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Original Research Article

Evaluation of outcome of cochlear implant surgery in tertiary care centre

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ABSTRACT

Background: Childhood deafness affects the hearing, speech and social development rendering individual socially isolated which further on aggravates language and auditory difficulties. A cochlear implant is a neuroprosthesis that bypasses the damaged inner hair cells and delivers the signal directly to brain which is then interpreted as sound. Cochlear implant when coupled with speech therapy plays an important role in determining the linguistic and cognitive outcome, thus allows candidate to integrate into the education system and the social world.
Methods: A prospective longitudinal study performed on 35 patients of age under 5 years presented with Profound hearing loss, underwent cochlear implant in ENT department NSCB and MCH Jabalpur. These patients were followed-up during the study period from 1st March 2020 to 31st August 2021 for progress and response to speech therapy.
Results: Mean age of patients underwent CI was 3.51years, 3 got explanted due to various reason and 1 lost to follow-up. Speech therapy was attended by 82.8% children both online and offline, and improvement in cognition and speech was noted in 80% children. About 45.7% cases could attain writing skills. 3 among 35 candidates are able to attend normal school.
Conclusions: After Cochlear implantation, continuous speech therapy by single therapist with dedicated team and committed parents results in favorable outcome in 80% patients in terms of improvement in cognitive and language development. Thus, every patient should get the chance to rehabilitate with CI and speech therapy.

Keywords: Cochlear implant, Speech therapy, Linguistic and auditory development, Supportive environment

INTRODUCTION

Deafness and hard of hearing is one of the common condition encountered in routine ENT OPD and it has been estimated to affect approximately 1 per 750 live births.[1] Childhood deafness affects the hearing, the speech and social development thus putting the individual at the risk of socially isolated which further on aggravates language difficulties and auditory perception.[2,3] Cochlear implant (CI) surgery is the blessing for deaf children as it improves the hearing, linguistic skills, to comprehend the words and their meanings thus affects overall development of child, it allows pre-lingual deafened children to integrate into the education system and the social world.[4,5] Following cochlear implantation, rehabilitation along with speech therapy also play an important role in determining the linguistic outcome.[6]

The first account of electrical stimulation of auditory system was given by Alessandro Volta[7] in early 1800's whereas the first direct simulation of auditory system of human being was performed by André Djourno and

Charles Eyriès in 1957.[8] In 1961, an otologist (Dr. House) along with a neurosurgeon (Dr. John Doyle) implanted first cochlea in Los Angeles.[9,10] Later, in 1990, cochlear implant was approved by FDA for young children for achieving better outcome in speech comprehension as well as production.[11] Since then, significant advancement have been made in cochlear implantation technology so as to improve the outcomes.[12]

Figure 1: Follow-up patient with *in situ* CI.

A cochlear implant is a neuroprosthesis, implanted in the cochlea that helps in providing electric stimulation of auditory nerve fibers directly. The implantation of this device bypasses the damaged/missing inner hair cells and deliver the signal directly to brain which is then interpreted as a sound. For effective hearing, the verbal and non-verbal stimuli need intact auditory processing. In typical hearing individual speech perception is better in presence of stronger and louder environmental sound in contrary the cochlear implant through its speech processor provides a relatively weak frequency resolution but it has found to have positive effect on auditory perception.[6,13-15]

Figure 2*:* Post-operative radiological image.

The microphone captures incoming sound and converts it into electrical signals. The processor configures, amplifies and manipulates it into the preferred paradigm, which is then transmitted to the internal receiver/stimulator and electrode array.

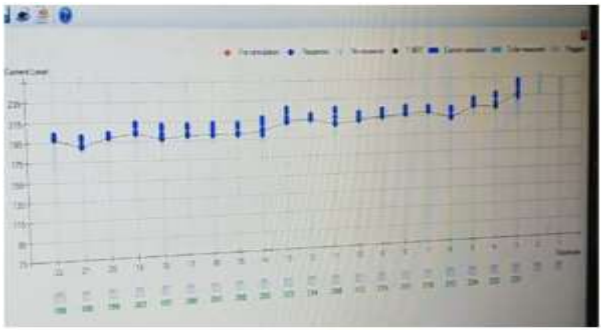

Figure 3: Post-operative NRT.

Subsequently, the electrodes are stimulated in a pattern, which is determined by the encoding strategy of a given prosthesis. The signal is then received by the auditory nerve and transmitted to the brain as an electrical signal. Acoustic to electrical transformation determined by "Map". CI candidates generally have severe to profound hearing loss over 80 Db as majority of sensory hair cells of cochlea are either absent or non-functioning; therefore, although sparse spiral ganglions located in modiolus can still be sensitive for electrical stimulation via hearing aids. So, they were been told to use BTE (behind the ear) hearing aid in contralateral ear to compliment hearing of the implant ear (by amplification of residual hearing in contralateral ear). It is significantly important for observer to know factors that will affect performance and typical progression of post implant speech, so that any deviation can be traced out timely and shortcomings can be overcome. Post operatively children are encouraged to enrol for speech language therapy twice or thrice a week with certified speech language pathologists (SLP) who closely monitors and evaluates the child's hearing and language skills according to expected outcomes. These evaluations include, auditory comprehensive skills of candidate, voice quality, intelligibility, receptive and expressive vocabulary and language skills. Guardians are also encouraged for consistent training at home.

Pre and post implant auditory and speech assessment can be done by methods that must suit the candidate according to Age, IQ, and pre/post-surgical status; for that purpose, there are, behavioral measures, objective physiological measures, and psychoacoustic methods. These methods when chosen suitably indicate the candidate's auditory and linguistic improvement. Basically, behavioral measures deals with intensity detection thresholds, detects maximum comfortable listening levels; objective physiological measures are used when patient cannot respond reliably (infant, child with severe intellectual disability), should include electrically evoked compound action potential (ECAP) that represents lowest stimulus level that elicits an auditory nerve response to electrical stimulus, electrical

stapedial reflex threshold (ESRT) attributed to stapedial reflex contraction, electrical auditory brainstem response (EABR) uses conventional ABR system. Psychoacoustic methods include pure tone audiometry (PTA), speech audiometry, localization of sound.

ECAP referred by different names commercially such as neural response imaging (NRI) by advanced bionics, neural response telemetry (NRT) by cochlear corp, auditory nerve response testing (ART) by MED-EL. Speech audiometry; speech perception test is done routinely to monitor device function, must include standardized tests in auditory settings. Listening skills of CI users are assessed, testing starts with detection and progresses to evaluate discrimination, identification and comprehension of speech. Test batteries include closed and open set tests. Closed set test is tailored according to vocabulary and language level of children, provided with a set of possible responses. They include ESPC (early speech perception test) to know whether child can at least identify temporal or rhythmic speech pattern, PSI (Pediatric speech intelligibility), WIPI (word identification by picture identification) set of 6 colored familiar pictures related to stimulus word, Minimum speech test battery. Open set tests on the contrary are more difficult, and does not provide possible responses. These tests are done in later stages when child is able to comprehend. Some of them are Lexical neighborhood test (LNT), multisyllabic lexical neighbourhood test (MLNT), CNC (consonant nucleus consonant test), REELS (receptive expressive emergent language scales), HINT-C sentences (hearing in noice test for children), pediatric AZ Bio sentences, Ling five and six sound tests: |a, u, i, s, f|, if these 5 sounds are audible to patient then inferred that child has hearing extent roughly from 500 to 8 k hertz, the sixth sound |m| implies for lower frequencies. 3D-LAT tests (3-dimensional language acquisition test) scale assess 3 dimensions: reception, expression, cognition. Self-help skills are been assessed implying cognition. Speech recognition tests are used to reveal candidate's auditory acquisition accuracy and speech progression especially monosyllabic words. Spoken language test are done to assess expressive vocabulary, verbal fluency, comprehension intelligibility, expressive grammar. Spoken language ability: expressive vocabulary: The Boston Naming test (BNT) with picture naming tasks, phonemic word fluency task (FAS), pragmatic skills done to reveal command and obey skills of child. Cognition and mental health are tested by test of everyday attention for children (TEA-Ch), for general working memory; sound information and processing system (SIPS), BRIEF-P and BRIEF-T (parent and teacher questionnaire respectively). Each of these tests includes subtests across several domains including IQ, memory, learning, fluency of speech, attention, mental health etc. Here, in our study, on regular basis we used WIPI, CNC, MLNT, PSI, REELS, RELT, SECS,3D-LAT, SIPS, AzBIO tests for analyzing the outcomes of post cochlear implant. The social back ground was assessed, whether patents are motivated or not, whether they can afford the broken battery of implant in future or not. Sequential improvement was assessed. First step being awareness to the sound in the form of verbal and nonverbal sounds, patients primed with high and low frequency sounds. Secondly, discrimination and identification of sound was assessed to observe whether the child is able to associate the source of sound. Third, comprehension and appreciation were assessed and fourth step was to assess the cognition of child, i.e., how he or she follows the command or reacts to situation using his own understanding. Next was trial of memory (short or long term) and sequencing level, followed by associated expression and jargons. Overall outcome was assessed in terms of response to name call, Main mode of expression (gestural, verbal or combined), behavior/nature (irritable or social), speech (monosyllables, bisyllables i.e., few familiar words or small sentences) and writing (copying alphabets, drawings) and reading skills.

Objectives

Objectives of current study was to evaluate outcome of cochlear implant surgery and its correlation between age of surgery and outcome regarding auditory and speech rehabilitation.

METHODS

Study design, location and duration

The present study was conducted as a prospective longitudinal study on 35 patients of less than 5 years of age, underwent cochlear implant in ENT department. The presented study carried out at Netaji Subhash Chandra Bose medical college and hospital, Jabalpur (MP) India. Patients were followed-up during study period from 1 March 2020 to 31 August 2021 for progress and response to speech therapy. Written consent was obtained from the guardian of all the participants after explaining them nature and purpose of study.

Inclusion criteria

All the patients of age limit <5 years receiving cochlear implant surgery in our hospital were included in the study.

Exclusion criteria

Children with cerebral palsy and post lingual candidates were excluded in the study.

Statistical analysis

Based on detailed history, related investigations and questionaries the data of 35 participants was entered in Microsoft excel, thoroughly analyzed and presented in the form of frequency and percentage and shown as pie and bar charts.

RESULTS

In our study, a total number of 35 children were studied who presented with sensory-neuronal hearing loss and underwent cochlear implantation. Majority of patient presented with complaint of deaf and mute belong to age group of 2 years to 5 years (71.4%). Male predominance was observed, with male:female ratio of 1.06:1. Symptoms were identified at birth in 14.3% cases only and majority of children were identified as having symptoms after one year of age (71.4%). Radiological findings revealed middle ear infections in the form of mastoiditis/ otitis media in 17.1% cases whereas cochlear deformity (Mondini's anomalies) was noted in 8.6% cases. Our study documented no significant impact of radiological abnormalities in outcome of children in long run, following cochlear implantation, in any age group. IQ was noted within normal limit (WNL) in 91.4% children.

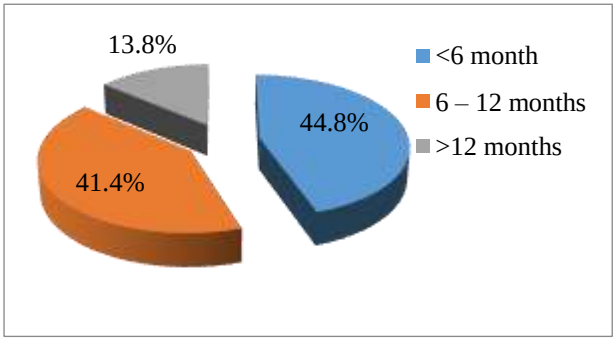

Figure 4: Distribution according to duration of speech therapy.

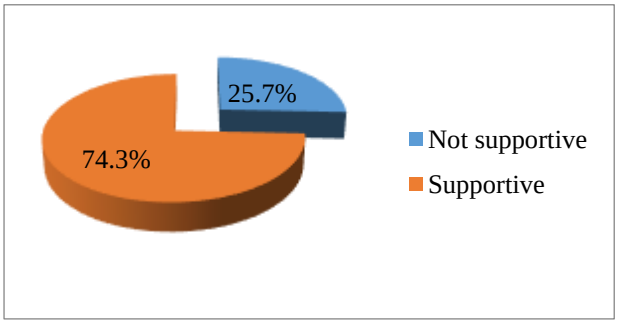

Figure 5: Distribution according to environment at home.

Surgical site infections were noted in 5 cases in our study cases following surgery. Speech therapy was attended by majority 29 (71.4%) children, 4 (11.4%) children attended tele sessions. Out of 4 children who attended the tele sessions, 50% were distracted during the sessions. It was attended for less than 6 months by 13 cases (44.8%). Only 4 (13.8%) children attended speech therapy for more than a year. 22.9% children encountered some shortcomings. Device was explanted in 8.6% cases whereas in 5.7% cases, the children had difficulty in implant maintenance. Dystonia and intolerance to loud sound was noted in 2.9% cases each.

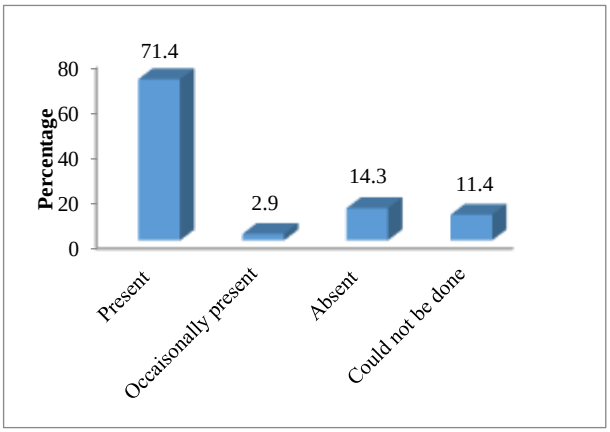

Figure 6: Distribution according to response on name call after implantation.

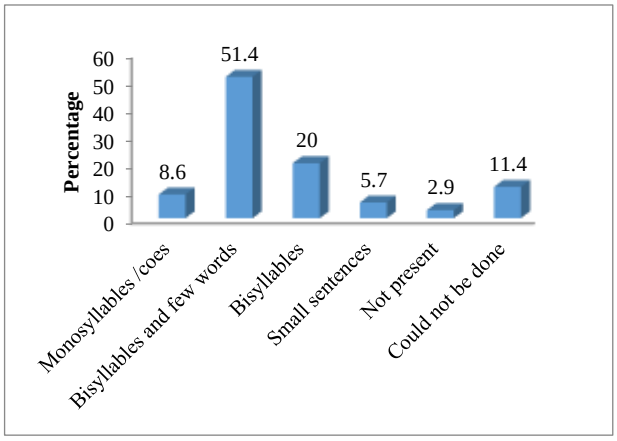

Figure 7: Distribution according to improvement in speech.

In our study, response to name call was present in 71.4% children and about 2.9% children responded occasionally. Gestural followed by combined gestural with verbal expression were the main mode of expression in 62.9% and 22.9% cases. Response was absent in 14.3% children; it was exclusively verbal in 1 case. Majority (18) of children could speak Bisyllables with few words (51.4%) whereas only bisyllables speech was noted in 7(20%) cases. Only 2 (5.7%) children could speak small sentence. 3 cases were able to speak monosyllables only and speech was not attained by children belonging to 2 to 5 years of age showed a significant association of outcome with speech. In 2-5 years, age group 82.4% candidates are satisfactorily able to speak bisyllables and few words with comprehension after speech and language training of approximately 5- 6 months. Reading and writing skills could be attained in only 45.7% children after cochlear implantation. The result of cochlear implantation was satisfactory in 21 cases (60%), whereas the results of surgery were unsatisfactory in 10 (28.6%)

children. Also, 1 child lost to follow up and explanation had to be done in 3 cases.

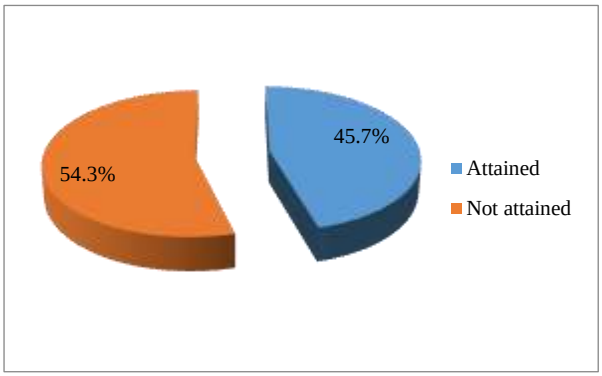

Figure 8: Distribution according to attainment of reading/ writing skills.

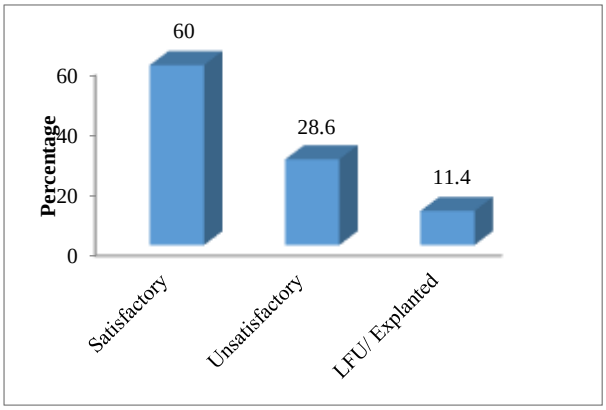

Figure 9: Distribution according to final results.

Immediate surgical complication was facial nerve palsy in 5.7% cases and surgical site infections was noted in as late complications in 14.3% (5 patients) cases. Late surgical complications like surgical site infections were associated with unsatisfactory outcome in children belonging to 2 to 5 years following CI. In children below 2 years of age, children who attended speech therapy for less than 6 months were significantly associated with unsatisfactory outcome. In current study, tests are done before and after CI for comparison of outcome, with a generalized low score prior surgery and relatively higher in those who are kept under satisfactory improvement group. WIPI; majority of patients were able to perform this test after minimum period of 2-3 month of speech therapy. CNC; performed in 9 candidates. MLNT; done in 12 candidates, children were able to perform after minimum 5-6 months of speech therapy. PSI; pediatric speech intelligibility test was analyzed in 10 candidates. AZ-BIO- only 3 candidates were able to perform satisfactorily after persistent speech therapy. Minimal speech test battery; 3 patients were able to perform after persistent speech therapy. Ling six test was also performed in children to compare their improvement pre and post CI.

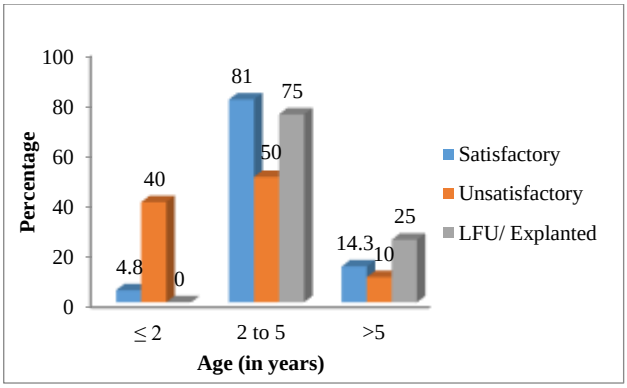

Figure 10: Association of final outcome with age.

DISCUSSION

WHO defines rehabilitation as the combined and coordinated use of medical, social, educational and vocational measures for training the individual to the highest level of functional ability. As the ultimate moto of cochlear implantation is to restore basic hearing in deaf child, the outcome must reflect experience of child undergone CI in its effect on linguistic development. Cochlear implantation alone will not improve the outcome unless coupled with postoperative persistent speech therapy.[18] In current study, after the cochlear implantation, all the children were advised speech therapy and family was counselled regarding their support and adherence to speech therapy post procedure to improve the overall outcome in these patients. Also, the parents were advised that child should wear the implant for maximum waking hours, except during sleep. They were counselled regarding the use of another hearing aid for contralateral ear based upon their affordability to achieve hearing as near as possible to normal hearing.

The result of cochlear implantation was excellent in 3 cases where children are able to attend normal school, good in majority of cases (60%) where candidate can talk in small sentences or few words, whereas the results of surgery were not up to the mark in 28.6% children (can say monosyllables). However, 1 child lost to follow up and explanation had to be done in 3 cases. Reading and writing skills could be attained successfully in 45.7% children after cochlear implantation coupled with Speech therapy. In current study we interpret that CI improves auditory and linguistic development of candidate and its success is significantly related to amount of exposure to meaningful sounds and the time length that candidate uses the implant correctly per day. Improvement was noted in cognitive performance over time. Successful rehabilitation program led them to re-enter in mainstream educational system. The findings of present study were supported by the findings of Ashori et al in which mean score of speech intelligibility as well as auditory perception improved significantly following cochlear implantation and the improvement was significantly higher as compared to those with hearing aid but was

significantly lower as compared to children with typical hearing.[19] Mittal et al documented higher utility of cochlear implant surgery in children even with ADHD provided behavior modification therapy (BMT) is given to them.[20] Isaiah et al concluded cochlear implantation to be a safe surgical procedure in children with Inner ear malformations (IEM) and speech perception though improved following CI, but it was notably below in IEM patients as compared to those with normal anatomy.[21] In a study of Nicolopolous et al the authors observed significant improvement in auditory perception in prelingually deaf children.[22,23]

Limitations

Limitations of the study were although results were little affected due to late switch-on or visits at longer intervals for speech therapy because of COVID-19 pandemic, patient who lost to follow-up or got explanted. Multiple factors determine the success following cochlear implantation in children, these include age at onset of deafness, residual hearing, pre/post lingual condition, age at time of implantation, consistency of device used, educational environment, family support (for persistent speech and auditory training at home) and postoperative complications etc.[9]

CONCLUSION

Cochlear implantation surgery turned to be blessing for deaf children as this surgical intervention not only improve the hearing, but also improve linguistic skills, social skills and overall development of child. Majority of children with profound hearing loss or severe to profound hearing loss are benefited by cochlear implantation. The surgical intervention must be offered to child of any age, preferable younger children during their prelinguistic phase. Cochlear implantation when coupled with persistent speech and language therapy and dedication of the family with positive environment results in favourable outcome in terms of improvement in speech and language development.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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