with the general implant population and suggested a positive impact on quality of life of majority of the families (five out of six) because of the improvements in behavior and interactions with others [5]. Also, in a similarly small sample of children with additional disabilities ( $n=4$ ), successful outcomes have been reported in terms of subjective indicators of quality of life improvements where speech and language progress was limited [6]. The primary focus of this study was to determine the effects of physical developmental delay on cochlear implant outcomes.

## 2. Patients and methods

A cohort study was conducted on children with pre-lingually profound hearing loss in Baqiyatallah cochlear implant center, Tehran, Iran between 2007 and 2009. Patients with following criteria were included; (1) permanent sensory-neural hearing loss, (2) onset of hearing loss before six months of age, (3) use of amplification and/or intervention program emphasizing spoken language, (4) Persian as the language of communication, and (5) the maximum age was 9 years old. Also, Children with severe motor delays (classification scale levels 4 and 5) and cognitive delays were excluded. Each child was examined by a developmental pediatrician, a clinical psychologist, an audiologist, and a speech/language pathologist. Before receiving a cochlear implant, all children received cognitive testing, GMFCS, Categories of Auditory Perception Scales (CAP), and Speech Intelligibility Rating (SIR).

This total group (262 children) was divided into two study-groups: group 1, children with normal motor development (NMD) ( $n=234$ , 89.3%), group 2, children with motor developmental delay (MDD) ( $n=28$ , 10.7%). Inclusion in the motor delay group was children in level of 1–3 (mild to moderate motor developmental delay) based on assessment with the Gross Motor Function classifications (GMFCS) [7].

The age distribution between these two groups was mentioned not to have significant differences. We tried to eliminate all biases by compatible age groups, same surgeon, same center, and same examiners. All the children after general anesthesia were implanted using the nucleus CI 22 (Nucleus 24 freedom of cochlea company, Van Cove, Sydney, Australia) cochlear implant device, and all had full insertion of the electrode array. All patients auditory and speech conceptions were evaluated by means of CAP and SIR score (Tables 1 and 2) [8]. They were followed up in the

**Table 1**  
Speech Intelligibility Ratings (SIR).

Category 1	Connected speech is unintelligible. Pre-recognizable words in spoken language (primary mode of communication may be manual)
Category 2	Connected speech is unintelligible. Intelligible speech is developing in single words when context and lip-reading cues are available
Category 3	Connected speech is intelligible to a listener who concentrates and lip-reads within a known context
Category 4	Connected speech is intelligible to a listener who has little experience of a deaf person's speech
Category 5	Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts

**Table 2**  
Categories of Auditory Perception Scale (CAP).

Category 0	No awareness of environmental sounds
Category 1	Awareness of environmental sounds
Category 2	Response to speech sounds (e.g. "go")
Category 3	Identification of environmental sounds
Category 4	Discrimination of some speech sounds without lipreading
Category 5	Understanding of common phrases without lipreading
Category 6	Understanding of conversation without lipreading
Category 7	Use of telephone with known listener Books

same cochlear implant center and speech perception abilities were evaluated before implantation and at 6, 12, 18, and 24 months after the device was activated. Cochlear implantation was performed by a single surgeon and each evaluation such as assessment of developmental delay or speech/language skills was performed by a single specialist in those fields. Furthermore, the post-cochlear implant outcomes and results were compared in normal children versus children with motor developmental delay in different age groups. All quantitative variables' distribution was assessed by Kolmogorov–Smirnov test and then represented as mean  $\pm$  SD (standard deviation) and qualitative variable presented as percent. *T*-test (paired and unpaired) was used to compare the effect of cochlear implantation on the CAP and SIR score and chi-square test was used to compare between qualitative variables and also Wilcoxon and Mann–Whitney *U* test was used for non-parametric parameters. All analyses were performed by using SPSS version 16th and *P*-values  $<0.05$  were considered statistically significant. Our study was approved by Baqiyatallah University Ethics committee and the study was explained for our patient's parents and consents were taken from all the patient's parents.

## 3. Results

Overall, the mean age for the study population was  $4.09 \pm 1.86$  years (with the range of 1–9 years). 129 Of cases were boys (49.2%) and 133 were girls (50.8%). Of these total cases 28 (10.7%) had motor developmental delay (Based on Gross Motor Function classifications), which were assessed in first group and the remaining 234 normal developed patients were assessed in second group. Age distribution between the MDD and NMD children did not have significant differences ( $3.54 \pm 2.08$  and  $4.22 \pm 1.19$ , respectively) ( $P=0.78$ ).

The outcomes of auditory speech perception tests were compared before surgery and 24 months after the device was switched on for all cases, then were compared between our 2 groups. In all 262 patients the mean CAP score after surgery ( $5.38 \pm 0.043$ ) had a marked difference in comparison with the mean score before surgery ( $0.482 \pm 0.018$ ) with ( $P=0.001$ ). In consistent with CAP, the mean SIR score after surgery ( $2.507 \pm 1.47$ ) had a meaningful difference versus the score before surgery ( $0.38 \pm 0.03$ ) ( $P=0.001$ ). Of the MDD cases, 20 patients obtained  $\geq 5$  of CAP (71.4%) and 14 obtained  $\geq 3$  of SIR score (50%). In comparison, among normal developed patients the final results of CAP  $\geq 5$  was obtained in 166 cases (70.9%) and SIR  $\geq 3$  in 126 cases (53.8%) which does not show significant contrast between two groups (Tables 3 and 4). Finally, the mean CAP score after surgery for Developmental delayed children was 5.03, and was 5.77 for normal developed children. The mean SIR score after surgery for MDD children was 2.53, and was 2.66 for normal developed children. The final results of CAP and SIR did not have significant difference between normal children versus MDD children (Fig. 1).

## 4. Discussion

This study was performed to evaluate the effects of concomitant motor developmental delay on post-cochlear implant outcomes.

**Table 3**

Cap distribution between different groups.

CAP	1	2	3	4	5	6	7
1+(developmental delayed)	0 (0%)	2 (7.1%)	2 (7.1%)	4 (14.2%)	9 (32.1%)	7 (25%)	4 (14.2%)
2+(normal developed)	0 (0%)	3 (1.2%)	36 (14.5%)	59 (24.2%)	45 (18.5%)	71 (29.5%)	50 (20.5%)

**Table 4**

SIR distribution between different groups.

SIR	1	2	3	4	5
1+(developmental delayed)	6 (21.4%)	8 (33.3%)	8 (33.3%)	5 (17.8%)	1 (3.5%)
2+(normal developed)	41 (16.8%)	27 (28.6%)	65 (27.7%)	52 (22.2%)	9 (4%)

Our hypothesis before study was that the children with hearing loss and additional disability could be affected the outcome of cochlear implantation. But our findings demonstrated that there are no significant final SIR and CAP differences between normal candidates versus candidates with motor developmental delay. The main theme arising from the results of this study is that, developmental delayed children can benefit from cochlear implantation like other normal developed children, especially those with motor developmental delay. It seems to cochlear implantation by enhancing children ability capability could improve quality of life of children and their family however; further studies are needed to prove it. The most prominent improvement was much easier communicating abilities than pre-implant.

During the past 10 years, there has been a dramatic rise in the number of studies that document the effectiveness of cochlear implantation in children with additional disabilities [4,8–11,15–19]. Holt and Kirk evaluated a group of 19 cochlear implanted children with additional developmental delay (mild cognitive delays) concluding that these children do lower benefit from cochlear implantation versus normal children in terms of speech perception that this result is different with our findings [4].

Donaldson et al. assessed the progress of six children with autistic spectrum disorder, and reported small gains compared with the general implant population and suggested a positive impact on quality of life of majority of the families (five out of six) because of the improvements in behavior and interactions with others [5]. This result was different with our findings that the outcomes of children with multiple disability similar to children without it however underlying disability in these studies was not similar. Also, in a similarly small sample of children with additional disabilities ( $n = 4$ ), successful outcomes have been reported in terms of subjective indicators of quality of life improvements where speech and language progress was limited [6]. The primary

focus of this study was to determine the effects of physical developmental delay on cochlear implant outcomes and quality of life was not evaluated.

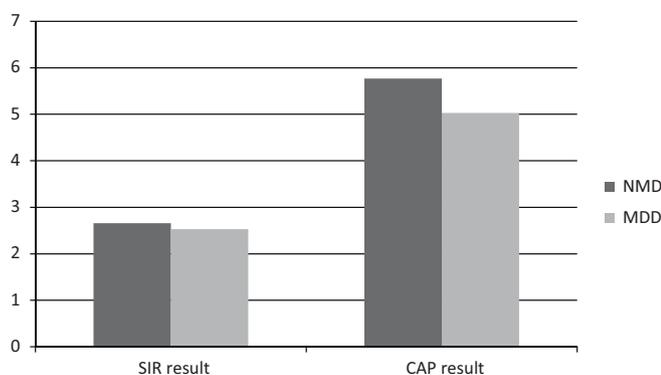
These disabilities range from cognitive and learning disabilities [3,4], visual impairment [8,9], autistic spectrum disorder [5]; moreover, some studies have evaluated mixed additional disabilities and do not define the disability of the children [11–15]. Hamzavi et al. reported substantial benefit in implanted deaf children with additional disorders [12]. Waltzman et al. also reported benefit from cochlear implantation in 31 children with additional needs in terms of speech perception. [11]. Beadle et al., reported that implanted children were making progress as measured by SIR, between 5 and 10 years after implantation [15]. In contrary, Nikolopoulos et al. reported that 30% of Cochlear implantation with additional disabilities developed no intelligible speech, as measured by SIR, after 5 years, versus 3.7% of the group without additional disabilities. Their results revealed that the number of additional disorders had the strongest correlation with speech quality, and the more additional disabilities are, the less resultant speech intelligibility will be [20]. But, they did not emphasize on any specific disability limited profit of cochlear implantation. Encountering controversial results from various research studies may confuse practitioner's decisions for cochlear implantation in developmental delayed children.

## 5. Conclusion

In current study, we concluded that developmental delayed children with concomitant hearing loss especially those with motor developmental delay can benefit from cochlear implantation similar to those of normal developed children and we can emphasize that additional motor developmental delay would not impair post-cochlear implant results but for other aspects of additional developmental delay more studies might be necessary for certain conclusions.

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**Fig. 1.** The mean SIR and CAP scores 24 months after surgery in normal versus motor developmental delayed children. NMD – normal motor developed children; MDD – motor developmental delayed children.

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