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Prediction of Factors Affecting Speech and Auditory Outcomes of Cochlear Implantation in Pre-Lingual Deaf Children: A Cross-Sectional Study

Sunita D*

Department of ENT and Head & Neck Surgery, Maulana Azad Medical College, India

Abstract

Objective: To determine the factors affecting speech and auditory outcomes of Cochlear Implantation (CI) in pre-lingual deaf children.

Methods: Cross-sectional study was performed on 40 pre-lingual deaf children who underwent CI at our institution at <6 years of age. Their speech and auditory outcomes were evaluated using Speech Intelligibility Rating Scale (SIRS) and Category of Auditory Performance (CAP). Further, the factors affecting the speech and auditory outcomes were analyzed.

Result: Mean age at the time of CI was 3.5 years (P=0.01). Postoperative speech and auditory rehabilitation therapy was received by 34 patients (P<0.01). Implant compliance was seen in 38 patients (P=0.01). Strong family support was received by 39 patients.

Conclusion: Age at the time of CI, postoperative speech and auditory rehabilitation therapy, implant compliance and family support play a vital role in determining the outcome of the surgery.

Keywords: Ear; Cochlear Implantation; Pre- lingual deaf children; Functional outcomes

Introduction

It is well established that hearing loss in early childhood affects the development of speech perception, language and reading skills. Hearing is vital for neurocognitive development, since sound deprivation early in life degrades the multiplicity of neural circuits that are responsible for information processing, especially those involved in acquisition of speech and language [1,2]. For children with profound sensorineural hearing loss, the auditory access provided by hearing aids is not sufficient, resulting in delayed spoken language development. An alternative for children who receive limited benefit from hearing aids is a Cochlear Implant (CI). Research on the efficacy of CIs in children shows improvements over time in speech perception [3], and language and reading skills [4]. Moreover, children with CIs reach levels of performance that surpass those of their non-implanted peers who use hearing aids [5]. This technology enables many children with congenital deafness to be educated in regular-education school settings alongside their hearing peers.

Within the group of children with CIs, however, language and listening outcomes are quite variable. Some factors that influence outcomes include age at onset of deafness, duration of profound deafness, age at CI, communication mode, preoperative residual hearing, postoperative Auditory Verbal Therapy (AVT), socioeconomic status and family support [6]. Children who are implanted earlier tend to show speech perception outcomes that are significantly better than children who are implanted later [7].

Various scoring systems used to assess functional outcomes in these patients are Speech Intelligibility Rating Scale (SIRS), Category of Auditory Performance (CAP), Meaningful Auditory Integration Score (MAIS) and many more. The aim of the study was to evaluate the hearing and speech outcome of cochlear implantation in pre-lingual deaf children <6 years of age at the time of implantation.

Subjects

A cross-sectional study was conducted in the Department of Otorhinolaryngology and Head and Neck Surgery, Maulana Azad Medical College, and Associated Lok Nayak Hospital (LNH), New Delhi. Forty pre-lingually hearing-impaired children (22 boys and 18 girls) were included in

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Correspondence:
Sunita Dhakal, Department of ENT and Head & Neck Surgery, Maulana Azad Medical College, Delhi, India, Tel: +918826749338;

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this study. Inclusion criteria were: (1) pre-lingual deaf children having undergone CI in LNH between the years 2013-2023; (2) age <6 years at the time of implantation. Exclusion criteria were: (1) post-lingual deafness; (2) children having cochlear vestibular malformation/ labyrinthitis ossificans; (3) bilateral cochlear implantation.

Auditory and Speech Assessment Methods

The assessment tools used were the Category of Auditory Performance (CAP) for hearing outcomes and Speech and Intelligibility Rating Scale (SIRS) for speech outcomes. Factors affecting the outcome were further analyzed *viz*: Age at implantation, auditory training, user or non-user, IQ/DQ status, socio-economic status and family support.

The CAP scores patient on a scale of 0 to 7: 0 = No awareness of environmental sounds; 1 = Awareness of environmental sounds; 2 = Response to speech sounds; 3 = Identification of environmental sounds; 4 = Discrimination of some speech sounds without lip reading; 5 = Understanding of common phrases without lip reading; 6 = Understanding of conversation without lip reading; 7 = Use of telephone with known listener.

Similarly, SIR scores on a scale of 1 to 5 as follows: 1 = Connected speech is unintelligible. Pre-recognizable words in spoken language, primary mode of communication may be manual; 2 = Connected speech is unintelligible. Intelligible speech is developing in single words when context and lipreading cues are available; 3 = Connected speech is intelligible to a listener who concentrates and lip reads; 4 = Connected speech is intelligible to a listener who has a little experience of a deaf person's speech; 5 = Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts.

A CAP score of 4 and above were taken as "good performers" and <4 as "poor performers". SIRS score of 3 and above were taken as "good performers" and <3 as "poor performers".

Observations and Results

The following factors were evaluated while assessing the auditory and speech outcome of the patients: Age distribution of study subjects, gender distribution, side of ear operated, age at the time of cochlear implantation, hearing aid trail before CI, HRCT temporal bone findings, MRI brain findings, IQ/DQ status, number of electrodes placed, auditory training, socio-economic status, user/ non-user, family support.

The data analysis was done using Chi-square test and Fisher exact test for qualitative data. For quantitative data, ANOVA test and Kruskal Wallis test was used. Amongst the factors mentioned above, the following factors seemed to have a major influence on the outcome of speech and hearing in these patients:

Age at the time of CI

Out of 40 subjects, 15 (37.5%) were 3 years of age at the time of CI, 10 (25%) were 2-years of age, 8 (20%) were 4 years of age and 7 (17.5%) were 5 years of age. After the data analysis, the calculated P value was 0.01 (CAPS and SIRS), which was statistically significant.

Auditory training

Out of 40 subjects, 45 (85%) underwent postoperative auditory/ speech rehabilitation, 6 (15%) did not. After the data analysis, the calculated P value was <0.01 (CAP) and <0.01 (SIRS) which was statistically significant.

User/non-user of the implant

Out of 40 subjects, 38 (95%) were regular users of the implant, 5% (2) were intermittent users. After the data analysis, the calculated P value was 0.01 (CAP) and 0.02 (SIRS) which was statistically significant.

Family support

Out of 40 subjects, 39 (97.5%) received family support, 1 (2.5%) did not. Due to small sample size and just 1 subject did not receive family support, the P value was 0.12 (CAP) and 0.17 (SIRS).

Discussion

From our study on determining the factors affecting the hearing and speech outcome of cochlear implantation, the various factors that directly affected the outcome of CI were the age at the time of CI, postoperative auditory and speech rehabilitation therapy, regular use of the implant and family support.

Age related demographics

In the present study out of 40 patients, all the patients were implanted at the age ≤ 6 years, 15 patients (37.5%) were implanted at the age of 3 years. In a study conducted by Mohan Kameswaran et al. on 100 patients, 39% patients were implanted between 1 to 5 years [8]. Another study done by Devendra Gupta et al. on 30 patients, the average age of the patients was 3 years, ranging between 2.5 to 3 years [9]. In a study conducted by Anjan Das et al. on 30 patients, 73.33% patients fell in the age group between 2 to 4 years [10]. Ismail Zodi et al. conducted a study on 70 patients with an average age of 4.70 years [11].

Considering the data from all these studies, the average age at the time of cochlear implantation was below 5 years which is comparable to our present study with a mean age of 4.29 years and P value =0.01. Improved social awareness and with the realization of better outcome with early implantation, there is an increasing trend of cochlear implantation at an early age.

User/non-user in study subjects

In the present study, 95% of patients were regular users of the implant whereas 5% of them were intermittent users. In a retrospective study conducted by Anne et al. on 317 cochlear implanters, they divided the patients into three groups. Group 1 comprised those patients implanted during adolescence. Group 2 included the patients implanted below the age of 3 years. Group 3 comprised those patients implanted between 3 to 11 years. In group 1, overall non-compliance was 15.2%, with 1 non-user (1.3%) and 11 partial users (13.9%). In group 2, there was a 3.8% non-compliance rate with 1 non-user (1.9%) and 1 partial user (1.9%). In group 3, there were 8 (9%) partial users and no non-users. In their retrospective review, they found out that the patients who were implanted during childhood on reaching adolescence faced bullying at school that contributed to their partial use. There were also some technical concerns from 4 adolescents in this group (50%), with 2 children reporting their implant to be too loud and 1 whose processor was rubbing against the ear. One patient reported imbalance [12]. Wheeler et al. reported a 6.9% rate of partial use in adolescents who had been implanted as children [13]. In the present study, the relationship between regular use of the cochlear implant and intermittent use was found to be statistically significant. The main factor contributing to the partial use of the implant was due to lack of awareness of the family members for the need of constant use of the cochlear implant. This patient after cochlear implantation

went to his village to live with his grandparents who had no knowledge about the implant. As a result, he had a poorer outcome in the follow up period. Hence, strict compliance is required for a better outcome post implantation.

Family support in study subjects

In the present study, during the follow up period we found a lack of family support in 1 (2.5%) patient. When the matter was further investigated into, the parents reported that they expected an immediate result in hearing and speech outcome and when the case did not turn out to be so, they thought of it as a failed surgery and never brought the child for rehabilitation therapy. The reason might be due to improper counselling and lack of awareness of the family members about the need of post op auditory verbal therapy and their belief that surgery would be enough for improvement in hearing. Also, the father had studied till 8th standard and the mother was illiterate, that can also be a contributing factor towards negligence of the parents towards their child. Due to lack of family support, the child performed poorly in the CAP (=1) and SIR (=1) scoring scale. In a study conducted by Spencer, where he examined different behavioral indicators of parental involvement related to their children's education and development both before and after cochlear implantation. Findings indicated an association between high levels of parental involvement, for example, learning sign language, advocating for their child's needs, devoting time, and effort to take their child to cochlear implant clinic for follow-up and monitoring children's language achievement [14]. In a study of parents' perceptions of their involvement related to their children's cochlear implant use, DesJardins found that mothers' higher sense of involvement was associated with enhanced language facilitation strategies and their children's improvement in language abilities [15]. Merv et al. conducted a study on 247 parents of cochlear implanters in the three eastern states of Australia. Mothers comprised the large majority (88.3%) of respondents, whereas 10.1% were fathers and 1.6% were "others" (two of whom were the child's grandmother, one the child's foster parent, and one the child's stepfather. Of the 247 surveys analyzed, 49.4% reported on a male child. They concluded from their study that the decision of a child receiving a cochlear implant and the outcome post implantation was dependent upon the parents' awareness about the cochlear implant program. They found out that information was often limited and that some parents made their decisions with a sense of urgency if having their children implanted [16]. In the present study, we found a strong co-relation between the hearing and speech outcome of the patient and family support.

Auditory training provided in study subjects

In present study, postoperative rehabilitation therapy was received by 85% of the patients whereas 15% of them did not. The main reason for not receiving the rehabilitation therapy was due to distant home addresses of the patients from the rehabilitation center which made it difficult for the parents to bring their child for regular follow-ups. Due to lack of awareness and low education level of the parents of these children, auditory training even at home was not provided to these children. Sabah et al. conducted a study on 30 patients, who were divided into two groups according to intensiveness of the auditory training. Each group included 15 patients (10 males and 5 females). Both the groups received the usual cochlear implant therapy program. Group 1 received an additional therapy other than the usual form. Minimal Auditory Capabilities Test (MAC Test) was used to assess auditory perception abilities and Speech Intelligibility Rating Scale (SIR) was used to assess speech production skills before implantation and 3, 6, 12, 18 months post-operatively. A significant difference was found when comparing the two groups in spondee words discrimination during the postoperative assessment periods with P value <0.05. A highly significant difference was found for spondee words recognition, sentence identification and high context sentence recognition at the 18-month assessment with P value <0.01. A significant mean difference with P value <0.05 for speech intelligibility scores at 18 months post-implantation was found between the two groups [17]. In another study conducted by Ting at el. on 7 cochlear implant users, wherein the patients were subjected to intensive auditory training ranging from 962 min to 1,271 min with a mean of 1,078 min the pertaining performance was measured once per week for 3 weeks. The study demonstrated that, on average, the phonemic-based auditory training resulted in a 10% improvement in vowel, consonant, and CNC (Consonant-Nucleus-Consonant) word identification performance in those patients who had extensive experience (at least 2 years) with their cochlear implant [18]. Even in the present study, we found out that the children who received extensive auditory training at the rehabilitation center/ home performed better than who received minimal or no training at all. Thus, an intensive form of auditory training can result in an improvement of both auditory abilities and speech intelligibility.

Conclusion

CI is an important modality of treatment for children with severe to profound sensorineural hearing loss who do not benefit from hearing aids. However, many factors like age at implantation, auditory training, compliance with the implant and family support play a vital role in determining the outcome of the surgery.

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