Journal of Clinical Case Studies and Reviews

Research Article Open Access

Comparison of Speech Outcomes in Unilateral and Bilateral Pediatric Cochlear Implants- Our Experience

Bhavya BM[1,2*], Neeraj Suri[1], Trupti U Bhat[1] and T Saikrishna Teja[1]

[1]Department of ENT & HNS, GMERS Medical College & Civil Hospital, Gandhinagar, Gujarat, India

[2]Department of ENT & HNS, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun, Uttarakhand, India

***Correspondence to:** Bhavya BM, Department of ENT & HNS, GMERS Medical College & Civil Hospital, Gandhinagar, Gujarat, India

Received: 19 May 2021; **Accepted:** 17 June 2021; **Published:** 24 June 2021

Abstract

Over the years FDA approved indications for Cochlear implant have expanded to include pre-lingual pediatric age as young as 12 months and post lingual adults, who have unilateral or bilateral moderate to profound SNHL. Earlier Unilateral CI was performed, bilateral implants are being popularized now.

Objectives: *The aim of our study is to compare the outcomes in unilateral and bilateral cochlear implants in pediatric age and also between simultaneous and sequential surgery.*

Material and Methods: *This retrospective study was carried out with 83 children aged which included 41 children with bilateral Cochlear implants and 42 with unilateral implants. Out of these 41 children 21 were simultaneous and 20 were sequential. All children were operated at civil hospital Gandhinagar, Gujarat, India. SIRS, CAP scores, speech perception in quiet and noise, sound localization and comprehension were assessed at regular intervals over the period of 4 years. Also, drug administration time, surgical time, operating room time were assessed for simultaneous and sequential surgery.*

Results: *Children with bilateral implants fared significantly better with sound localization, speech comprehension and speech production tests, expressive language subscales than unilateral implants with a significant difference (p=0006) of means t tests between the two groups. Children with simultaneous bilateral implants achieved significantly higher scores in vocabulary outcomes and expressive language subscales than those with sequential bilateral implants. Simultaneous Surgery is associated with reduced surgical time, operating room time, it shortens the total in patient stay. There is less of drug administration and both ears get stimulated simultaneously*

Conclusion: *Bilateral Cochlear implants are associated with better expressive language and receptive language when compared with unilateral implants, these differences were not statistically significant when simultaneous and sequential implants were compared but simultaneous surgery is better and safe option for pediatric cochlear implantation.*

Abbreviations: *SNHL– Sensory Neural Hearing loss, CI – Cochlear Implant, SIRS– Speech Intelligibility Score, CAP – Categories of Auditory Performance Test.*

Keywords: *Bilateral Cochlear Implant; Prelingual Deafness; Binaural hearing*

Introduction

Cochlear implantation has proven to be very successful way to restore auditory communication in severe to profound hearing loss, especially for patients who have well developed central auditory pathways [1]. Cochlear implant is being done for both pre-lingual type of hearing loss, post lingual hearing loss, and as a treatment option if hearing aids do not provide sufficient benefit. Prelingual learning loss is when the hearing impairment occurs prior to acquisition of language, and auditory cortex development before 2 years of age. Overall long-term outcomes of cochlear implantation before the critical age of 5-6 years when auditory pathway has greatest neuroplasticity, results reveal that most children are able to recognise the spoken word in an open context without the support of lip reading or gestures [2].

Although cochlear implant patients generally hear well in quiet surroundings, hearing with background noise as is normal in daily situations remains a challenge [3-5]. There is an ongoing discussion on whether or not bilateral CI should be the standard care for all Prelingual hearing loss. Our auditory system is anatomically and functionally prepared to receive stimulus from outside from both ears under normal conditions [2]. Binaural hearing enables one to differentiate sounds of interest from background noise, sound localisation, by using different effects of binaural hearing: head shadow, squelch and summation [6-9]. Doing bilateral implantation either simultaneous or sequential will benefit the children to overcome all these difficulties of unilateral implants and monaural hearing[10] . Several studies have been published that demonstrate that bilateral CI in Prelingual deafened children below the age of 5 years, had a positive effect on speech and language development. Literature also shows that speech understanding in noise and sound localization significantly improved in patients who underwent bilateral CI [11]. However, there is limited literature available on outcomes of bilateral and unilateral cochlear implants from south Asian region. In developing countries like India, where deafness is a social stigma, though government is promoting many programs to bring awareness among medical personnel and public for early diagnosis of deafness and early intervention.

The aim of our study is to evaluate the speech outcomes in children diagnosed with congenital severe to profound hearing impairment and treated with cochlear implant below the age of 2.2 years, and to compare the said outcomes between those children who received bilateral implants and those who received unilateral implants.

Material and Methods

Retrospective study was carried out, covering a total of 83 children diagnosed with severe to profound congenital hearing loss. The subjects were children were aged between 8 months to 2.2 years, who underwent cochlear implantation between Jan 2016 to Nov 2017. Out of these, 41 children underwent bilateral CI, and 42 underwent unilateral implant at the Department of ENT, Civil hospital Gandhinagar, Gujarat, India. Inclusion criteria: children diagnosed with severe to profound bilateral hearing impairment with thresholds over 85dB, with or without minimum benefit from hearing aids, thresholds to conversational frequencies in visual reinforcement tests or behavioural audiometry over 50dB. Children who had undergone first cochlear implant at other centre with a different implant make opting for second implant at our centre were also included in the study. Children with abnormal inner ear anatomy, neurocognitive delays, were excluded.

All children underwent imaging studies using computerised tomography and MRI to demonstrate anatomy of Cochlea for insertion of electrode and presence of cochlear nerve. A neuropsychological and paediatric assessment was also done prior to the surgery. All recipient's (both unilateral and bilateral Implants), had their devices switched on at 2 weeks post-operatively, and were enrolled in standardized speech therapy at the same centre. Post-operative, pure tone laminar audiometry was done at 3-6 months intervals, both in sound proof room and in open spaces. All were assessed monthly during the first 6 months and 3 monthly for upto 4 years post implant activation.

Diverse tests were also included in the assessment of children to measure their behaviour to sound in everyday real-life situations including the Nottingham auditory performance scale which includes 8 categories, complete inability to perceive environmental sounds despite appropriate prosthesis on one end of spectrum, and the ability of patient to maintain a telephonic conversation with unknown person on unfamiliar subject as the last. Questionnaires were filled by the parents to assess audio-communicative improvements with cochlear implantation. And individual hearing level tests carried out without the help of lip reading and in open context with no background noise delivered at 65dB at 1 metre distance, digitally altered noise used as competing noise at 50,60,70 dB for speech recognition in noise. SIRS, CAP scores, speech perception in quiet and noise, sound localisation and comprehension were assessed at regular intervals up to 36-48 months post implantation. Audio-communicative skills were tested using Little Ears questionnaire which covers 35 items.

Statistical analysis:

The data was gathered in Microsoft excel, and SSPS 20 software used for the statistical analysis. Measures of ability to understand speech in noise were compared with paired t test or with student t test. To compare baseline characteristics, student t test was used for numeric variables, normally distributed data and chi square test for ordinal data. The speech outcomes between the two groups: children with unilateral CI, and those with bilateral CI was systematically analysed using Student t test to a previously standardised samples and a statistical significance was established as $P<0.05$.

Results

The 83 children were analysed retrospectively, all had been diagnosed to have bilateral severe to profound hearing impairment. All children operated were under the age of 2.2 years. Minimum age of implantation was 8 months. The average age of implantation was 16 ± 3 months in group with bilateral implants, and 18 ± 5 months in group with unilateral implants. 41 children received bilateral implants and 42 children received unilateral implants. The children were also divided on the base of age at implantation: 38 children who received cochlear implant below the age of 1 year, 45 patients who received implants between 1-2.2 years.

In the bilateral implantation group, the 15 children who received both implants simultaneously, formed part of the group that received implants under 1 year of age. 6 children were implanted simultaneously between 1 -2.2years of age. 20 children received second implant sequentially with a gap between implants of 6-9 months Of the 41 bilateral patients, 15 were operated at less than 1 year of age, 26 received both implants within 2.2 years of age. (Table 1)

	Unilateral	Bilateral		
		ALL	Simultaneous	Sequential
No of children	25	24	17	7
Chronological age (mean)	25 ± 5 months	20 ± 3 months	12 ± 5 months	30 ± 4 months
Gender (n)				
Male	14	9	5	4
female	11	15	12	3
Age at diagnosis (mean)	18 ± 6 months	15 ± 4 months		

Table1: Biographical data for the participants. For ages and durations, means in years

In the unilateral group of 42, 23 received implants within first year of life, 19 within 2.2 years of life. (Table 2)

Table 2: Age at implantation

All bilateral implant patients used hearing aids before implantation, compared to 37 in unilateral group who used hearing aids. Preoperatively there were no differences between the unilateral and bilateral group on the quality of hearing (questionnaire results) with or without hearing aid use.

Residual hearing: In the unilateral group 10 out of 42 patients did not use contralateral hearing aids at 1 year follow up, either due to no benefit from it or unaffordability or lack of compliance. The objective test outcomes however, did not correlate significantly with the maximum CAPS, CVC scores with (n=32) or without (n=10) wearing hearing aids ($p>0.05$). These values also meant that residual hearing did not influence the post implant speech outcomes. Auditory thresholds were measured in both groups, at 1year interval in each age group. The student t test was used to compare these auditory thresholds within both groups. Threshold in both bilateral and unilateral cochlear implant groups, who were operated within 1 year of life and those operated within 2 years of life obtained similar values, of around 28±5dB after 2 years of implantation.

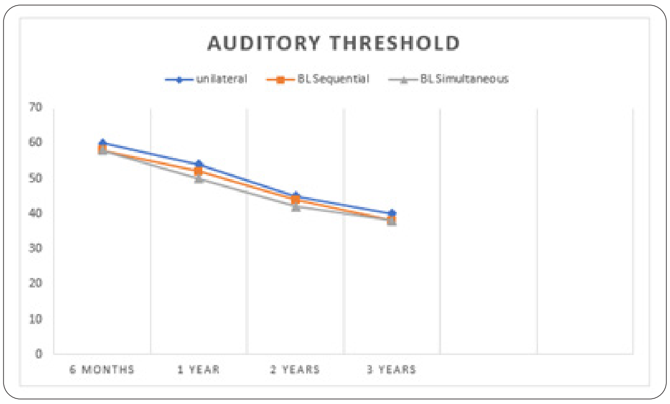

Figure 1: Auditory thresholds measured in both unilateral and bilateral CI groups (operated <12 months of age)

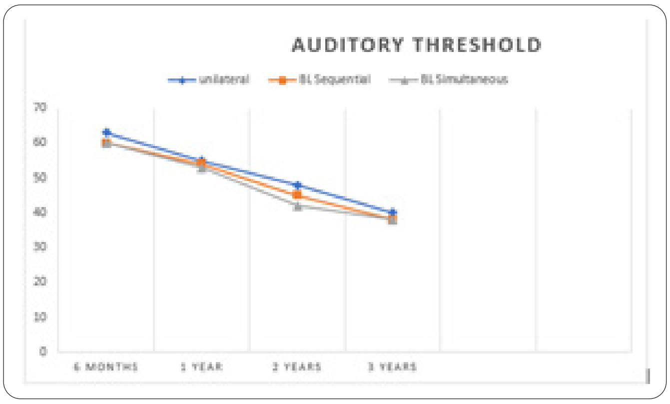

Figure 2: Auditory thresholds measured in both unilateral and bilateral CI groups (operated 12months – 2.2 years).

When auditory thresholds were compared between bilateral and unilateral implant groups separately, we found a difference of 5±2Db, but did not show any statistically significant difference with significant level results of $p>0.05$. (fig-1 & 2) We observed that maximum scores obtained at 2-3 years post implantation in patients with unilateral and bilateral implants had no marked differences; except that bilateral implants, both simultaneous and sequential scored a maximum of 35-40 points (IT Mais scale) at 2 years, while unilateral implants scored the same at 3 years post implantation.

Auditory comprehension skills scored better in those patients operated less than 1 year of age than those operated between 1-2.2 years of age, irrespective of the fact whether they received unilateral or bilateral implants. The Speech test studies the child's ability to discriminate, identify, recognise, and understand the spoken word. Figure 3 & 4 shows the results of two syllable and sentence tests, with minimal differences between both age groups, and between unilateral and bilateral implant groups, with slightly better outcomes in those operated in their first year of life.

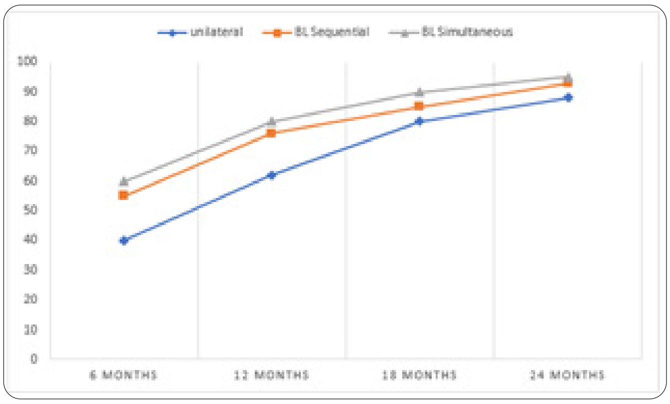

Figure 3: Auditory comprehension skills measured in both unilateral and bilateral CI groups (operated <12 months of age group)

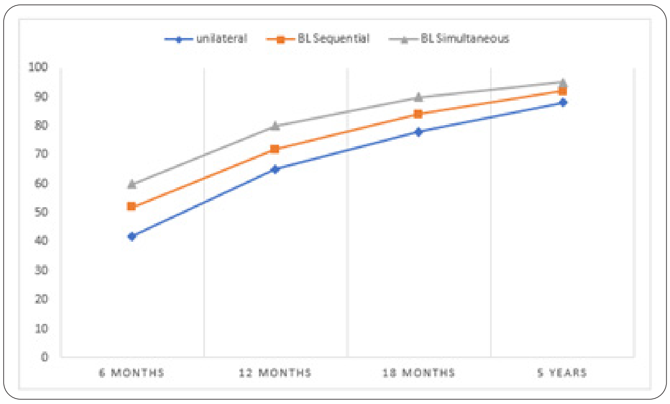

Figure 4: Auditory comprehension skills measured in both unilateral and bilateral CI groups (operated 12months – 2.2 years age group).

If we compare the CAPS and SIRS scores between unilateral and bilateral implant groups, bilateral implant groups both simultaneous and sequential scores fairly high when operated within 1 year of age with a p value of 0.004. Mean vocabulary scores of both groups of children were within 2SD of the mean for children with normal hearing. Variability in scores is high as with many other studies which reveals better scores with the increasing number of years spent with bilateral implants.

Speech intelligibility in silence was tested between both groups, we did not find any statistical significance (Table 3).

Unilateral				Bilateral			
	25th percentile	Median	75th percentile		25th percentile	Median	75th percentile
Noise front (n=12)	-0.42	+0.63	+4.13	Noise front (n=17)	-1.90	+0.42	+2.85
Noise ipsilateral (n=15)	+2.68	+3.9	+6.89	Noise ipsilateral (n=18)	-4.11	-2.91	-0.62
Noise contralateral (n=5)	-4.60	-3.8	-0.87	Noise contralateral (n=18)	-6.7	-5.03	-2.83
Quiet (n=9)	+32.5	+35.2	+38.3	Quiet (n=19)	+30.6	+33.1	+33.2

Table 3: Results of speech intelligibility in quiet and noise for participants. Noise front, Noise ipsi., and Noise contra. Refer to conditions with noise from the front, from the side ip bilateral to the first device, and from the side contralateral to the first device. The 25th percentile (25th), 50th percentile (Median), 75th percentile (75th), and the number of participants contributing data (N) are listed for each group. The scores for the Quiet condition are in dB (A) SPL; the scores for all other conditions are a signal-to-noise ratio in dB.

Speech intelligibility in noise: Speech level was fixed at 65 dB at 1 meter from the source yielding a speech of 58 dB at the recipient's head. Digitally altered noise was used as competing noise presented at 50, 60, and 70 dB. When speech intelligibility was measured with background noise, the group with bilateral implants whether simultaneous or sequential fared better with a significant p value of 0.03 when compared to the group with unilateral implants. However, there was no significant difference when speech intelligibility was checked with noise from straight ahead in both group patients. These results were similar to other studies [12-14]. Inter implantation delay however no effect had in performance in background noise in patients with bilateral implants [15].

Sound Localisation: similar to other studies, We found that ability to localise sound were better in patients with bilateral implants compared to the unilateral group, regardless of simultaneous or sequential implants. Reported that early implantation less than 2 years of age is an important predictor of better sound localisation [16, 17]. They also compared the results of children who received second implants before the age of 4 years. They concluded that early implantation of second CI is an important factor for binaural localisation development especially for those in whom hearing side is ineffective and does not provide any auditory benefit on non-implanted side.

Discussion

This retrospective study conducted in the dept of ENT, GMERS Medical College, General hospital, Gandhinagar, Gujarat, India, included children under 2.2 years who underwent either unilateral or bilateral cochlear implantation. The aim of our study was to compare the speech outcomes between children who received unilateral and bilateral implants, to find out the advantages of bilateral CI whether done simultaneous or sequentially. And to note whether any auditory differences in communication skills among these children based on whether they received single or bilateral implants. Study design and samples were standardised prior to the study.

All the children were assessed pre and post operatively by the same team. The device programming was same in all children irrespective of the devices by different manufacturers. Minimum age of implantation in our study was 8 months. The average age of implantation was 16 ± 3 months in the bilateral implant group, and 18 ± 5 months in the unilateral implant group.

A study on 34 Prelingual deaf children who underwent cochlear implantation [18]. Concluded that auditory performance is inversely related to implantation age. Other similar studies conclude that there is a lapse in language development in those children with hearing impairment and when such children undergo CI language development develops at almost normal rhythm when compared to normal children [18-20] . In his study compared language skills of normal children and Prelingual deafened children who received cochlear implants at 2,3, and 4 years of age[21]. He found that the differences maintained between implantation at ages below 4, with better outcomes when implantations were done below 2 years of age. We found similar results in our study. Many studies have been done to analyse the effects of age at first implants, and second implant, unilateral implants with assisted hearing for the other ear, family background, parenting style, parental education, child characteristics like order of birth, siblings who have hearing impairment [22].

Effect of binaural hearing: Vocabulary outcomes & Language outcomes

Many earlier studies have speculated that the perceptual benefits of bilateral cochlear implants like improved speech perception in quiet and noise, better sound localisation, reduced listening effort, will facilitate better spoken language. With multiple factors and large variability in language outcomes, they found significantly faster rates of vocabulary and language development in children who underwent bilateral CI.

Several studies have been published that demonstrated that bilateral CI in Prelingual deafened children below the age of 5 years, had a positive effect on speech and language development. Literature also shows that speech understanding in noise and sound localization significantly improved in patients who underwent bilateral CI. These benefits also improved quality of hearing and quality of life [23, 24]. They also concluded that majority of studies had a low level of evidence and that there was a lack of well controlled randomised studies [25].

In This study concluded that the main advantage of bilateral CI is better speech recognition in noisy environment and better sound localisation, but there are no significant differences in children with single implant with regards to specific hearing improvement [26]. Other studies also confirm these advantages with reference to sound localisation, in overcoming head shadow effect and word perception in noise with bilateral implants and also to reach bilateral stimulation of pathways and auditory centres during the period of greatest auditory neuroplasticity [27-29]. Reported that early implantation at less than 2 years of age is an important predictor of better sound localisation [16,17]. They also compared the results of children who received second implants before the age of 4 years. They concluded that early implantation of second CI is an important factor for binaural localisation development especially for those in whom hearing side is ineffective and does not provide any auditory benefit on non-implanted side.

In our study, maximum scores on the Nottingham auditory performance scales, SIRS, CAP scores, audio-communicative skills tests, 2 syllable and sentence tests were found at 2-3 years post implantation. There was a statistically significant difference in benefits with regards to vocabulary and language outcomes with bilateral CI as compared to children who received unilateral implant. We could not analyse any statistically significant difference in bilateral CI done simultaneously or sequentially as we had only 4 cases of bilateral CI operated sequentially. And 3 of them were operated 2-3 years after the first implant operated elsewhere. Having bilateral implants is not a significant predictor of outcomes; however, the age at which a child receives bilateral implants is a significant predictor of total language, speech and auditory comprehension scores. ($p=0.03$, 0.021). Children who received bilateral implants either simultaneous or sequentially <2-3 years of life fared better than unilateral implants. The results of age at first Cochlear implant had a qualitatively similar outcomes for children with unilateral implants, ($p=0.04$, 0.022).

Study limitations

Although the perceptual benefits of bilateral CI conferred a statistically significant advantage in terms of learning, spoken language and speech reception, when compared to those children with unilateral implants, it is not known whether these benefits are due to binaural auditory input or as a result of true binaural processing. Therefore, further studies are required to overcome those limitations. Another potential limitation is the number of unilateral and bilateral CI studied, and the limited representation of unilateral CI, which can be overcome by larger sample size studies. The analysis of inter implantation delay in patients with bilateral CI is complicated by several factors like age at first CI, age at second CI, residual hearing, child characteristics, parenting style, family background, motivation of parents, duration of post-operative rehabilitation which are difficult to assess and compare on a larger scale.

There is limited literature available on outcomes of bilateral and unilateral cochlear implants from south Asian region. In developing countries like India, where deafness is a social stigma, though government is promoting many programs to bring awareness among medical personnel and public for early diagnosis of deafness and early intervention, lack of a centralised subsidized scheme, only few states are performing unilateral implants at no cost. Due to high cost of the surgery, higher prevalence of congenital deafness in lower socio-economic strata and affordability issues, many patients are unable to undergo unilateral cochlear implant, and bilateral Cochlear implants seems to be out of reach.

Conclusion

In our study, Children with bilateral implants fared significantly better with sound localisation, speech comprehension and speech production tests, expressive language subscales than unilateral implants these outcomes were significantly affected by number of factors like age at first implant, simultaneous or sequential implants, delay between two implants. Though we found, Simultaneous bilateral implants were associated with better expressive language and receptive language outcomes than those with unilateral implants, these differences were not statistically significant when simultaneous and sequential implants were compared.

References

1. Sharma A, Dorman MF, Spahr AJ. “Sensitive period for the development of the central auditory system in children with cochlear implants: implications for age of implantation”. Ear Hear 23(2002):532-539.

2. Escorihuela Garcia V, Pitach Ribas MI, Llopez Carratala L. Comparative study between unilateral and bilateral Cochlear implantation in children of 1 and 2 years of age. Acta Otorrinolaringol Esp 67(2016): 148-155.

3. L Crathorne , M Bond, C Cooper, J Elston, G Weiner, et.al. “A systematic review of the effectiveness and cost effectiveness of bilateral multichannel cochlear implants in adults with severe to profound hearing loss”. Clin Otolaryngol 37(2012):342-354.

4. Gaylor JM, Raman G, Chung M, Lee J, Rao M, et.al. “Cochlear implantation in adults, a systematic review and meta-analysis”. JAMA Otolaryngol Head Neck Surg 139(2013):265-272.

5. Van schoonhoven J, Sparreboom M, Van Zanten GA, Scholten RJPM, Mylanus EAM, et al. “The effectiveness of bilateral cochlear implants for severe to profound deafness in adults: a systematic review”. Otol Neurotol 34(2013):190-198.

6. Middlebrooks JC, Green DM. "Sound Localisation by human listeners". ANN Rev Psychol 42(1991):135-59.

7. Bronkhorst AW, Plomp R. "The effect of head induced interaural time and level differences on speech intelligibility in noise". J Acoust Soc Am 83(1988):1508-1516.

8. Dirks DD, Wilson RH. "The effect of spatially separated sound sources on speech intelligibility". J Speech Hear Res 12(1969):5-38.

9. Mackeith NW, Coles RRA. "Binaural advantages in hearing of speech". J Laryngol Otol 85(1971):213-232.

10. Scheperle RA, Abbas PJ. "Peripheral and central contributions to cortical responses in cochlear implant users". Ear Hear 5(2015): 430-440.

11. CI-ON (Dutch Cochlear implantation Group) 19th December 2012. Guideline indication bilateral cochlear implantation in Children of 5-18 years of age.

12. Scherf F, Van DL, Van WA, Wouters J, Desloovere C, et.al. "Subjective benefits of sequential bilateral cochlear implantation in young children after 18 months of implant use". ORL J Otorhinolaryngol Relat Spec 71(2009):112-121.

13. Kuhn-Inacker H, Shehata-Deiter W, Muller J. "Bilateral cochlear implants: a way to optimise auditory perception abilities in deaf children?". Int J Pediatr Otorhinolaryngol 68(2004):1257-1266.

14. Zeitler DM, Kessler MA, Terushkin V, Roland JTJ, Svirsky MA, et.al. "Speech perception benefits of sequential bilateral cochlear implantation in children and adults: a retrospective analysis". Otol Neurotol 29(2008):314-325.

15. Gordon KA, Papsin BC. "Benefits of short inter implant delays in children receiving bilateral cochlear implants". Otol Neurotol 30(2009):319-331.

16. Van Duen L, Van Wieringen A, Scherf F, Deggouj N, Desloovere C, et.al. "Earlier intervention leads to better sound localisation in children with bilateral cochlear implants". Audiol Neurotol 15(2010):7-17.

17. Grieco-Calub TM, Litovsky RY. "Sound localisation skills in children who use bilateral cochlear implants and in children with normal acoustic hearing". Ear Hear 31(2010): 645-656.

18. Fryauf-Bertschy H, Tyler RS, Kelsay DMR, Gantz BJ, Woodworth GC, et al. "Cochlear implant use by prelingually deafened children: the influences of age at implant use and length of device use". J Speech Lang Hear Res 40(1997):183-199.

19. Svirsky MA, Teoh SW, Neuburger H. "Development of language and speech perception in congenitally profoundly deaf children as a function of age at Cochlear implantation". Audiol Neurotol 9(2004):224-233.

20. Boons T, de Reave L, Langeries M, Peeraer L, Wouters J, Wieringen AV, et.al. "Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early implantation". Res Dev Disabil 34(2013):2008-2022.

21. Martinez-Beneyto P, Morant A, Pitarch MI, Latorre E, Platero M, et.al. "La Implantation coclear pediatrica en el perido critic de la via auditive, neustra experiencia". Acta Otorhinolaringol Esp 60(2009):311-317.

22. Sarant J, Harris D, Bennet L, Bant S. "Bilateral versus unilateral cochlear implants in children: A study of spoken language outcomes". Ear and Hearing 35(2014):396-409.

23. Laszig R, Aschendorff A, O 'Driscoll M, Maune S, Weber B, et.al. "Benefits of bilateral electrical stimulation with the nucleus cochlear implant in adults: 6 months postoperative results". Otol Neurotol 25(2004):958-968.

24. Neuman AC, Haravon A, Sislian N, Waltzman SB. "Sound direction identification with bilateral cochlear implants". Ear Hear 28 (2007):73-82.

25. Dunn CC, Noble W, Tyler RS, Kordus M, Gantz BJ, et.al. "Bilateral and unilateral cochlear implant users compared on speech perception in noise". Ear Hear 31(2010):296-298.

26. Waltzman S, Cohen NL. "Cochlear implantation in children younger than 2 years old". Am J Otol 19(1998):158-162.

27. Schlein P, Nopp P, D Haese P. "Head shadow, Squelch and summation effects in bilateral users of the Med-El Combi 40/40 cochlear implant". Ear Hear 25(2004):197-204.

28. Litovsky RY, Johnstone PM, Godar S, Agarwal S, Parkinson A, et.al. "Bilateral cochlear implants in children: localisation acuity measured with minimum audible angle". Ear Hear 27(2006):43-52.

29. Spareboom M, Langereis MC, Smk AF, Mylanus FA. "Long term outcomes on spatial hearing, speech recognition and receptive vocabulary after sequential bilateral cochlear implantation in children". Res Dev Disabil 5(2014):328-337.

Citation: Bhavya B M, Suri N, Bhat TU, Teja T S et al. "Comparison of Speech Outcomes in Unilateral and Bilateral Pediatric Cochlear Implants- Our Experience." J Clin Case Stud (2021): 001-014 doi: 10.47755/2766-9556.100111