ASSOCIATION OF AGE WITH HEARING REHABILITATION AFTER COCHLEAR IMPLANT

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ABSTRACT

Objective: To determine the hearing outcomes following unilateral cochlear implantation & speech therapy in patients with bilateral severe to profound sensorineural hearing loss.
Study Design: Prospective observational study.
Place and Duration of Study: Department of ENT, Head and Neck Surgery, Combined Military Hospital Rawalpindi, from Dec 2018 to Dec 2019.
Methodology: We included 40 cases who underwent unilateral cochlear implantation at the Cochlear Implant Centre of Combined Military Hospital Rawalpindi and later on had at least 6 months of continuous speech rehabilitation (post-activation) at Speech Rehab Center of the same hospital. All patients had their cochlear implants activated 6 weeks after the surgery. Auditory rehabilitation was assessed continuously at each session by a single speech therapist and documented using the "5 stages of listening i.e. has a very good vocabulary, has a basic vocabulary, understands words, responds to sounds, doubtful response to sound."
Results: Out of 40 patients, 22 (55%) were male and 18 (45%) were females. Age at the time of cochlear implantation ranged from 2 to 8.4 years with a mean age of 4.5 ± 1.34 years. At 6 months 50% of children in age group 2-3 years had clinically and statistically significant response to speech rehabilitation post cochlear implant surgery.
Conclusion: We concluded that a cochlear implant is a safe and highly effective treatment for bilateral severe to profound sensorineural deafness in pediatric age from 2 to 8 years while the best results documented in our study are for age 2 and 3 years at implantation.

Keyword: Cochlear implant, Congenital deafness, Sensorineural hearing loss, Speech rehabilitation.

INTRODUCTION

Sensorineural hearing loss severely impairs the quality of life of a human being by impairing the cognitive and social functioning of a person and it even has more drastic effects when a person is suffering from it in the pre-lingual stage. It is also associated with increased morbidity and mortality and the latest survey documented that mild and moderate deafness increases the mortality risk by 21% and 39% respectively[1]. Congenital mild or worse hearing loss is one of the commonest sensory disorders and has a prevalence of 3.1% in United States[2]. The screening and diagnosis of congenital hearing loss is based upon careful history, physical examination, screening tests, and detailed workup. With the advancement of medicine and diagnostic tests numerous screening test have been introduced for early detection of sensorineural hearing loss including otoacoustic emissions (OAE), brainstem evoked responses audiometry (BERA) are frequently used and BERA being more sensitive screening test[3]. The most efficient diagnostic tool in the workup of pediatric sensorineural hearing loss is the use of diagnostic radiological imaging modalities. CT scan temporal bone with cochlear protocol involves the radiation exposure but gives a thorough evaluation of the bony abnormalities and its sensitivity is directly proportional to the severity of sensorineural hearing loss[4]. MRI scans are more useful in giving soft tissue details and have a diagnostic yield of up to 60%[5].

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A variety of treatment options are available for patients with bilateral sensorineural hearing deafness. Bilateral hearing aids are recommended for all children with bilateral deafness[6]. The FDA-approved gold standard treatment for pediatric bilateral sensorineural deafness is a cochlear implant. A cochlear implant (CI) is an electrical device that converts external sound waves into electrical signals which ultimately replaces the function of spiral ganglion cells of the auditory neuronal pathway and ultimately produces acoustic signals. Early age of implantation has been associated with better auditory rehabilitation and that's why the FDA recommends the use of CI in children from the age as young as 12 months[7]. The cochlear implant in the recipients is activated after 4 to 6 weeks of surgery and the recipients then undergo a series of speech rehabilitation sessions at an auditory rehabilitation center. The patients are assessed at 3, 6 and 12 months rehabilitation therapy. After regular speech therapy sessions, gradual but significant improvements in hearing, speech and cognitive abilities of children have been documented. Multiple factors including the number of therapy sessions, financial and educational status of parents have been found to have an impact on the hearing outcomes of these patients[8].

In Pakistan being a developing country, there is the scarce availability of newborn hearing screening tests and due to limited health care facilities and accessibility to the general population, a high prevalence of sensorineural deafness is reported. Previously, no cochlear implantation program was present and the patients who were planned for cochlear implant surgery had to pay for the cost on their own. The launch of the 'Prime Minister Cochlear Implant Program' and 'Pakistan Bait-ul-Mal Cochlear Implant program' has extended promising services to the deserving candidates[9]. The objective of our study was to determine the hearing outcomes following unilateral cochlear implantation & speech therapy in patients with bilateral severe to profound sensorineural hearing loss.

METHODOLOGY

It was an IRB and ERC (IRB approval ENT No. 1018) approved prospective observational study, carried out at the department of ENT, Head and Neck Surgery, Combined Military Hospital Rawalpindi, from December 2018 to December 2019. A total of 43 patients with bilateral severe to profound sensorineural hearing loss were assessed for cochlear implantation candidacy in 6 months from December 2018 to May 2019. After complete clinical, audiological and radiological workup, these 40 cases were found fit for cochlear implantation. Sample Size was calculated by WHO Sample size calculator with 1.5% reference prevalence of congenital bilateral sensorineural deafness[1]. A minimum sample size of 25 was calculated but we included all consecutive cases in the study period which fulfilled the inclusion criteria by non-probability convenient sampling technique. Typical candidacy criteria followed for Cochlear implantation at Combined Military Hospital Rawalpindi was (1) Patients of both genders irrespective of age (2) Bilateral severe to profound permanent hearing loss >70 dB (3) No response after high-frequency hearing aid trial for 6 months (4) Intact vestibulocochlear nerve and (5) Fit for cochlear implantation declared by Cochlear Implant board Meeting. Unilateral 12 Channel implant was inserted in 38 patients via Posterior tympanotomy approach while 2 patients received an 8 Channel implant via Per meatal approach. We included 40 cases who underwent unilateral cochlear implantation at the Cochlear Implant Centre of Combined Military Hospital Rawalpindi and later on had at least 6 months of continuous speech rehabilitation (post-activation) at Speech Rehab Center of the same hospital. A single experienced Head and Neck Surgeon performed the cochlear implant surgery. All patients had their cochlear implants activated 6 weeks after the surgery.

Data from patients' clinical charts were prospectively collected from December 2018 to December 2019 including age, gender, development, results of pre-implantation radiological and audiological investigations (MRI, CT scan, BERA,

and Tympanogram), decision of cochlear implant board, educational and financial status of parents, ear side which was implanted, complications following surgery and outcomes in terms of hearing rehabilitation at 6 months by using cochlear implant listening skills development chart. Age at CI surgery divided into four groups (1) 2-3 yrs, (2) 3.1-4 yrs (3) 4.1-5 yrs (4) 5.1-6 yrs (5) 6.1-7 yrs (6) 7.1-8 yrs (7) >8 yrs. Auditory Rehabilitation was assessed continuously at each session by a single speech therapist and documented using the "5 stages of listening i.e. has a very good vocabulary, has a basic vocabulary, understands words, responds to sounds, doubtful response to sound."

Written informed consent was taken from the parents and all the parents participated voluntarily. We analyzed the data by using SPSS version 22 software and Microsoft excel 365.

Table-I: Complications of cochlear implant surgery.

Complications of Surgery	n (%)
Facial Nerve Palsy	1 (2.5%)
Procedure abandoned due to excessive bleeding (redone latter)	2 (5%)
Round window not found (contralateral side used)	2 (5%)

Table-II: Outcomes of Speech rehabilitation after 6 months of implant activation.

Response to speech rehabilitation at 6 months	n (%)
Has very good vocabulary	2 (5%)
Has basic vocabulary	4 (10%)
Understands words	13 (32.5%)
Responds to sounds	14 (35 %)
Doubtful response to sound	7 (17.5%)

RESULTS

Out of 40 patients, 22 (55%) were male and 18 (45%) were females. Age at the time of cochlear implantation ranged from 2 to 8.4 years with a mean age of 4.5 ± 1.34 years. On pre-implantation radiological investigations, 1 patient had 1.5 coils of the cochlea at CT scan and MRI of the temporal bone with the cochlear protocol. BERA revealed hearing below 100 dB in 32 cases, between 80-100 dB in 6 while in 2 cases hearing was between 70-80 dB. Only 1 case had otitis media with effusion (OME) at the pre-implan-

Table-III:Association of age group and outcomes of speech rehabilitation.

Age Group (years)	Outcomes of speech rehabilitation at 6 months					*p*-value
	Doubtful Response to Sound	Responds to Sound	Understands Words	Has Basic Vocabulary	Has Very Good Vocabulary	
2-3	3 (7.5%)	5 (12.5%)	7 (17.5%)	2 (5%)	2 (5%)	0.994
3.1-4	1 (2.5%)	3 (7.5%)	2 (5%)	1 (2.5%)	-	
4.1-5	1 (2.5%)	3 (7.5%)	1 (2.5%)	-	-	
5.1-6	2 (5%)	2 (5%)	1 (2.5%)	1 (2.5%)	-	
6.1-7	-	-	1 (2.5%)	-	-	
7.1-8	-	-	1 (2.5%)	-	-	
>8	-	1 (2.5%)	-	-	-	

Table-IV: Severity of pre-implant hearing loss and post-implantation auditory outcomes.

		Six Months Follow-up					*p*-value
		Doubtful Response to Sound	Responds to Sounds	Understands Words	Has Basic Vocabulary	Has very Good Vocabulary	
Brainstem Evoked Response Audiometry	Hearing between 70 - 80 dB	-	-	-	2 (5.0%)	-	0.342
	Hearing between 80-100 dB	3 (7.5%)	3 (7.5%)	-	-	-	
	Hearing below 100 dB	4 (10.0%)	11 (27.5%)	13 (32.5%)	2 (5.0%)	2 (5.0%)	

tation tympanogram. The cochlear implant board meeting had labeled 38 patients as fit for an implant and 2 cases were negotiable because of age but ultimately received the implant. Only 2 cases had left ear cochlear implants (CI) due to difficulty in locating the Round window in the right ear, while the rest of them received CI in the right ear. Only 4 cases faced complications of cochlear implant surgery shown in table-I. Using stages of listening the outcomes of auditory rehabilitation are given in table-II. Stratification of outcomes of auditory rehabilitation with age at implantation was done and shown in table-III. In table-IV severity of pre-implant hearing loss and post-implantation auditory outcomes are compared.

DISCUSSION

Around the globe, bilateral severe to profound hearing loss has been managed by cochlear implantation and is reported to have reasonably acceptable results in children whose parents showed strict compliance with regular speech therapy sessions. In the past decade, early cochlear implantation has received a lot of attention and has been advocated for the early age of 12 months and onwards. The documented evidence showed improved hearing outcomes and language performance and thus age at implantation is the most useful determinant for the children who have met the candidacy criteria for cochlear implantation[10].

Fitzpatrick *et al*, in his study of 187 patients who received a cochlear implant reported the median age of implantation to be 36.2 months and documented a delay of 12 months in 118 (63.1%) patients after diagnosis of severe bilateral hearing loss. The major reason for the delay in the implantation was progressive hearing loss[11]. Kim *et al*, enrolled all the patients of <60 months age at the time of CI and the mean age was 17 ± 5.7 months[12]. Pirzadeh *et al* in his study at Tehran reported the 3 ± 2 years as mean age of implantation[13]. The age range in our study was 2 to 8.4 years with a mean age of 4.5 ± 1.34 years which was higher than reported in other studies in the literature. The most common age group receiving CI was 2-3 years.

Pirzadeh *et al*, reported that the most common complication after cochlear implant surgery was prosthesis rejection followed by facial nerve paralysis and suture rupture[13]. Postelmans *et al*, reported major complications in 3.6% of the implant recipients[14]. The commonest complication in our patients was the failure of implant surgery due to the absence of a round window in one ear (5%) followed by facial nerve palsy (2.5%) and profuse per-operative bleeding (5%).

In our study, patients of all age groups have shown significant improvement at 6 months assessment by using post cochlear implant listening skills and stages of listening[15]. The patients of age group 2 to 3 years showed the maximum response to speech rehabilitation where 85% showed positive outcome at 6 months followed by age group 4.1-5 years (84%) and then 3.1-4 years (80%). The result was statistically insignificant with a *p*-value of 0.994 but these results were clinically significant. One reason for this marked difference was the lesser sample size and also the maximum participation from age groups 2 and 3 (i.e. 39-48 and 49-60 months). We excluded congenital anomalies in our study and found better results of speech rehabilitation in maximum recipients. Celik *et al*, reported adequate response in both children with or without inner ear malformations[16]. Weber *et al*, investigated outcomes of cochlear implant in patients with congenital malformations and found encouraging results in 30 patients[17]. Liu *et al*, assessed 98 patients before implantation and then at 3,6 and 12 months post-implantation and found out a marked improvement in all age groups in terms of hearing rehabilitation but also concluded that earlier the age of implantation the better the results of speech therapy would be and also clinical and statistically significant results can be documented at 12 months assessment[8-18].

Owing to strict inclusion criteria the majority of patients who received a cochlear implant in our study sample had profound hearing loss of

>100 dB and thus the overall outcomes were positive in each age group. The limitation of our study was that it had a small sample size and secondly follow up results of only 6 months were assessed. Long term prospective studies are recommended in cochlear implant recipients.

CONCLUSION

We concluded that a cochlear implant is a safe and highly effective treatment for bilateral severe to profound sensorineural deafness. Patients with prelingual hearing loss aged between 2 to 3 years who received a cochlear implant had a better outcome post-rehabilitation whereas the outcome of post-lingual cases was very good within 5 years of acquired deafness.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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