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Research Article

A Comparative Study of Receptive Language Between Patients with Unilateral Cochlear Implants and Patients with Bilateral Cochlear Implants in Arabic Speaking Children

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Abstract

This research investigates receptive language development in Arabic-speaking children with cochlear implants, comparing those with unilateral and bilateral implants. The study includes 50 participants aged 5-7, utilizing the JISH School Readiness Test for data collection. Statistical analysis using SPSS and Excel reveals significant differences in mean scores between the two groups in pre-test and post-test assessments after one month of treatment. The results indicate that Arabic-speaking children with bilateral cochlear implants develop receptive language more rapidly than those with unilateral implants. The study underscores the importance of bilateral implantation, early intervention, and parental involvement in supporting language development in children with hearing loss. Future research recommendations include focusing on larger sample sizes, standardized tests, longitudinal studies, exploration of additional influencing factors, and comparative studies across diverse populations.

Keywords: *Cochlear Implant (CI); Hearing Loss (HL); Evidence-Based Practice (EBP); Receptive Language*

Introduction

ASHA [1] defines cochlear implants (CI) as electronic prosthetic devices directly providing electrical signals to the auditory nerve fibers. They avoid damage to the internal ear hair cells to send messages to the brain, where they are translated into sound. Cochlear implants can be implanted in one or both ears, referred to as bilateral and unilateral cochlear implants. Hearing loss in both ears is referred to as bilateral hearing loss. Whereas unilateral hearing loss refers to hearing loss in only one ear. Wolfe and Schafer [2] defined cochlear implants as "Replacing inner hair cells, which act as biological microphones. They imitate the technical aspects of the normal hearing process by tonotopically presenting the basilar membrane on different hearing nerve segments" (p.74).

A collaborative interdisciplinary panel evaluates and endorses cochlear implants, such as the patient and their family, audiologists, speech therapists, surgeons, pediatric specialists, mental health professionals, occupational therapists, educators, vocational counselors, and neurologists [3].

An audiogram is a graphical representation delineating the nature and extent of a child's hearing impairment, where low-frequency sounds manifest audibly at standard volumes. At the same time, louder noises are perceived as high-pitched. Notably, the auditory perception of both low and high frequencies follows a consistent pattern [3].

Boons [4] examined spoken language outcomes in children undergoing bilateral cochlear implantation compared to matched peers undergoing unilateral implantation. Her study involved Twenty-five children with unilateral cochlear implants matched with Twenty-five children with bilateral cochlear implants selected from a retrospective sample of 288 children who underwent cochlear implantation before five years of age. Based on the study results, Children with bilateral implantation outperformed those who received unilateral implantation on the receptive and expressive language tests Reynell Developmental Language Scales [5] and The Schlichting Expressive Language Test [6]. The Reynell Developmental Language Scales (RDLS) assessed the receptive language outcome. The age range for this standardized language evaluation instrument is 1.02 to 6.03 years old. The exam assesses language comprehension skills at progressively harder difficulty levels. The child's vocabulary is initially evaluated by asking them to name things or pictures (e.g. "Where is the ball?"). Afterward, the objects have brief phrases that require the youngster to complete them, like "Put the spoon in the cup".

Also, The Schlichting Expressive Language Test (SELT) was used; the range for this standardized test is 1.09 to 6.03 years. The Sentence Development and Word Development SELT subtests were given out. The Word Development Subtest assessed the children's expressive vocabulary by asking them to name pictures or objects. The Sentence Development Subtest asks the child to repeat specific sentences to determine their understanding of grammatical patterns.

The two groups were carefully matched based on ten auditory tests, child, and environmental characteristics; therefore, the bilateral implantation may have been primarily a sign of the performance difference. Children with two simultaneous cochlear implantations performed better on the receptive and expressive language tests Reynell Developmental Language Scales [5] and The Schlichting Expressive Language Test [6] than those with two sequential cochlear implantations. The authors reported the small sample size and the lack of a control group to be two drawbacks of the study.

Sarant., *et al*. [7] reported that many children with severe to profound hearing loss benefit from bilateral cochlear implants (CIs) for better speech perception and localization. However, the investigators noted that it has yet to be proven that perceptual skills enable noticeably more significant language development. Sarant., *et al*. [7] objectives were to contrast quantifying children's linguistic skills with unilateral and bilateral CIs. Also, to investigate the rate of any linguistic progress brought on by bilateral CIs and enumerating additional language development indicators in children with CIs. To achieve that end, the study design included the Peabody Picture Vocabulary Test-fourth edition (PPVT-4) [8], the Preschool Language Scales-4 (PLS-4) [9] and the Clinical Evaluation of Language Fundamentals (fourth edition) was used to measure the receptive vocabulary and language development of 91 children when they were either 5 or 8 years old.

Cognitive ability, family reading habits, and parental involvement in children's intervention or education programs were also assessed. Analyses using linear regression were used to investigate language outcomes. As a result of predictors, the role of parenting style components, child traits, and family background was investigated. The study concluded that bilateral CI use predicted vocabulary and language development at considerably quicker rates than unilateral CI use. Additionally, parental solid participation, little screen time, and more excellent adult reading time to children resulted in noticeably higher vocabulary and language results. Lastly, the study found that parenting, kid traits, and family history strongly influenced language development outcomes [7].

One of the limitations of the study by Sarant [7] is that the study might only apply to some populations of kids with CIs. In other words, the research cohort was drawn from a region in Australia with a high population density, and the pace of recruitment was equivalent to that of epidemiological studies.

According to McSweeny [10], poor binaural hearing in children was hypothesized to contribute to related cognitive and academic deficits. Binaural hearing means that children with unilateral hearing have normal hearing in one ear but no access to binaural (both ears) cues. Those children may have unique cognitive and academic deficits that vastly differ from children receiving bilateral cochlear implants (CIs) at young ages. Children with no binaural hearing may have poor access to spectral cues and impaired binaural sensitivity. Both study groups were at risk for vestibular/balance deficits, which could have contributed to memory and learning challenges. As such, McSweeny [10] conducted a series of tests completed by 88 children divided into three groups: those with typical academic, sensory, and cognitive development, those with bilateral CI, and those with unilateral hearing loss. The study analyses revealed that children in both hearing loss groups had significantly poorer skills on most tests than their typical hearing peers. Although language and balance deficits were comparable in the two hearing loss groups, children with unilateral hearing loss had more asymmetrical speech perception than children with bilateral CIs. Both hearing loss groups experienced deficits in visual-spatial memory, but children with unilateral hearing loss performed better across tests. Self-reported hearing, balance and vestibule function, and speech perception deficits were all found to be grouped in the remaining components. The findings showed that poor binaural hearing significantly negatively impacts children's development [10]. Despite being one of the most frequent causes of delayed language development in children, CI has received little attention in the Arab population, and clinicians and researchers who work with this population encounter numerous difficulties. One is the lack of standardized tests and official tools for identifying children with unilateral and bilateral cochlear implants in Arab children for receptive and expressive language. This is the first obstacle any researcher studying this population must overcome.

Consequently, this current research aims to compare unilateral and bilateral cochlear implantation effects on the receptive language development of children with cochlear implants.

Research Question

Do Arabic-speaking children with unilateral cochlear implants develop receptive language at the same pace as children with bilateral cochlear implants?

Methodology

This study is a quantitative, descriptive, between-subject design. The study included 50 participants (25 bilateral cochlear implants and 25 unilateral cochlear implants) with an average age of 5 - 7 years. The participants were children with cochlear implants in government and private hospitals in the Kingdom of Saudi Arabia. The participants were divided into two groups: those with bilateral and those with unilateral cochlear implants. Both groups were assessed for one month before and after the receptive language treatment program. A verbal sample compared the results of the two samples, and the linguistic metaphors were evaluated. A metaphor is a semantic change based on a similarity in form or function between the original concept and the target concept named by a word. Participants had to be native speakers of Arabic to be included. Also, the children were excluded from the study sample if they were not native Arabic speakers, were wearing hearing aids, had a cognitive impairment, or had any medical diagnosis that affected their communication skills other than a cochlear implant.

Participants were required to sign an informed consent form that described the benefits, potential risks, confidentiality, and privacy. They were allowed to choose if they would participate in the study. Only the primary investigator had access to the collected data. Also, the study was approved by the research committee at Dar Al-Hekma University.

JISH School Readiness Test [11] was used to collect the data. The test is designed to evaluate a child's initial level of readiness for school within the age range of five to six years and eleven months. JISH School Readiness Test consists of 11 subtests: answering questions, recognizing vocabulary, following verbal instructions, naming/narration, questions for comprehension, repetition of sentences, pronunciation, recitation skills, fluency skills, voice and intonation skills.

The treatment program of the research study involved individual treatment for both unilateral and bilateral cochlear implant patients. The same program was provided for the two groups. The entire study sample received this treatment program for a month, with two weekly sessions, each lasting 60 minutes. The treatment sessions focused on the development of receptive language skills. Specific skills targeted in the treatment sessions included vocabulary development, remembering story details, and answering questions related to the story. The treatment aimed to enhance the participants' receptive language abilities, allowing them to understand and comprehend spoken language more effectively. For example, during the sessions, participants were engaged in activities that involved naming objects or pictures, following multi-verbal instructions, answering questions, and narrating stories. These activities aimed to improve their vocabulary, comprehension, and memory skills. The treatment program emphasized the importance of receptive language skills in children with cochlear implants. By providing individualized therapy sessions, the researchers aimed to support the participants' language development and enhance their overall communication abilities.

The research study treatment is designed to target the needs of these patients specifically. The treatment program aims to enhance receptive language skills in children with cochlear implants, and it includes the following components:

1. Vocabulary development: Emphasize building a solid vocabulary by introducing new words and concepts through various activities. This included labeling objects, categorizing words, and using visual aids to support understanding.
2. Comprehension of the storytelling: Engage children in storytelling activities to improve their comprehension skills. This involved reading age-appropriate stories and asking questions about the stories.
3. Following instructions: Help children develop their ability to understand and follow multi-verbal instructions. This can be done through activities that involve listening to instructions and carrying out specific tasks.
4. Answering questions: Practice answering questions related to different topics and contexts. This included simple and complex questions to challenge and expand their language skills.
5. Parental involvement: Involve parents in the treatment program to ensure consistency and carryover of skills at home. Provide parents with strategies and resources to support their child's language development.

Confounding factors of the treatment and research requirement included continuity, follow-up of aural rehabilitation sessions, irregular cochlear implant wear, delays in cochlear implantation, and follow-up of periodic programming schedules. To close the gap between the chronological, auditory, and linguistic ages, emphasis was placed on participating in the aural rehabilitation sessions, adhering to the programming deadlines during this time, and continuing after the study's conclusion. Because those children were more susceptible to language delay, there was an incentive to sign the approval and study. They provided incentives such as free aural rehabilitation sessions, family support, reinforcement and communication, progress monitoring, and free evaluation pre-post treatment.

Statistical Analysis and Results

Data was collected and analyzed through the Statistical Package for the Social Sciences using (SPSS) version 28 (IBM Co., Armonk, NY, USA). And Excel Microsoft Office 365 (Microsoft, USA). Charts were developed to compare and summarize the results between unilateral and bilateral CIs. The result of the JISH School Readiness Test pre-post aural rehab treatment was concluded. Comparison between the results was subjected to the paired sample t-test.

To conclude, the current study examined the different impacts of unilateral and bilateral cochlear implants on receptive language. To answer the main question, "Do Arabic-speaking children with unilateral cochlear implants develop receptive language at the same pace as children with bilateral cochlear implants?" the study used descriptive statistics and compared means (independent sample t-test) as follows:

First, the descriptive statistics of the study variables included (Mean, Median, Mode, Std. Deviation, Range, Minimum, Maximum) (See table 1 and 2).

	Unilateral CI		Bilateral CI	
Statistics	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Mean	33.5200	52.3200	104.4000	116.2000
Median	27.5000	58.0000	110.0000	122.5000
Mode	20.00a	34.00a	93.00	126.00
Std. Deviation	21.41451	22.00412	16.71368	15.30506
Range	67.00	69.00	66.00	53.00
Minimum	.00	10.00	60.00	76.00
Maximum	67.00	79.00	126.00	129.00

Table 1: *Descriptive statistics (Mean, median, mode, std. deviation, range, minimum, maximum).*

Pre-test	Mean ± Std. Deviation	95% Confidence Interval of the Difference		t	p-value
		Lower	Upper		
Bilateral CI	104.4 ± 16.7	63.26	78.50	18.450	.000
Unilateral CI	33.5 ± 21.4				

Table 2: *Independent sample t-test between (Bilateral CI and unilateral CI) in the pre-test.*

The table shows an independent sample t-test to find differences between (Bilateral CI and unilateral CI), based on p-value (.000 < 0.05). This indicates statistical differences between the two groups (Bilateral CI, Unilateral CI). These statistical differences mainly were in favor of the group (Bilateral CI), based on the value of the mean (104.4), which was higher than the other group (Unilateral CI = 33.5). The figure below shows these means:

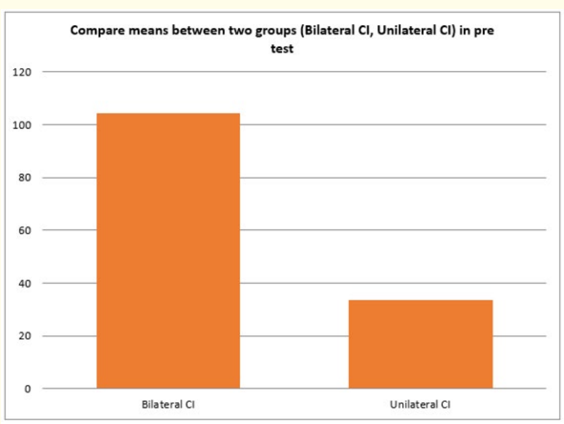

Figure 1

The table also shows that the patients' average scores on the pre-test ranged from 63.3 at the lower limit to 78.5 at the upper limit.

Finally, in the pre-test, the (Bilateral CI) group was generally more effective than the (Unilateral CI) group and achieved the desired benefits.

Post-test	Mean ± Std. Deviation	95% Confidence Interval of the Difference		t	p-value
		Lower	Upper		
Bilateral CI	116.2 ± 15.3	56.36	71.40	16.852	.000
Unilateral CI	52.32 ± 22.0				

Table 3: *Independent sample t-test between (Bilateral CI, Unilateral CI) in post-test.*

The table shows an independent sample t-test to find differences between (Bilateral CI and unilateral CI), based on p-value (.000 < 0.05). This indicates statistical differences between the two groups (Bilateral CI, Unilateral CI) in the post-test. These statistical differences mainly were in favor of the group (Bilateral CI), based on the value of the mean, which was (116.2), which was higher than the other group (Unilateral CI = 52.33). The figure below shows these means:

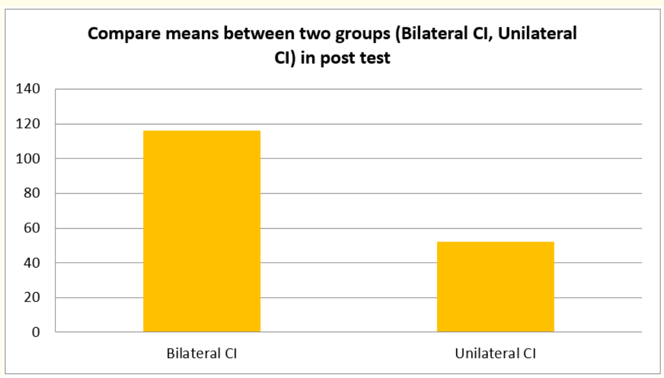

Figure 2

The table also shows that the patients' average scores on the post-test ranged from 56.36 at the lower limit to 71.40 at the upper limit.

Finally, in the post-test, the (Bilateral CI) group was generally more effective than the (Unilateral CI) group and achieved the desired benefits.

In general, the current study found an improvement in the patients' scores between the pre-test and the post-test, as evidenced by the mean values of the two groups (Bilateral CI) and (Unilateral CI). The advantage was better in the first group (Bilateral CI). All of this was evident in the post-test, where the means increased significantly from the values in the pre-test. The figure below illustrates these increases:

In summary, the descriptive statistics and independent sample t-test results indicated that the bilateral cochlear implant group had higher mean scores in both the pre-test and post-test, suggesting better receptive language development than the unilateral cochlear implant group. The study concluded that Arabic-speaking children with bilateral cochlear implants develop receptive language better than those with unilateral implants.

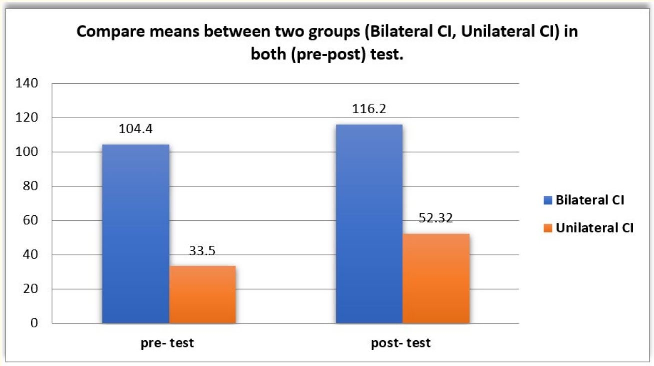

Figure 3

Discussion

The research study compared receptive language development in Arabic-speaking children with unilateral and bilateral cochlear implants. Previous studies have shown that children with bilateral implants have better language outcomes. The current study used the JISH School Readiness Test to assess the participants before and after treatment. The descriptive statistics and independent sample t-tests indicated that the bilateral cochlear implant group had higher mean scores in both the pre-test and post-test, suggesting better receptive language development than the unilateral cochlear implant group.

These findings are consistent with Boons's [4] and Sarant., *et al*. [7] research, which also reported better language outcomes in children with bilateral cochlear implants. Boons [4] found that children with bilateral implants outperformed those with unilateral implants on receptive and expressive language tests. Sarant., *et al*. [7] concluded that children with bilateral implants showed faster vocabulary and language development than those with unilateral implants.

The current study suggests that the benefits of bilateral cochlear implants may be attributed to improved access to binaural cues and enhanced speech perception. It also emphasizes the importance of parental involvement, reduced screen time, and increased adult reading time in promoting vocabulary and language development in children with cochlear implants.

The study's limitations included the small sample size. Additionally, they are investigating the long-term effects of the treatment to provide more comprehensive and valuable results and an understanding of their sustainability and continued benefits. Further research is recommended to validate these findings and explore other factors that may influence language development in this population.

Finally, the current study proves that Arabic-speaking children with bilateral cochlear implants develop receptive language better than those with unilateral implants. These findings have implications for clinical practice and highlight the importance of considering bilateral implantation for children with hearing loss [12].

Conclusion

In conclusion, the research study compared receptive language development in Arabic-speaking children with unilateral and bilateral cochlear implants. The findings of the study, supported by previous research, indicate that children with bilateral cochlear implants tend to have better language outcomes than those with unilateral implants. The descriptive statistics and independent sample t-tests showed that the bilateral cochlear implant group had higher mean scores in both the pre-test and post-test, suggesting better receptive language development. The study highlights the importance of considering bilateral implantation for children with hearing loss, as it can lead to improved access to binaural cues and enhanced speech perception. Parental involvement reduced screen time, and increased adult reading time were crucial factors in promoting vocabulary and language development in children with cochlear implants. However, it is essential to acknowledge the study's limitations, such as the small sample size and the lack of standardized tests for Arabic-speaking children with cochlear implants.

Further research is recommended to validate these findings and explore other factors that may influence language development in this population. The implications of this research are significant for clinical practice, as it emphasizes the benefits of bilateral cochlear implants and the importance of early intervention and parental involvement in promoting language development in children with hearing loss. The findings also highlight the need for standardized tests and improved access to cochlear implantation services for Arabic-speaking children. Overall, this research contributes to the understanding of receptive language development in Arabic-speaking children with cochlear implants and provides valuable insights for clinicians, researchers, and parents in supporting the language development of children with hearing loss.

Future Research

Future research on cochlear implants and receptive language development in Arabic-speaking children can focus on several areas to enhance our understanding and improve clinical practice.

1. Larger sample size: One limitation of the current study is the small sample size. Future research should include a more extensive and diverse sample of Arabic-speaking children with cochlear implants. This would provide more robust and generalizable findings.
2. Longitudinal studies: The current study assessed receptive language development before and after treatment. However, conducting longitudinal studies that follow children with cochlear implants over an extended period would provide valuable insights into the long-term effects of bilateral and unilateral cochlear implants on language development.
3. Factors influencing language development: Future research should explore additional factors that may influence language development in Arabic-speaking children with cochlear implants. Factors such as gender, follow-up quality in hospitals, age at implantation, and language skills can be considered in interpreting the results. Understanding these factors can help tailor interventions and support strategies for optimal language outcomes.
4. Comparative studies: Comparative studies between different populations and cultural contexts can provide a broader perspective on the impact of cochlear implants on receptive language development. Comparing outcomes between Arabic-speaking children and children from other linguistic backgrounds can help identify potential cultural and linguistic factors that may influence language development.
5. Intervention strategies: Further research can focus on evaluating the effectiveness of different intervention strategies in promoting receptive language development in children with cochlear implants. This can include exploring the impact of specific therapy techniques, parental involvement, and educational programs on language outcomes. Future research in the field of cochlear implants and receptive language development in Arabic-speaking children should aim to address the limitations of the current study, expand the sample size, develop standardized tests, conduct longitudinal studies, explore additional influencing factors, compare outcomes across populations, and evaluate intervention strategies. By advancing our knowledge in these areas, we can improve clinical practice and enhance the language development outcomes for children with cochlear implants.

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