

Evaluation of Speech Perception Skills after Unilateral Cochlear Implantation in 45 Pre Lingual Deaf Patients

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Abstract: Under B.J. Medical College Cochlear and Hearing Implant Programme 45 prelingual deaf patients who underwent unilateral Cochlear Implantation were selected and divided into five groups on basis of age at which participants underwent implantation: ≤ 3 years, 3 to 6 years, 6 to 9 years, 9 to 12 years, and 12 to 15 years. Speech perception skills were assessed using phonetically balanced Hindi word list before implantation and at specified post-implant switch-on time periods for upto 2 years. The scores increased significantly in all five groups from pre- to post- CI in every follow-up. Positive effect of time was seen with better results in those implanted at younger age.

Keywords: Cochlear Implantation, prelingual deaf patients, speech perception skills, phonetically balanced Hindi word list

1. Introduction

In the past thirty years, Cochlear Implants have evolved from a single-channel device, providing little or no speech understanding, to multi-channel implants using advanced signal processing strategies. Cochlear Implantation is a well-established intervention for both adults and children with severe to profound bilateral sensorineural hearing loss, who receive no useful benefit from hearing aids (HAs) [1], [2]. As of December 2010, approximately 219,000 people worldwide have received Cochlear Implants; in the United States, roughly 42,600 adults and 28,400 children are recipients [3]. Hearing loss interferes with a person's ability to communicate effectively. Profound or severe hearing impairments in young children often result in poor speech perception skills. Multichannel Cochlear Implantation of profoundly hearing impaired children unable to benefit from hearing aids results in significant improvements in speech perception following implantation [4], [5], [6], [7], [8].

2. Literature Survey

Cochlear Implant (CI) is an electronic device that aims to restore hearing to a person who is profoundly deaf or severely hard of hearing. Unlike HAs, the CI does not amplify sound, but works by directly stimulating any functioning auditory nerves inside the cochlea with electrical impulses. The electrodes are placed inside the cochlea and bypass the damaged or missing hair cells which would usually code sound, and stimulate the auditory nerve directly. Electrical currents from the implant then initiate action potentials in the auditory nerve, which travel to the brain.

A CI has internal and external components. The external components include a microphone, a speech processor, connecting cables, and a transmitting coil. The microphone detects the sound signal which is sent to the speech processor. The speech processor (which may be behind-the-ear or body-worn type) transforms the sounds picked up by the microphone into electronic signals and creates set of coded electrical stimuli that represent the frequency and temporal content of the input sound. This information is then sent to the transmitter located on the outside of the implant user's head which is aligned with the internal receiving coil by magnets. The signal is then delivered via transcutaneous transmission (i.e. delivered across intact skin using a radio frequency link) to the internal components of the CI [9]. The internal components of the implant which are surgically implanted in the skulls' temporal bone comprise a receiver-stimulator (RS) unit and electrodes (ground and active electrodes). The RS comprises a magnet (for attachment of the external headset) and an antenna [10]. Ground electrode sits on skull, below the temporalis muscle whereas the active electrodes (which might be standard, medium, short, compressed, contour, split) are housed along an electrode array. The electrode array is made from a type of silicone rubber, while the electrodes are platinum or a similar highly conductive material. Electrode array is inserted into the cochlea in the scala tympani to a depth of one and a half turns of the cochlea [11]. The antenna receives power and information for controlling electrical stimulation from the transmission coil. This information is then used to stimulate the electrodes along the array which stimulate different subpopulations of neurons. Multichannel CIs, which use multiple intracochlear electrodes, take advantage of the

tonotopic organization of the cochlea by electrically stimulating high frequency basal electrodes, followed the lower frequency apical regions [12].

3. Previous Work

Zakirullah et al (2008)[13] conducted a prospective study which was designed to evaluate the development of auditory perception skills and language in children, over a twelve months period, following Cochlear Implantation. Twenty-one patients were enrolled in this evaluation. These were divided into three groups as per age factor and were evaluated using "Evaluation of Auditory Responses to Speech" (EARS) which includes Open set monosyllabic words (OSM). Improvement in performance on all measures was noticed in all the groups over a twelve months period following implantation. Dynamics of improvement in auditory skills suggested more and rapid development in younger age group.

Richard Dowell et al (2002)[14] studied long-term speech perception outcomes in children using Cochlear Implants. A group of 102 children using the Nucleus multichannel Cochlear Implant were assessed for open-set speech perception abilities using the open-set Phonetically Balanced Kindergarten (PBK) words [15] and the open-set Bench-Kowal-Bamford (BKB) sentence test [16] at six-monthly intervals following implant surgery. Multivariate analysis indicated that a shorter duration of profound hearing loss, later onset of profound hearing loss, exclusively oral/aural communication and greater experience with the implant were associated with better open-set speech perception.

4. Method

A total of 45 prelingual deaf patients (satisfying the inclusion criteria) who underwent unilateral Cochlear Implantation under B.J. Medical College Cochlear Implant Programme from April 2007 to August 2010 were included in the study. All participants underwent Cochlear Implantation by Transcanal "Veria" Technique. Full insertion of the active electrode array was accomplished in all subjects. Tempo+ speech processor was used in these subjects. All participants used the CIS speech processing strategy with a stimulation rate of 1500 pulses per second. All participants underwent Auditory-Verbal training and had strong family support systems.

4.1 Study design

The study was retrospective and prospective comparative interventional type. In this study a quantitative approach was used to collect, analyze and interpret the data. The quantitative approach allows the researcher to describe and objectively assess the outcomes [17].

4.2 Inclusion Criteria

Inclusion criteria for the study were:

- Prelingually deafened CI recipients.
- Patients with severe to profound bilateral congenital sensorineural hearing loss with pre-op average pure-tone thresholds worse than 70 dB HL.

- Patients who received no useful benefit from hearing aids (HAs).
- Patients ≤ 15 years age.
- Patients who underwent unilateral Cochlear Implantation.
- Patients implanted with the MED-EL Combi 40+ implant (standard electrode) (MED-EL medical electronics, Innsbruck, Austria).
- Patients having normal cochlea, vestibulo-cochlear nerve with normal Broca's area.
- Patients without external and middle ear infections.
- Patients with normal IQ.
- Patients without additional syndromes/illness that could affect the child's development.
- Patients having access to post-Cochlear Implant rehabilitation (through auditory verbal training).
- Patients having high motivation from family and family willing to work toward speech and language skills with therapy.

4.3 Study groups

Whole of participants were divided into five groups on the basis of age at which participants underwent implantation: ≤ 3 years, 3 to 6 years, 6 to 9 years, 9 to 12 years, 12 to 15 years. This was done to enable evaluation in each group.

4.4 Materials

The phonetically balanced Hindi Word List of 51 words prepared by Ali Yavar Jung National Institute For The Hearing Handicapped (AYJNIHH), Mumbai was used to determine the speech perception skills by open-set testing.

4.5 Procedure

Open-set testing using phonetically balanced word list (P.B. List) was used to ascertain the speech perception skill to determine the subjects' ability to recognize words. Open-set speech perception score was assessed before implantation (aided with amplification) and at six post-implant switch-on time periods : 1 month, 3 months, 6 months, 9 months, 1 year, 2 years with the Cochlear Implant alone. A list of 20 words from P.B. Hindi Word List, AYJNIHH, Mumbai was presented using live voice by audiologist in a quiet, sound-treated room. All testing was carried out using audition alone, with visual cues including lip-reading and sign unavailable. The percentage of total number of such presented words that the subject correctly identified was determined.

4.6 Statistical analysis

All the patients were assessed and data obtained both preoperatively and postoperatively at appropriate intervals according to the follow up protocol. Scores for open-set tasks were averaged and plotted for each group. The study was based on individual children evaluated with repeated measures, each child serving as his own control. The significance of the difference between the individual preoperative and postoperative scores was evaluated using the post hoc test of repeated measure analysis. The statistical software used for analysis of the results of this study was

SPSS version 17. A 'p' value of < 0.05 was regarded as statistically significant.

5. Results and Discussion

Our study showed that Cochlear Implantation provides a significant speech perception benefit for prelingually deafened children. All the subjects in the study did show improved speech perception score on open-set testing postoperatively compared to pre-op attaining significance (p< 0.05) in all implanted age groups and there was positive effect of time with scores increasing on every follow-up. Pre-op average speech perception score was ≤ 5% in all implanted age groups with scores increasing over time to attain average speech perception score ranging from 52.5 to 77.7% in all implanted age groups after 2 years of implantation as illustrated in table 1 and fig. 1. Possible reasons for better performance include provision of consistent auditory experience, regular auditory verbal training and strong family motivation. Zakirullah et al (2008) also showed that there is a significant improvement open set skills over time [13]. The results were consistent with Richard Dowell et al (2002) who showed that children implanted before the age of 4 years had mean scores of 79% for open-set phonemes after three years of experience with the Cochlear Implant [14].

Table 1: Descriptive statistics for speech perception score based on open-set testing

Implantation age group	≤ 3 years	3 - 6 years	6 - 9 years	9 - 12 years	12 - 15 years
Pre-op	3.44 (3.63)	4.21 (3.44)	3.85 (3.63)	2.5 (3.54)	2.5 (3.54)
Post-op 1 month	18.89 (1.67)	18.42 (2.39)	16.15 (3.63)	12.5 (3.54)	10 (0)
Post-op 3 months	33 (3.54)	30 (3.9)	26.62 (3.2)	20 (0)	17.5 (3.54)
Post-op 6 months	53.11 (3.91)	49.21 (3.82)	48.46 (4.74)	30 (0)	25 (0)
Post-op 9 months	62.78 (2.2)	59.47 (4.05)	55 (3.54)	42.5 (3.54)	40 (0)
Post-op 1 year	72.67 (2.5)	68.16 (2.48)	63.85 (3)	50 (0)	47.5 (3.54)
Post-op 2 years	77.67 (2.5)	74.47 (2.3)	69.62 (2.47)	55 (0)	52.5 (3.54)
p-value	< 0.05 significant				

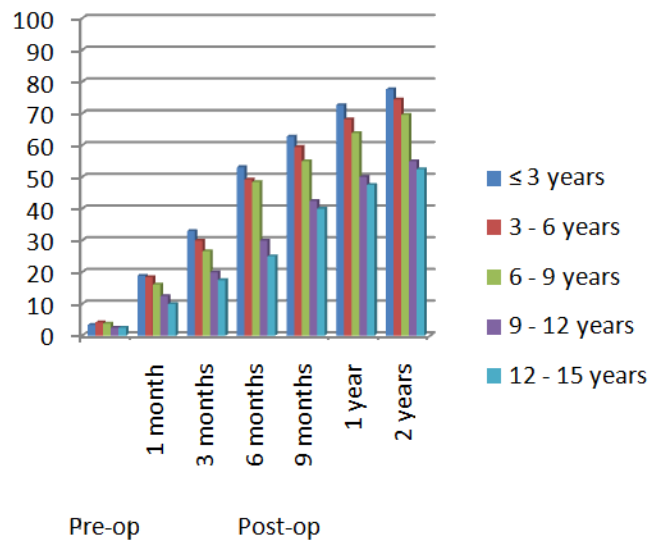


Figure 1: Speech perception means score (in %) based on open-set testing

In current study it was noticed that younger age group (≤ 3 years) subjects had shown better results compared to older age group. These results are similar to Kirk (1996) who showed that children who were implanted early (2-5 years) performed better on speech perception open-set tests than those implanted late [18]. Wong-Kein Low et al (2008) also concluded that more rapid development of speech perceptive skills was achieved in children who were implanted early [19]. This informs us about the developmental plasticity of the auditory system. This might be because of possible atrophy of the auditory tract on account of non-stimulation as they are born with the insult. Sensory activity leads to neural development, and the sustained effects of sensory inactivity can lead to a loss of responsiveness. These effects may be reversed by the subsequent provision of sensory stimulation, such as that delivered by Cochlear Implants [20]. Early implantation therefore, enables children to develop good core listening skills and to potentially develop spoken language at a young age and to integrate into mainstream education.

6. Conclusion

Cochlear Implant is a recognized treatment option for patients suffering with profound sensorineural hearing loss. A team approach including experts from various fields concerned is mandatory for a successful outcome. These patients need to be continuously rehabilitated and monitored following implantation.

This study aimed to obtain information regarding pre- to post- CI changes in speech perception skills. Results showed that there is significant improvement in speech perception skills over time. This study highlights the importance of age of implantation. Improved ratings were found for those implanted at younger age (≤ 3 years) than those implanted later. Significant effect of age at implantation was also demonstrated. As technology continues to improve, the future of CIs is even more promising.

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