

EVALUATION OF AUDITORY PERCEPTION SKILLS DEVELOPMENT IN PROFOUNDLY DEAF CHILDREN FOLLOWING COCHLEAR IMPLANTATION-PRILIMINARY REPORT

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Background: Cochlear implant is a medical treatment option for individuals with severe to profound sensori-neural hearing loss on account of non-functioning cochlea or part thereof. Technology is ever evolving and the candidacy criteria are widening. Appropriate selection of patient, successful implantation of an appropriate device and adequate post-implantation rehabilitation protocol are the key factors that dictate the eventual outcome. Bilateral cochlear implantation in children and combined electro-acoustic stimulation are the new developments in this field of rehabilitation for the deaf. Pakistan Cochlear Implant Programme was started in year 2000 and one hundred and fifty subjects have undergone cochlear implant surgery so far at Karachi, Lahore and Peshawar since. This prospective study was designed to evaluate the development of auditory perception skills and language in children, over a twelve months period, following cochlear implantation. **Methods:** Twenty-one patients were enrolled in this evaluation. These were divided into three groups as per age factor. Group 1 included eleven children of ages less than five years, Group 2 included eight children of ages between five and nine years whereas, Group 3 included two eleven years old children. Furthermore, subjects in Group 1 & 2 were pre-lingual whereas those in Group 3 were post-lingual. The three groups were evaluated using "Evaluation of Auditory Responses to Speech" (EARS). **Results:** 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. **Conclusion:** Children of varying ages, both pre and post lingual, did show improvement in the development of auditory perception skills, that was evident more in the younger age group.

Key words: Hearing loss; Sensorineural; Cochlear implant; Evaluation; EARS tests; Auditory perception; Language development

INTRODUCTION

Cochlear implant is an electronic device consisting of an internal component implanted surgically and externally worn equipment. Cochlear implant is primarily a non-surgical treatment option for individuals with severe to profound sensorineural hearing loss. In such cases, a hearing aid may provide limited or no benefit at all, as it would only amplify the sound stimuli whereas in such cases the cochlea is not able to process this amplified stimulus. A cochlear implant bypasses the non-functioning part of the cochlea and delivers sound signals directly to the auditory nerve. Cochlear implant has become an established means of auditory rehabilitation in selected severe and profound deaf patients, both adults and children.^{1,2} Its efficacy, safety and reliability are well recognised. Over 200,000 patients have received cochlear implants worldwide and children are emerging as the largest group of patients to benefit. Technology is evolving and the candidacy criteria are widening. 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. Bilateral cochlear implantation in children and combined electroacoustic

stimulation are the new developments in this field of rehabilitation for the deaf.³

Children with cochlear implants are expected to achieve successful outcome, i.e. facilitated perception of sound and better oral communication. To achieve this, continuous combined team approach by a number of professionals is mandatory. In order to attain the greatest benefit from a cochlear implant, candidates should be fully committed to the follow-up programme designed by the local team.

The follow-up programme include:

- Regular assistance and help available to the implantee and his/her family.
- Regular medical check up.
- Re-programming of the speech processor as per schedule.
- Continuous speech and language therapy and educational advice.

The various speech tests used including Evaluation of Auditory Response to Speech (EARS) for assessment following implantation are based on the English language. They may be translated into local languages where the assessment and training can be carried out accordingly.⁴

The EARS comprise seven tests and two questionnaires used by a team of audiologist and speech therapist to evaluate auditory perception skills development.

Various studies have shown continuous improvements in both closed and open set speech perception following cochlear implantation although variability in individual's performances among the children has been noted.⁵⁻⁹ Test results exhibited steady improvement on all parts of the EARS test battery, even upto three years post implantation.¹⁰

The Pakistan Cochlear Implant Programme started in year 2000. One hundred and fifty subjects have so far undergone cochlear implant surgery during the period 2001 to 2007 at three centres, namely Karachi, Lahore and Peshawar.

The goal of this study, first such in Pakistan, was to evaluate auditory perception development in children over a period of twelve months following cochlear implantation.

MATERIAL AND METHODS

Twenty-one patients, all children, were enrolled for this study on the basis of selection criteria. Primarily, they were grouped as pre and post lingual but pre-lingual group was further divided into two on the basis of age to enable evaluation of auditory perception development in each group.

Medel Combi 40+ implant and Tempo+ speech processor (MED-EL medical electronics, Innsbruck, Austria), were used in these patients.

Selection criteria:

- Profound bilateral sensori-neural hearing loss ($\geq 100\text{dB}$)
- Cochlear implant user for a period of at least one year.
- Less than 12 years of age.
- High motivation and appropriate expectations of the family and child.
- Access to education and rehabilitation follow up.
- Absence of additional syndromes/illness that could affect the child's development.

Table-1: Age group and speech status of patients (n=21)

Group/Series	Speech status	No of children	Age in years
1	Pre-lingual	11	<5
2	Pre-lingual	8	5-9
3	Post-lingual	2	11

Test Setup:

Erber's⁹ developmental stages of auditory reaction to stimuli were used to serve as basis of the EARS tests, i.e., Detection, discrimination, identification, recognition and comprehension. EARS tests comprise seven tests and two questionnaires, covering all the stages.

EARS protocol:

- Listening progress profile (LiP), developed by Archbold S¹¹
- Monosyllabic-Trochee-Polysyllabic (MTP)-3 & 6 pictured words.¹²
- Closed set bi-syllabic words (MSW)-4 & 12 pictured words.
- Closed set sentences, developed by Tyler & Holstad¹³
- Open set monosyllabic words (OSM)
- Language specific sentences
- Glendon Auditory Screening Procedure (GASP)
- Questionnaires:
 - a. Meaningful use of speech scale (MUSS)¹⁴
 - b. Meaningful auditory integration scale (MAIS)¹⁵

Testing intervals:

- Pre-operatively
- One week after switch on
- One month after switch on
- Three months after switch on
- Six months after switch on
- Twelve months after switch on.

RESULTS

All the patients were assessed and data obtained both preoperatively (with or without amplification) and postoperatively at appropriate intervals according to the follow up protocol. Scores were averaged for each group and plotted, showing progress for each group. Results revealed that all the groups made progress and substantial improvement was noticed in all the patients at twelve months post-stimulation compared to preoperative status. Average preoperative total score (EARS protocol) and the average postoperative total score revealed 100% achievability as shown in Tables 2 & 3. The average scores for all the children, preoperatively and postoperatively, considering vocalization behaviour, alertness, attendance and understanding of a sound stimulus, indicated increased use of vocalization following implantation (Tables 2 and 3). Group/Series 3 (post-lingual) performance reveals a higher MUSS and MAIS scores compared to Groups/Series 1 & 2 (pre-lingual). This is mainly because post-lingual children had speech developed already before they had gone deaf. All groups in this study exhibited post-implantation progress, however the improvement rates in auditory and linguistic development after twelve months of device use were most impressive with Group/Series 1 & 3.

Table-2: Pre-operative assessment (EARS)

Test	Group/Series1 (%)	Group/Series2 (%)	Group/Series3 (%)
LiP	5	5	20
MTP3	0	0	0
MTP6	0	0	0
MSW4	0	0	0
MSW12	0	0	0
OSM	0	0	0
GASP	0	0	0

MAIS	20	25	37
MUSS	8	13	88

Table-3: Post-operative assessment (EARS) at twelve months

Test	Group/Series1 (%)	Group/Series2 (%)	Group/Series3 (%)
LiP	85	90	99
MTP3	90	80	98
MTP6	70	60	98
MSW4	70	65	98
MSW12	55	40	96
OSM	30	25	80
GASP	25	40	85
MAIS	85	85	98
MUSS	75	65	90

DISCUSSION

Cochlear implant has emerged as a new, effective and accepted treatment method for adults and children with severe to profound sensorineural hearing loss. Cochlear implants over the years have evolved from single channel devices providing little or no speech understanding to multi-channel implants using advanced signal processing strategies. Adults and paediatric cochlear implant users have been provided with a possibility to communicate, acquire education, build professional careers and enjoy better and more independent lifestyle. To achieve this goal, a number of professional experts have to extend their best.

Successful outcome depends upon a number of factors like appropriate case selection, surgery and post-implant rehabilitation. All these are equally important and none can be neglected. Patient/family has to be convinced that rehabilitation programme is as important as the surgery itself.

Rehabilitation programme following switching on the device includes regular visits as per schedule developed for each patient. During these visits, the auditory tract is stimulated and responses are recorded and monitored as regards the progress in terms of auditory perception, language development and speech intelligibility.¹²

This study was designed to evaluate development of auditory perception skills in profoundly deaf children following cochlear implantation over twelve months period. These patients were evaluated using EARS. Auditory perception skills assessment in children by use of EARS is being performed in many institutions in Europe and United States of America and a number of studies have used EARS protocol to evaluate speech perception performance.¹⁶

Improvement in implant technology and the fact that children with cochlear implants have surpassed all expectations have led to the fact to believe that open set speech understanding is a common and expected outcome.

The findings from the EARS tests on children implanted with Medel Combi 40+ on average obtain significant benefit from cochlear implants.⁵⁻⁹

Different studies show that open set skills emerge by 6 months after cochlear implantation.^{10,11,16} There is a significant improvement over time, even after 3 years of the cochlear implant experience. A significant effect of age at implantation is also demonstrated.¹⁷

Results suggest that cochlear implanted children develop speech recognition soon after implantation and these skills develop over long period of time, highlighting the need for continued therapy to maximize listening and learning.^{12,17,18}

All the subjects in the study did show improved performance on all counts of EARS protocol over the specified time of assessment but it was noticed that post-lingual did better than pre-lingual, apparently because they had speech developed already before they had gone deaf. On the other hand dilemma with pre-lingual subjects is possible atrophy of the auditory tract on account of non stimulation as they are born with the insult. Furthermore, younger age group subjects had shown better results compared to older age group.

The EARS study conducted in 28 centres with over 700 subjects also included some children implanted under the age of 2. Results in 37 children under the age of two clearly demonstrate that these children perform as well as or better than those who were implanted after 2 years of age. Generally the results show an impressive improvement in auditory listening skills, which starts immediately after implantation and continues to develop overtime.¹⁷ Similar auditory listening skill response was observed in our cases. In another multi-centre study with 140 pre-lingually children gathered extensive data about auditory and linguistic development. These children were split into four age groups; ≤ 3 years, 3 to 6 years, 6 to 10 years and children who were older than 10 years at the time of implantation. EARS test results revealed that older children started at a higher performance level, but their younger peers caught up within 24 months of device use.¹⁸ All groups in this multi-centre study exhibited post-implantation progress; the improvement rates in auditory and linguistic development after 12 months of device use were most impressive with the youngest group. Same has been noticed in our study. Our results are comparable with quite a few other studies^{12,19,20} as far as rapid development of auditory skills and language are concerned.

CONCLUSION

Cochlear implant is a recognized treatment option for patients suffering with profound sensori-neural hearing loss. Significant improvement in technology has been noticed over the years resulting in better outcome. 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.

Many studies including this have noticed improvement in performance after cochlear implantation on all measures at twelve months; however, further studies over a longer period after implantation are suggested.

Dynamics of changes in auditory skills in the younger children may suggest higher and more rapid development of auditory skills. There is significant improvement over time. A significant effect of age at implantation is also demonstrated.

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