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Original article

Auditory Temporal Processing Tests in Unilateral and Bimodal Cochlear Implant in Pediatric Age Groups

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ABSTRACT

Background and aims. *Bilateral Cochlear Implantations (CIs) are considered the standard care for children with bilateral severe to profound sensori-neural hearing loss. However, the possibility of getting a bilateral CIs for every candidate is not always available. In order to improve speech localization, perception and language developmental, an early period of bilateral hearing aid stimulation is important for neuro-plasticity of central auditory system. So, a continuous acoustic stimulation of non-implanted ear with hearing aid (bimodal CIs) is beneficial in unilateral CIs to optimize outcome. The study was conducted to compare auditory temporal processing test in cochlear implants groups: unilateral CIs and bimodal CIs.* ***Methods****. A total of 23 cochlear implant user,14 unilateral ,9 bimodal were included in this study, their ages ranged from 6 to 13 years. Participant was assessed using pitch pattern test and duration pattern test.* ***Results****. Temporal processing ability among bimodal CIs users is significantly better than candidates with unilateral CIs.* ***Conclusion****. Our finding show that bimodal use of Cochlear implant should be recommended for those presently using unilateral device, moreover temporal processing test should be used regularly for evaluation of CI patients.*

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INTRODUCTION

Cochlear implantation (CI) is treatment of choice to all severe to profound sensorineural hearing loss that not response and audiological to conventional hearing aid [1]. Bilateral cochlear implantations are considered as the best choice to bilateral severe to profound sensorineural hearing loss due to obvious improvements of speech perception in quiet and noise and improve subjective sound quality [2].

Until near time, only severe to profound sensorineural hearing loss children are candidate for cochlear implant, however during last year's children with residual hearing are adding universal cochlear implant protocol, these patients are candidate for unilateral cochlear implantation in one ear and hearing aid in another ear, this referred as bimodal cochlear implantation [3]. Many studied provided the bimodal stimulation was found to be more cost-effective than unilateral and bilateral CI in both pediatric and adult age groups [4,5]. Temporal processing is one of the most basic and important functions of the central auditory system. It is critical to wide variety of everyday listening tasks including perception of speech, music, speech discrimination in noise [6]. Furthermore, temporal fine structure cues (amplitude fluctuation) play a role in the

perceptual segregation of speech from background noise [7]. In addition, temporal auditory processing is the auditory mechanism responsible for temporal resolution, temporal summation, temporal masking and temporal ordering [8]. The efficacy of temporal processing in children is poorer than that of an adult. It continues to grow with the child's age to reach maturity between 8 to 10 years of age [9]. Bimodal hearing combines the benefits of a hearing aid in one ear and a hearing implant in the other ear. The result is a richer and more natural hearing experience [10]. With a bimodal hearing solution, may experience many benefits, including: Clearer sound and improved speech understanding, especially in noise, better sound localization, music understanding was improved [11].

There is still limited information temporal ordering test in CIs users, therefore principle aim of this study compare temporal ordering test in unilateral and bimodal CI users. by using pitch pattern and duration pattern tests as test of temporal ordering abilities for unilateral and bimodal CIs, to because they are tonal (non-verbal) tests to exam the temporal ordering and due to their effect on improve quality of sound perception in prelingual cochlear implant user.

METHODS

Study design and patients

A comparative prospective case study, was conducted in Omar Almokhtar university clinic during the period from September 2020 to July 2023. The protocol of this study was approved by the ENT department, Omar Almokhtar University. A total of 23 cochlear implant user (14 unilateral, 9 bimodal) were included in this study, with their ages ranged from 6 to 10 years, and all of them were implanted at age 2-4 old.

The inclusion criteria were; 1). Congenital sensorineural hearing loss, 2) used spoken Arabic as primary mode of communication at time of test, and as native language, 3). no other significant disabilities as autism cerebral palsy, mental retardation and degenerative diseases, 4). there are no other craniofacial anomalies, congenital ear malformations, middle ear anomalies, 5). All children had same CI device model and version, and same company of HA in bimodal Cis.

All children undergoing basic audiological evaluation: Clinical otoscopic examination, tuning fork test, Tympanometer (by interacoustic A222 MODEL) 226Hz probe, F-F audiogram (by 2 channel- intercounty A222 MODEL). Participant was assessed using pitch pattern test and duration pattern test sound delivered by sound speakers (by interacoustic A222 MODEL) at 0^{o} azimuth degree.

Pitch Pattern Sequence Test (PPST)

PPST for children was developed by Pinheiro [12], and standardized on Egyptian children by Soliman et al [13]. This test is composed of a sequence of three tones either high (1122Hz) or low (880Hz) in frequency. There are six possible randomized patterns (HHL, LLH, HLH, LHL, LHH, HLL), with none of the patterns ever consisting of the same frequency appearing in triplicate (i.e., HHH or LLL). Each tone is 150 msec in duration with a 10 msec rise-fall time and inter-tone interval of 200 msec. PPST was done by presenting 20 patterns to each ear at 50 dB SL.

Scoring

Scoring was calculated in percentage correct which is equal to the number of correct patterns multiplied by five for each ear.

Duration pattern sequence (DPST)

DPST for children also was developed by Pinheiro [12], and standardized on Egyptian children by Soliman et al [13]. It is composed of three tones per pattern each tone 1000Hz; either short (250msec) or long (500msec). In duration with 300msec inter-tone interval. There are six possible randomized patterns that occurred (LLS, LSL, LSS, SLS, SLL, SSL). This pattern test utilizes 6- sec inter-pattern interval, duration pattern test is administered by presenting 20 patterns to each ear at 50 dBSL [12]. Score was calculated in percentage correct which is equal to the number of correct pattern multiplied by five for each ear.

Statistical methods

Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version 21. Numerical data were summarized using means and standard deviations. Data were explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. Categorical data were summarized as percentages. Comparisons between the 2 groups were done using the independent t-test. For categorical variables, differences were analyzed with c^2 (chi square) tests. All p-values are two-sided. P-values ≤ 0.05 were considered significant.

RESULTS

The current study was conducted on a total number of 23 participants, 12 females (52.1%) and 11males (47.8%). Their age ranged from 6 to 10 years. They were divided into two groups (unilateral CI and Bimodal CI).
As in (tables 1,2) there were no statistically significant differences between the subgroups as regards to their age and gender

Table 1. Age distribution in unilateral and bimodal cochlear implant

Groups	Age (in years)		P -value
	Range	mean± SD	
Unilateral	6 -10	8.7 ±1.4	0.964
Bimodal	6 -10	8.7 ±1.4	

Table 2. Gender distribution in unilateral and Bimodal CI groups

Gender		Groups		
		Unilateral	Bimodal	Total
Male	**N**	6	5	11
	%	54.5	45.4	47.8
Female	**N**	6	6	12
	%	50.0	50.0	52.1
Total	**N**	12	11	23
	%	100	100.00	100
P- value		1.00		

Statistical analysis based on temporal processing ordering tests scores showed statistical significance with mean PPT score of 74.7 for bimodal CIs, 63.4 for unilateral CIs ($p < 0.001$). Mean DPT score were also statistical significance with 72.3 for bimodal CIs,61.2 for unilateral CIs ($p < 0.001$).

Table 3. Pitch pattern test and duration pattern test in both unilateral and bimodal CIs users

Test	Bimodal CI		Unilateral		
	Mean	SD	Mean	SD	P- value
PPT	74.7	4.5	63.4	4.4	<0.001*
DPT	72.3	4.8	61.2	6	<0.001*

PPT: pitch pattern test. DPT: duration pattern test

DISCUSSION

The present study aimed to assess central auditory processing abilities in patients with unilateral and bimodal CI, and reveled that there is no statistical significance difference among the unilateral and bimodal CI user groups in term of age or gender. Pitch pattern sequences test (PPT) and duration pattern sequences test (DPST) are temporal ordering tests with more sensitivity of PPT to cerebral and cortical lesions more than DPT [7]. Pattern Tests assess frequency pattern recognition and temporal ordering task of different stimuli, and involves both hemispheres, a skill that is performed at the cortical level by the brain hemispheres with participation of the corpus callosum (CC) to transfer information between the two hemispheres [14] In our study, there were high statistically significant differences between the two CI user groups in pitch pattern test and duration pattern test with superiority of pitch pattern test in score, as shown in table (3). We can explain that by acoustic stimulation on non-implanted ear can improved temporal ordering abilities, that not provided completely by cochlear implant alone. Our study results are consistence with a previous study compared unilateral and bimodal CI users in pitch ranking and speech recognition [15]. Another study compared unilateral and bimodal cochlear implant user in song recognition abilities [16], and they observed there is statistical significance difference between two groups cause of effect of bilateral cochlear stimulation improvement of temporal processing abilities in bimodal cochlear implant users. Also, in

another study [17] compared prelingual bimodal and unilateral cochlear implant user and the result prefer bimodal user in speech in quit and noise environment also explained the cause of superiority of bimodal user due to acoustic stimulation in non-implanted ear. From this study, it is eminent that effect of acoustic stimulation is important to increase of sound melody in post cochlear implant rehabilitation period and follow up.

Limitation and need of further research

The small sample size for bimodal and unilateral listener was an important limitation of present study because limit of bimodal technique introduced in cochlear implant procedure in Libya, our cases considered as only bimodal technique user in present time. Limitation of unilateral cases due to stoppage of public cochlear implant implantation program in Libya since 2020, our study recommends another study on larger samples size must be recommended after establishment of cochlear implantation again in future.

CONCLUSION

Our finding show that bimodal use of Cochlear implant should be recommended for those presently using unilateral device, moreover temporal processing test should be used regularly for evaluation of CI users, but Further studies on the auditory central processing tests in CIs children by other behavioral and electrophysiological tests on a larger sample size are recommended

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

REFERENCES

1. Dazert S, Thomas JP, Loth A, Zahnert T, Stöver T. Cochlear Implantation. Dtsch Arztebl Int. 2020 Oct 9;117(41):690-700. doi: 10.3238/arztebl.2020.0690.
2. Kleijbergen WJ, Sparreboom M, Mylanus EAM, de Koning G, Helleman HW, Boermans PPBM, Frijns JHM, Vroegop JL, van der Schroeff MP, Gelders EEJ, George ELJ, Lammers MJW, Grolman W, Stegeman I, Smit AL. Benefit of sequential bilateral cochlear implantation in children between 5 to 18 years old: A prospective cohort study. PLoS One. 2022 Jul 28;17(7):e0271497. doi: 10.1371/journal.pone.0271497.
3. Leigh JR, Dettman SJ, Dowell RC. Evidence-based guidelines for recommending cochlear implantation for young children: Audiological criteria and optimizing age at implantation. Int J Audiol. 2016;55 Suppl 2:S9-S18. doi: 10.3109/14992027.2016.1157268.
4. Swami H, Ap A, Shivanand S. Cost-effectiveness of Pediatric Unilateral/Bilateral Cochlear Implant in a Developing Country. Otol Neurotol. 2021 Jan;42(1):e33-e39. doi: 10.1097/MAO.0000000000002862.
5. Theriou C, Fielden CA, Kitterick PT. The Cost-Effectiveness of Bimodal Stimulation Compared to Unilateral and Bilateral Cochlear Implant Use in Adults with Bilateral Severe to Profound Deafness. Ear Hear. 2019 Nov/Dec;40(6):1425-1436. doi: 10.1097/AUD.0000000000000727.
6. Bellis TJ, Bellis JD. Central auditory processing disorders in children and adults. Handb Clin Neurol. 2015;129:537-56. doi: 10.1016/B978-0-444-62630-1.00030-5.
7. Qin MK, Oxenham AJ. Effects of simulated cochlear-implant processing on speech reception in fluctuating maskers. J Acoust Soc Am. 2003 Jul;114(1):446-54. doi: 10.1121/1.1579009.
8. Schow RL, Seikel JA, Chermak GD, Berent M. Central auditory processes and test measures: ASHA 1996 revisited. Am J Audiol. 2000 Dec;9(2):63-8. doi: 10.1044/1059-0889(2000/013).
9. Wolfe J, Morais M, Schafer E. Speech Recognition of Bimodal Cochlear Implant Recipients Using a Wireless Audio Streaming Accessory for the Telephone. Otol Neurotol. 2016 Feb;37(2):e20-5. doi: 10.1097/MAO.0000000000000903.
10. Irwin RJ, Ball AK, Kay N, Stillman JA, Rosser J. The development of auditory temporal acuity in children. Child Dev. 1985 Jun;56(3):614-20.
11. Crew JD, Galvin JJ 3rd, Fu QJ. Perception of Sung Speech in Bimodal Cochlear Implant Users. Trends Hear. 2016 Nov 11;20:2331216516669329. doi: 10.1177/2331216516669329.
12. Musiek FE, Baran JA, Pinheiro ML. Duration pattern recognition in normal subjects and patients with cerebral and cochlear lesions. Audiology. 1990;29(6):304-13. doi: 10.3109/00206099009072861.
13. Soliman S, Tawfik S, Shalaby A. Development and standardaztion of Arabic central test battery for children. In: folia phoniatrica et logopaedia. 1995;47(2):106-107.
14. Musiek FE, Pinheiro ML. Frequency patterns in cochlear, brainstem, and cerebral lesions. Audiology. 1987;26(2):79-88.
15. Bartov T, Most T. Song recognition by young children with cochlear implants: comparison between unilateral, bilateral, and bimodal users. J Speech Lang Hear Res. 2014 Oct;57(5):1929-41. doi: 10.1044/2014_JSLHR-H-13-0190.

16. Looi V, Radford CJ. A comparison of the speech recognition and pitch ranking abilities of children using a unilateral cochlear implant, bimodal stimulation or bilateral hearing aids. Int J Pediatr Otorhinolaryngol. 2011 Apr;75(4):472-82. doi: 10.1016/j.ijporl.2010.12.023.
17. Fam M, Eloseily A, Mohamed E. Advantages of bimodal stimulation compared to unilateral cochlear implant use in children with hearing loss. J Curr Med Res Prac. 2023;8(3):123-127.

اختبارات المعالجة الزمنية السمعية في زراعة القوقعة الصناعية الأحادية والثنائية في الفئات العمرية للأطفال

نجاة بلقاسم

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المستخلص

الخلفية والأهداف. تعتبر عمليات زراعة القوقعة الصناعية الثنائية (CIs) الرعاية القياسية للأطفال الذين يعانون من فقدان السمع الحسي العصبي الشديد إلى العميق. ومع ذلك، فإن إمكانية الحصول على CIs ثنائية لكل مرشح ليست متاحة دائمًا. من أجل تحسين توطين الكلام والإدراك وتطور اللغة، تعد فترة مبكرة من تحفيز السمع الثنائي أمرًا مهمًا للمرونة العصبية للجهاز السمعي المركزي. لذا، فإن التحفيز الصوتي المستمر للأذن غير المزروعة باستخدام أداة السمع (CIs ثنائية النسق) مفيد في CIs أحادية الجانب لتحسين النتائج. أجريت هذه الدراسة لمقارنة اختبار المعالجة الزمنية السمعية في مجموعات زراعة القوقعة الصناعية: CIs أحادية الجانب وCIs ثنائية الوضع. **طُرق الدراسة**. تم تضمين ما مجموعه 23 مستخدمًا لزراعة القوقعة الصناعية، 14 من مستخدمي زراعة القوقعة الصناعية من جانب واحد، و9 من مستخدمي زراعة القوقعة الصناعية في هذه الدراسة، وتراوحت أعمارهم بين 6 إلى 13 عامًا. تم تقييم المشاركين باستخدام اختبار نمط الملعب واختبار نمط المدة. **النتائج**. تعد قدرة المعالجة الزمنية بين مستخدمي CIs ثنائية النسق أفضل بكثير من المرشحين الذين لديهم CIs من جانب واحد. **الخاتمة**. تظهر النتائج التي توصلنا إليها أنه يجب التوصية باستخدام زراعة القوقعة الصناعية ثنائية الوضع لأولئك الذين يستخدمون حاليًا جهازًا أحاديًا، علاوة على ذلك، يجب استخدام اختبار المعالجة الزمنية بانتظام لتقييم مرضى CI.

الكلمات الدالة. اختبار نمط الملعب، اختبار نمط المدة. زراعة القوقعة الصناعية ثنائية الوضع.