ORIGINAL RESEARCH

Factors Affecting Short-term Outcome of Cochlear Implant: A Retrospective cum Prospective Study

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Abstract

Aim: The fundamental aim of this study is to determine the factors affecting the audiological, speech, and language-related short-term outcomes achieved by the recipients of cochlear implants (CI) and to assess the category of auditory performance (CAP), speech intelligibility rating (SIR), and meaningful auditory integration scale (MAIS) scores on various factors to calculate the outcome.

Materials and methods: This study was a hospital-based retrospective cum prospective study carried out in the Department of Otorhinolaryngology, Government Medical College (GMC), Kota, from May 2018 to June 2020 in a sample size of 15 patients who underwent CI with satisfying inclusion and exclusion criteria with written informed consent and follow-up for 12 months. Three scoring systems are used for evaluation: revised CAP score, SIR of O'Donoghue, and MAIS. A total of six factors are considered, and for all, the relationship with outcome postimplant is calculated using three scores (CAP, SIR, and MAIS). The statistical tests applied are the Chi-square test, Fisher's exact test, Spearman's rho test using Statistical Package for the Social Sciences (SPSS) software and tables are computed using Microsoft Excel.

Results: Factor 1: relationship with a common cause of sensorineural hearing loss (SNHL)—children having a history of postnatal infection shows significant (p-value = 0.01) poor outcome. Factor 2: relationship with an abnormality of the inner ear shows significant (p-value 0.03, 0.077, and 0.033 for CAP, SIR, and MAIS scores, respectively) poor outcome. Factor 3: relationship with a duration of implant use—with time, CAP, SIR, and MAIS scores improve significantly (p-value 0.001, 0.0169, and 0.001 for CAP, SIR, and MAIS scores, respectively), with the best score at 12 months postimplant. Factor 4: relationship with parent's education level—no significant (p-value 1.0, 0.70, and 0.33 for CAP, SIR, and MAIS scores, respectively) difference seen. Factor 5: relationship with speech rehabilitation—no significant (p-value 0.833, 0.833, and 0.467 for CAP, SIR, and MAIS scores, respectively) difference seen. Factor 6: relationship with rural vs urban population—no significant (p-value 0.837, 0.782, and 1.02 for CAP, SIR, and MAIS scores, respectively) difference seen.

Conclusion: Patients with a history of postnatal infection and inner ear abnormality had a poor outcome which improved with time post-CI.

Clinical significance: This study concludes on the factors which affect the outcome post-CI and thus help to improve the results of cochlear implantation.

Keywords: Cochlear implant, Sensorineural hearing loss, Speech rehabilitation.

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Introduction

Hearing is necessary for speech and subsequently required for school learning. Auditory function depends on the integration of peripheral and central parts of the auditory pathway. Sensorineural hearing deafness[1,2] is primarily a defect of the hair cell of the organ of Corti and the auditory nerve being intact in most cases. A CI is an artificial sense organ that bypasses the defect in hair cells by directly stimulating the auditory nerve fibers. The implant has an external component[3] that resides behind the pinna and is held with a magnet over the receiver of an internal component which in turn is connected with an electrode array placed in the cochlea.[4] The postoperative performance remains incompletely understood in relation to the factors affecting the outcome. Predictions of postimplantation benefits are considered based on various factors, like age at implantation, duration of auditory deprivation, relationship with common causes of SNHL, abnormalities of the inner ear, duration of implant use, education level of parents, speech rehabilitation, and rural vs urban population.[5,6]

Materials and Methods

This research was a hospital-based retrospective cum prospective study carried out in the Department of Otorhinolaryngology, GMC and Associated Group of Hospitals, Kota, from May 2018 to June 2020 in a sample size of 15 patients who underwent CI. Follow-up is done for 12 months. Three scoring systems are used for evaluation: revised CAP score described by The Shepherd Centre based on Nottingham CI Programme, SIR of O'Donoghue, and hearing was assessed by the MAIS. Every patient follows a prefixed protocol for surgery and comprehensive audiological evaluation before surgery. The onset of hearing loss in all cases was of congenital etiology. Children taken into the study had bilateral severe to profound sensorineural prelingual hearing loss. A total of six factors are considered. For all six factors' relationship with the outcome,

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postimplant is calculated using three scores (CAP, SIR, and MAIS). Statistical tests applied are the Chi-square test, Fisher's exact test, Spearman's rho test using SPSS software and tables are computed using Microsoft Excel. Turnitin is used to check plagiarism.

Inclusion Criteria

- Prelingual deaf patients.
- Willing to give written informed consent.

Exclusion Criteria

- Age more than 10 years.
- Posttraumatic profound hearing loss.
- Lost to follow-up.

Methods of Measurement

- All patients were assessed thoroughly. A detailed history was taken. Data were collected from clinical records. The communication strategy included a discussion with the implantee's guardians about the outcomes. After taking written informed consent, a set of questions was given to the parents of each implant recipient, and a cumulative assessment of the outcome was done.
- Wherever required, feedback from the speech therapist about the performance of each CI was taken. The attainment of speech abilities postoperatively was evaluated on the basis of CAP, SIR, and MAIS scores.[7,8]
- Category of auditory performance score assesses the extent of auditory perception in terms of day-to-day tasks. The assessment was done on the basis of the number of months taken to understand speech with or without lip reading.[2–4]
- Meaningful auditory integration scale score is based on the behavioral response of the child reported by the parents in the real-world situation.[9–12]
- Speech intelligibility rating score evaluates the intelligibility and quality of speech achieved in the number of months which can be discriminated by the listener.[13–15]

Factors chosen for this study are:

- Age at implantation in years.
- Duration of auditory deprivation.
- Relationship with common causes of SNHL.
- Abnormalities of the inner ear.
- Duration of implant use.
- Education level of the parents.
- Speech rehabilitation.
- Rural vs urban population.

Data Collection Methods

Patients who underwent CI surgery in the ENT Department of GMC Kota were evaluated. Written informed consent was taken from all the patients, and evaluation was done according to the questionnaire.

Statistical Methods

- Null hypothesis (H_0): Factors like age at implantation in years, duration of auditory deprivation, relationship with common causes of SNHL, abnormalities of the inner ear, duration of implant use, education level of parents, speech rehabilitation, and rural vs urban population do not affect the speech and language outcomes following CI.
- Alternate hypothesis (H_a): Factors like age at implantation in years, duration of auditory deprivation, relationship with common causes of SNHL, abnormalities of the inner ear, duration of implant use, education level of parents, speech rehabilitation, and rural vs urban population affects the speech and language outcomes following CI.
- Level of significance: $p < 0.05$.
- If the p-value is less than 0.05, the null hypothesis is rejected.

Results

In Table 1, relationship between CAP score (calculated post-CI) and a common cause of SNHL (postnatal infection) is formulated, and it is observed that CAP scores calculated after CI is significantly low (p-value = 0.01) in children having SNHL and history of postnatal infection as compared to those children who do not have any history of postnatal infection.

Fisher's exact test is applied to calculate the statistical difference, and the p-value is found to be significant.

p-value = 0.01 (significant).

In Table 2, CAP, SIR, and MAIS scores are calculated in post-CI patients in relation to the abnormality of the inner ear (hypoplasia of the inner ear), and it is found that children who have hypoplasia of the inner ear have significantly lower CAP and MAIS scores (p-value 0.033 each) as compared to children who do not have any abnormality or hypoplasia of the inner ear.

The SIR score does not show any statically significant difference between the two groups.

Chi-square Fisher's exact test for CAP score: 0.033.

p-value for CAP score: −0.033 (significant).

Fisher's exact test for SIR score, p-value = 0.0769 (nonsignificant).

Fisher's exact test for MAIS score, p-value = 0.033 (significant).

In Table 3, for CAP score Spearman's rho test: Spearman's rank correlation coefficient (RS) = −1. p-value: 0.001 (significant).

Fisher's exact test between 1 and 12 months: 0.001 (significant).

Results: According to the correlation coefficient, as the time increases, the CAP score improves significantly (p-value 0.01). CAP score was calculated after the implantation at 1, 3, 6, and 12 months. Up to 3 months after implant, no child got a CAP score of 7 and above. After 6 months of implant use, 10 children got 7 and above CAP scores, while five children got a CAP score of 6 and below. After 12 months of implant use, four children got a CAP score of 7 and above, while 11 children got a CAP score of 6 and below. p-value for the CAP score is 0.001.

For SIR Score, Chi-square Fisher's exact test: 0.0169, p-value: 0.0169 (significant).

Table 1: Relationship with postnatal infection—a common cause of SNHL and CAP scores in post-CI patients

	CAP score of 6 and below	*CAP score of 7 and above*	*Total*
Postnatal infection present	4	1	5
Postnatal infection absent	1	9	10
Total	5	10	15

Spearman's rho correlation test: RS = −1, p-value (two-tailed) = 0.001.

Results: The SIR score was calculated at the duration of use of implant 1, 3, 6, and 12 months. At 1 month of implant use, no child got SIR scores of 4 and 5. At 3 months of implant use, two children got SIR scores of 4 and 5. At 6 months of implant use, two children got SIR scores of 4 and 5. For 12 months of implant use, six children got SIR scores of 4 and 5. Statistical analysis got a p-value of 0.0169.

For MAIS score, Chi-square Fisher's exact test: 49.753. p-value: 0.001 (significant).

Spearman's rho correlation test: X ranks (mean: 2.5, standard deviation: 1.29) and Y ranks (mean: 2.5, standard deviation: 1.29).

Results: The MAIS score is calculated for the duration of implant use calculated at 1, 3, 6, and 12 months. At 1 month, 2 out of 15 children got good scores, while 13 children got satisfactory scores. At 3 months, 7 out of 15 children got good scores, while eight children got satisfactory scores. At 6 months, 11 out of 15 children got good scores, while four children got satisfactory scores. At 1 year, 14 children out of 15 children got good scores, while one child got a satisfactory score. p-value for MAIS score is 0.001.

In Table 4 two groups are formed.

Group I: Graduate and above.

Group II: Below graduate.

For CAP score, Chi-square: 0, p-value: 1.0 (nonsignificant).

Category of auditory performance scores for parents' education is calculated at 1 year of implantation. In group I, three children out of five got a CAP score of 7 and above, while two children got a CAP score of 6 and below. In group II, six children out of 10 got a score of 7 and above, while four children got a score of 6 and below. p-value for CAP score is 1.0.

For SIR score, Chi-square: 0.15, p-value: 0.698 (nonsignificant).

Speech intelligibility rating score for parent's education calculated at the end of 1 year after implantation. In group I, two out of five children got a SIR score of 4 and 5, while three children got a score of 3 and below. In group II, 7 out of 10 children got an SIR score of 4 or 5, while three children got an SIR score of 3 and below. p-value for the SIR score is 0.698.

For MAIS score, Chi-square: 0.33, p-value: 0.33 (not significant).

Meaningful auditory integration scale score for parent's education calculated at the end of 1 year of implantation. In group I, four out of five children got a MAIS score as good, while one child got a MAIS score as satisfactory. In group II, all 10 children got MAIS scores as good. p-value for MAIS score is 0.33.

In Table 5, for CAP score, Chi-square: 0.0446, p-value: 0.832662 (nonsignificant).

Category of auditory performance score for speech rehabilitation calculated at the end of 1 year of implantation. Five out of eight children who had regular follow-up got a CAP score of 7 and above, while three children got a score of 6 and below, and four out of seven children who were not on regular follow-up (irregular group) got a CAP score of 7 and above, while three children got score[6] and below. p-value for CAP score is 0.833.

For SIR score, Chi-square: 0.0446, p-value: 0.832662 (nonsignificant).

The SIR score for speech rehabilitation is calculated at the end of 1 year of implantation. Three out of eight children who had regular follow-ups got a SIR score of 4 or 5, while five children got a score of 3 and below. Three out of seven children who were not on regular follow-ups got a SIR score of 4 or 5, while four children got a score of 3 and below. p-value for the SIR score is 0.833.

For MAIS score, Chi-square Fisher's exact test: 0.4667, p-value: 0.4667 (nonsignificant).

Meaningful auditory integration scale score for speech rehabilitation calculated at the end of 1 year of implantation. All eight patients who had regular follow-ups got MAIS scores as good. Six out of seven children who were not on regular follow-up got MAIS scores as good, while one child got a score as satisfactory.

In Table 6, for CAP score, Chi-square: 0.0446, p-value: 0.83662 (nonsignificant).

For SIR score, Chi-square: 0.0765, p-value: 0.782055 (nonsignificant).

Table 2: Relationship between abnormality of inner ear and various scores post-CI

	CAP score of 7 and above	*CAP score of 6 and below*	*SIR score of 4 or 5*	*SIR score of 3 or below*	*MAIS score good*	*MAIS score satisfactory*
Hypoplasia of cochlea	1	3	1	3	1	3
Normal	10	1	9	2	10	1
Total	11	4	10	5	11	4

Table 3: Relationship between duration of CI and various scores post-CI

Duration in month/ months	*CAP 6 and below*	*CAP 7 or above*	*SIR 4 and 5*	*SIR 3 and below*	*MAIS satisfactory*	*MAIS good*
1	15	0	0	15	13	2
3	15	0	2	13	8	7
6	10	5	2	13	4	11
12	4	11	6	9	1	14

Table 4: Relationship between parent's education level and various scores post-CI

	CAP 7 or above	*CAP 6 and below*	*SIR 4 and 5*	*SIR 3 and below*	*MAIS good*	*MAIS satisfactory*
Group I	3	2	2	3	4	1
Group II	6	4	3	7	10	0

Table 5: Relationship between speech rehabilitation and various scores post-CI

	CAP 7 or above	*CAP 6 and below*	*SIR 4 and 5*	*SIR 3 and below*	*MAIS satisfactory*	*MAIS good*
Regular follow-up	5	3	3	5	0	8
Irregular follow-up	4	3	3	4	1	6

Table 6: Relationship between rural vs urban population in relation to various scores post-CI

	CAP 7 or above	*CAP 6 and below*	*SIR 4 and 5*	*SIR 3 and below*	*MAIS satisfactory*	*MAIS good*
Rural	5	3	4	4	1	7
Urban	4	3	3	4	0	

For MAIS score, Chi-square Fisher's exact test: 1.02, *p*-value: 1.02 (nonsignificant).

Discussion

Our study does not show a significant difference in outcome with regards to a relationship with all common causes of SNHL, parents' educational level, and speech rehabilitation. However, studies by other researchers document significant difference in outcome with regard to these factors. The difference in results in our study could be because of the following limitations in our study: small sample size and shorter follow-up. The long-term analysis and sufficient sample size may prove a positive correlation between outcome and factors.

A similar study was done by Swami et al. in 2013. This study strongly correlates the duration of preimplant auditory deprivation, parental education, and cochlear morphology with the outcome. It showed that half of the implantees with abnormal cochlear morphology achieved good results.[16,11]

Another similar study was done by Chen et al. in 2014. This study showed that Mondini dysplasia can occur similarly in both groups of children having normal or abnormal inner ears over a period of 3 years after cochlear implantation.[12,17]

A similar study done by Suh et al. showed that children who were 4–6 years of age appeared to have poor improvement scores after 1–3 years postcochlear implantation. The CAP score continued to improve with time, but the improvement of the CAP score did not depend on the age of the children.[18]

Another similar study was done by Sharma et al. found that children whose parents have higher education performed best as compared to other children. However, no correlation was observed between the CAP, MAIS, and SIR scores obtained at 1 year of age with the education level of the parents.[19]

Conclusion

In our study, we noted that patients with a history of postnatal infection and inner ear abnormality had a poor outcome post-CI. We also noted a significant improvement in CAP, SIR, and MAIS scores over the period of 1-year postimplant. This study helps to find out the factors which affect the outcome post-CI and thus helps to improve the results of CI.

Clinical Significance

This research will help to predict the outcome of CI in a better way.

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