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When to provide bimodal stimulation in unilateral cochlear implant recepients

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ABSTRACT

Background: With the steady increase in unilateral cochlear implant surgery as management of bilateral sensorineural hearing loss, the benefits of bimodal hearing have been well documented. However very few studies are available on the timing of bimodal hearing stimulation after cochlear implantation. The present study deals with when to provide bimodal hearing in unilaterally implanted children to achieve maximum benefit.

Methods: This study was carried out in 120 children aged between 3-5 years who underwent unilateral cochlear implant surgery. The implant was switched-on two weeks after surgery in all cases. The children were randomized into two groups of 60 each. Group 1 comprised of children who continued to use hearing aid in the non-implanted ear immediately after the cochlear implant surgery. Group 2 children discontinued using hearing aid in the non-implanted ear after surgery and restarted its usage after four weeks of switch on of the cochlear implant. The progress in both groups was monitored using category of auditory performance (CAP) scores and through a questionnaire.

Results: The mean age of the children was 3.55 years. 11.6 % of the recipients could localize sounds and 5% could understand speech in noisy environment in Group 2 whereas in 1.7% of the recipients could localize sounds and none of the recipient could understand speech in noisy environment in Group 1 after 3 months of follow up. CAP scores increased steadily in Group 2 over the study period whereas Group 1 recipients did not show the same progress.

Conclusions: We recommend that bimodal fitting should be the standard practice for clinical management of children who receive unilateral cochlear implant. The best practice is to restart the use of the hearing aid in the non-implanted ear, after one month of activation of the implant to achieve maximum benefit.

Keywords: Cochlear implant, Bimodal hearing, Hearing aids

INTRODUCTION

The advantages of bilateral auditory amplification with hearing aids are now a well-accepted norm and it is standard clinical practice to fit hearing aids bilaterally. However with the steady increase in cochlear implant recipients, the benefits of bimodal hearing are also well accepted now. Cochlear implant recipients may receive bilateral stimulation in two ways - a cochlear implant in one ear and a hearing aid in the non-implanted ear (bimodal hearing) or a cochlear implant in each ear (bilateral cochlear implants). Bilateral cochlear implants are becoming increasingly common but may not be

possible in all cases due to various reasons like unsuitability of the other ear for surgery, economic non viability or in many cases due to significant residual hearing in the non-implanted ear. In these cases, the use of a hearing aid in the non-implanted ear is an affordable and beneficial choice for bilateral stimulation.^{2,3}

Bimodal hearing implies stimulation by two different modes of hearing in a hearing challenged individual i.e. hearing aid in one ear to provide acoustic stimulation and cochlear implant in other ear to provide electrical stimulation. The present study was conducted in a tertiary care hospital in northern India with one of the largest

cochlear implant centers in the country with a government funded cochlear implantation programme. India being a developing country, government aid is intended to reach more individuals. Approximately 60-70 children in the age group of 2-7 years are being provided with unilateral cochlear implants every year at our centre. Bilateral implants are seldom offered in our programme as the aim is to benefit more individuals with hearing loss. Moreover with the expanding candidacy criteria, children with unilateral cochlear implants have significant residual hearing in the non-implanted ear.4 The benefits of providing bimodal hearing are well documented in literature. However not many studies are available on when to start providing bimodal hearing stimulation after cochlear implantation. In the present study we share our experience in terms of when to provide bimodal hearing in unilaterally implanted children so as to achieve maximum benefit in terms of speech language proficiency and sound localization in a day-to-day setting.

METHODS

A prospective study was carried out in 120 children aged between 3-5 years who underwent unilateral cochlear implant surgery in our tertiary care referral hospital. The children were evaluated for hearing loss and fitted with bilateral high power digital hearing aids at our out-patient center prior to cochlear implant surgery. All the children were implanted using Nucleus CI 24 RST implant. The implant was switched-on two weeks after surgery in all cases. Informed consent was taken from the parents of children participating in the study. The children were randomized into two groups of 60 each. The groups were matched for age, sex, economic background and parental education. Children with syndromic hearing loss, anatomical anomalies of the cochlea or auditory nerve or other neurological deficits were excluded from the study. All the participating children received speech language therapy sessions at our own center. Group 1 comprised of children who were instructed to continue to use hearing aid in the non-implanted ear immediately after the cochlear implant surgery. Group 2 children were

instructed to start using hearing aid in the non-implanted ear after four weeks of switch on of the cochlear implant. The progress of the cochlear implant recipients was monitored using category of auditory performance (CAP) scores and the ease of bimodal hearing was assessed through the questionnaire (appendix A). 5 CAP scores were obtained serially by the audiologist at an interval of 0, 1, 2 and 3 months post switch on and questionnaire was filled by parents and the audiologist at similar intervals. The parents were required to observe their child's performance in a range of real-life situations over a week during which the child used either a cochlear implant alone, or a cochlear implant with a hearing aid. Each question in the questionnaire could be answered either by a 'yes' or a 'no' response. Each 'yes' response was coded as 1 and 'no' response as 0. In order to find out significant difference between two listening conditions the data was subjected to t test and the results are discussed as follows.

RESULTS

The mean age and male to female ratio in both the groups are depicted in Table 1.

Table 1: Comparison of mean age, male to female ratio between two groups.

	Group 1	Group 11
Mean±SD (years)	3.5±0.85	3.6±0.97
M:F	3:2	1:1

Table 2 & 3 depict CAP scores at various intervals for cochlear implant recipients in Groups 1 & 2. 88.3% of the cochlear implant recipients in Group 1 and 90% in Group 2 had awareness of environmental sounds at switch on. 11.6% in Group 1 and 10 % in Group 2 could respond to speech sounds at the time of switch on. CAP scores steadily increased over the study period for the recipients in Group 2 after switch on. The cochlear implant recipients of Group 2 accepted bimodal hearing easily as given in Table 5.

Table 2: CAP scores of 60 CIR in Group I.

	CAP - 0	CAP- 1	CAP - 2	CAP - 3	CAP - 4	CAP -5
Switch on	0	88.3% (53/60)	11.6% (7/60)	0	0	0
1 month	0	88.3% (53/60)	11.6% (7/60)	0	0	0
2 month	0	0	83.3% (50/60)	16% (10/60)	0	0
3 month	0	0	0	68.3% (41/60)	28.3% (17/60)	3.3% (2/60)

Table 3: CAP scores of 60 CIR in Group 2.

	CAP - 0	CAP- 1	CAP - 2	CAP - 3	CAP - 4	CAP -5
Switch on	0	90% (54/60)	13.3% (8/60)	0	0	0
1 month	0	0	75% (45/60)	16.7% (10/60)	8.3% (5/60)	0
2 month	0	0	0	68.3% (41/60)	28.3% (17/60)	3.3% (2/60)
3 month	0	0	0	0	68.3% (41/60)	31.7% (19/60)

Table 4: The results of questionnaire in Group 1.

Question number	Switch-on (0 Month)	1 month post switch - on	2 months post switch - on	3 months post switch - on
1.	96.6% (58/60)	96.6% (58/60)	0/60	0/60
2.	3.3% (2/60)	3.3% (2/60)	0/60	100% (60/60)
3.	0/60	0/60	60/60	0/60
4.	0/60	0/60	0/60	1/60
5.	0/60	0/60	0/60	0/60

Table 5: The results of questionnaire in Group 2.

Question number	Switch-on (0 Month)	1 month post switch	2 months post switch	3 months post
		- on	- on	switch - on
1.	0/60	0/60	0/60	0/60
2.	0/60	0/60	100% (60/60)	100% (60/60)
3.	100% (60/60)	100% (60/60)	0/60	0/60
4.	0/60	0/60	0/60	11.6% (7/60)
5.	0/60	0/60	0/60	5% (3/60)

However the cochlear implant recipients of Group 1 did not show increase in CAP scores after one month of switch on as in Table 3. They preferred to use hearing aids alone over bimodal hearing as given in Table 4. The parents of Group 1 recipients were then instructed not to use hearing aids and only use cochlear implant after one month of switch on. After one month of using only cochlear implant (and two months of switch on), CAP scores increased for cochlear implant recipients of Group 1. They now preferred using cochlear implants over hearing aids alone. They also accepted bimodal fitting with ease after using cochlear implant alone for a month and showed increase in CAP scores thereafter as shown in Tables 2 & 4.

After three months of switch on 11.6% of the recipients could localize sounds and 5% could understand speech in noisy environment in Group 2 whereas 1.7% of the recipients could localize sounds and none of the recipient could understand speech in noisy environment in Group 1.

None of the parents judged their child to be functioning poorer when wearing a cochlear implant with a hearing aid compared to wearing a cochlear implant alone. On average, the questionnaire score for the binaural condition was significantly better than the monaural condition (p < 0.05).

DISCUSSION

Providing binaural hearing is a vital component of aural rehabilitation and bilateral auditory input is essential for binaural hearing. Binaural hearing uses auditory inputs from both ears and helps to localize sounds and to understand speech better in adverse listening situations such as presence of noise or when there are many speakers at the same time. Bilateral cochlear implantation may not be possible for every cochlear implant. The

reasons could be parent's apprehension about surgery, expense of procedure and preserving one ear for possible future technology or treatment. Unilateral cochlear implant does not give the advantage of binaural hearing. Despite cochlear implants having had significant advances in the past few decades both in terms of technology and patient friendliness, the current devices still do not restore normal perception of speech. Initial concerns with bimodal hearing were that patients might be unable to combine the two very differently processed sound stimuli for central processing. Fortunately, this has not proven to be the case and in fact some researchers have argued that bimodal stimulation may provide complimentary cues for processing of signals that may be advantageous for speech perception especially in listening situations such as in the presence of noise.⁷ Specifically, the hearing aid provides needed information in the lower frequencies consisting of fundamental frequency of the speaker's voice and vowel information, while the cochlear implant provides needed information in the mid and high frequencies consisting of manner and place of articulation of consonants.⁶ Another potential advantage of providing auditory input via hearing aid to the non-implanted ear is that it might help to reduce the neuronal degeneration that is associated with auditory deprivation.8 Improvement in localization abilities and higher levels of satisfaction and perceptual benefits with bimodal devices had been reported in literature. However there are no studies available in literature on the timing of starting bimodal stimulation of hearing.

The ultimate goal of providing bimodal hearing is to enable unilateral cochlear implant users to derive the benefit of binaural hearing in real life. The speech perception and localization benefits as quantified in the laboratory may not be a valid evidence of binaural advantage. It is of clinical relevance only if they predict advantages in real-life situations that depend on hearing ability. Therefore, functional performance in real life

situations was assessed through the parent questionnaire. However standardized assessment was also kept in mind and assessed by serial CAP scores at switch on, after 1 month, 2 months and 3 months. In our study, the group of children who were given the opportunity to adapt to stimulation by the unilateral cochlear hearing implantation for four weeks before resumption of use of hearing aid in the non-implanted ear (Group 2), performed better both subjectively as reported by the parents through the questionnaire and also as per the CAP score. Children in Group 1 continued to use the hearing aid immediately after the implant. At switch on of the implant after two weeks, they were uncomfortable with the cochlear implant and failed to show the desired improvement in the CAP scores in the following months. But when the hearing aids were withdrawn and they were instructed to use only cochlear implant for a month, over the next month of follow up, they gradually accepted the implant and were at ease with bimodal fitting thereafter and also showed progress in terms of CAP scores. If optimization of the bimodal fitting is to be ensured, it has been recommended that bimodal hearing be started once the recipient is well adjusted to the cochlear implant.

11.6 % and 5 % of children in Group 2 started localizing sounds and understanding speech in noisy environment respectively after 02 months of bimodal hearing. In Group 1, 1.7 % could localize sounds and none could understand speech in adverse conditions after 01 month of effective bimodal stimulation. Hence, the benefit of the bimodal hearing should be evaluated after at least 8 weeks of usage of bimodal fitting as some familiarization and adaptation is required to localize sound accurately and receive full benefit. 9.

CONCLUSION

Bimodal fitting should be the standard practice for clinical management of children who receive unilateral cochlear implant. The best practice is to restart the use of the hearing aid in the non-implanted ear after one month of activation of the implant to achieve maximum benefit in terms of speech performance and sound localization.

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Appendix A: Questionnaire.

Questions	Yes	No
Q1. Does the child prefer hearing aid to cochlear implant?		
Q2. Does the child prefer bimodal hearing to cochlear implant?		
Q3. Does your child prefer cochlear implant to hearing aid alone or bimodal hearing?		
Q4. Is your child able to localize sounds?		
O5. Is your child able to understand speech in noisy environment?		