Review Article

Comparative Study of Speech and Language Development in Children with Normal Hearing and Cochlear Implant in Iran

Hamed Ahmadi, Hamed Mahmoudian Sani[1], Gholamreza Farnoosh[2], Mohammad Reza Mahmoudian Sani[3]

Department of Psychology and Educational Sciences, School of Psychology, Allame Tabatabaei University, Tehran, [1]Department of Educational Sciences - Exceptional Children Education, Farhangian University (Pardis, Shahid Bahonar), Isfahan, [2]Applied Biotechnology Research Center, Baqiyatallah University of Medical Sciences, Tehran, [3]Department of Genetics and Molecular Medicine, Hamadan University of Medical Sciences, Hamadan, Iran

Abstract

Today, cochlear implant provides an appropriate opportunity for the development of speech and language in children. In some studies, the age of children at the time of surgery has been stated as the most important factor in the development of speech and language of children after cochlear implant, while in other studies factors, including participation in rehabilitation programs, parental educational level, and lack of other disability have been regarded as key factors in the development of speech and language in these children. This review aims to assess the conducted studies in Iran to identify factors contributing to improving the auditory perception, language, and other skills in children with cochlear implants in comparison to children with normal hearing. The purpose of this study is to review the results of studies conducted on speech and language abilities in children with cochlear implant compared to the normal group in Iran. Directory of Open Access Journals, Google Scholar, PubMed (NLM), LISTA (EBSCO), and Web of Science have been searched. cochlear implants in deaf children before language learning results in the acquisition of speech and language skills in children. Timely detection of hearing impairment, early implantation, duration of hearing, and parental involvement in the rehabilitation process are important factors that affect the development of speech and language. The child's age at the time of implantation, continued participation in rehabilitation programs and the lack of associated problems directly impact the development of auditory perception, speech and language of children with cochlear implant while family education level indirectly impacts this developmental process.

Keywords: Cochlear implant, deafness, Iran

Introduction

Currently, due to genetic testing, prenatal care, premarriage counseling, and decreased consanguineous marriages, the incidence of profound hearing loss has been considerably reduced. However, due to the industrialization and its subsequent noise pollution as well as the use of noisy toys, the incidence of mild-to-moderate deafness has increased and has become more common. Hearing is one of the most important human senses, without which many of human adaptations to the environment is disrupted, and the development of mental processes is often delayed. Hearing impairment can profoundly affect some aspect of a person's behavior and on other aspects; its effect is little or basically none.[1] The main problem of deaf children is not merely their hearing loss, but the main problem is the lack of access to a suitable communication system. When deaf students are compared with their hearing peers, they demonstrate difficulties in abstract thinking, reading, writing, communication, and memory. Hearing and deaf people receive and process auditory information differently, so comparison of these two groups should be done with caution.[2] One of the most advanced achievements of modern technology for giving normal life to those who are not benefited by hearing aids is cochlear implantation (CI). This prosthesis converts sound stimuli into electrical signals and through electrodes implanted in the cochlea; these signals are used to directly stimulate nerve endings of ninth pair.[3] CI is a new technology

Address for correspondence: Dr. Mohammad Reza Mahmoudian Sani, Hamadan University of Medical Sciences and Health Services, Khajeh Rashid Crossroads - Ayatollah Kashani Blvd, Hamadan, Iran.
E-mail: mahmoudiansani96@gmail.com

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in hearing aids and an accepted treatment method for children with severe to profound sensorineural deafness.[4] In addition, cochlear implant is the main method of treatment for these individuals.[4,5] The cochlear is surgically implanted into the inner ear and stimulates the fibers of the auditory nerve for creating sense of hearing in people with severe and profound sensorineural hearing loss (SNHL).[5] The surgically implanted cochlear bypasses the damaged hair cells, and the auditory nerve is stimulated directly.[4] Currently, there is a high demand for this surgery, especially for children because the early stages of life are critical periods for (language) learning.[6] Cochlear implant makes the sense of hearing sounds possible for a person with deafness or hard of hearing. The purpose of cochlear implants is to help the development of speech in deaf people. Several studies have shown that many of deaf children, after cochlear transplantation can acquire speech and language skills.[7,8] The early implantation can facilitate speech and language acquisition at different level and proportional to the age of patient.[9] Age is one of the most important factors determining the success of CI in children who were deaf before the age of spoken language development. In the past, most children used to undergo cochlear transplantation at the age of 2 years or later.[10] Evidence shows that children who underwent implantation between the age of 2 and 5 years have a better understanding ability than children who underwent implantation after 5 years of age.[11,12] The studies have demonstrated that the development of language skills in children with early cochlear implant is faster than children without implants and its level resembles language skills of children with normal hearing.[13] Age of CI can determine the development and evolution of speech and language in the future. Auditory stimulation can lead to better auditory perception and the use of spoken language, therefore, CI in the early ages in children with hearing impairment gives them the opportunity of exposure to auditory stimulations. In the first 2 years of life, CI results in a growing increase in auditory perception skills.[14] Comparison of speech and language development in profound hearing loss and deaf children who underwent CI with children who use hearing aids indicates the success of implantation method in rehabilitation of children's hearing. Hearing age of deaf children before language learning begins when such children are equipped with hearing aids such as cochlear implant. Therefore, it can be expected that children's verbal language to evolve similar to normal hearing children in different areas such as vocabulary, syntax, morphology, pragmatics, voice production, and phonology.

Cochlear Implantation in the World and Iran

The first hearing cochlear prosthesis was implanted in 1961, and then, the first commercial single channel auditory prosthesis in 1972 received the production license from the Food and Drug Administration in the United States. This prosthesis has been implanted in thousands of patients. Later in 1985, multichannel prosthesis became commercially available. In Iran, the use of this prosthesis was started in 1991.[15] In Iran, the first cochlear implant surgery was performed in 1991 in Tehran. Later, two centers in Mashhad and Shiraz were established with the support of CI Center in February 2003. So far, over 1000 cases of surgery and rehabilitation have been carried out in these centers. Currently, these centers have been expanded, and new centers have established in other cities such as Isfahan, Tabriz, Kerman, and Ahvaz.[16] CI is currently subsidized by the government and hence is only performed for profound hearing loss. Iran is a leading country in the region and the number of implants that have been carried out in Iran is comparable with developed countries. In addition, cochlear implants in Iran are mostly recommended for profound hearing loss, especially for babies who were born with hearing loss. In some cases, adult can also benefit from government subsidy; however, priority is given to children under 2 years of age who suffer from profound hearing loss since birth.

Results

Skills listed in Table 1 were investigated in children with cochlear implants and compared to children with normal hearing. A number of skills such as basic theory of mind (ToM), language development, speech intelligibility in farsi speaking, phonological awareness, speech intelligibility, auditory perception, intonation production, and perception of intonation was lower than normal peers, and some of them such as lexical diversity and syntactic complexity, nonverbal skills, speech, auditory skills, ToM, and executive functions, Improvement of hearing performance, comprehension and expression of passive verbs, auditory language and speech skills, phonological awareness, and reading skills was similar to normal peers [Table 1]. ToM: According to the results of ToM, children with cochlear implant compared to normal children had poorer performance in the assessment of ToM. There was no difference between girls and boys in ToM test. There was no relationship between age of CI and the ToM ability.[17] Lexical diversity and syntactic complexity in speech of children who had cochlear implant for 60–72 months was similar to normal children aged 36–72 months. The duration of cochlear implant is an important factor in the acquisition of speech and language skills in children with cochlear implants.[18] Language development in children with cochlear implant in many parts of language development is similar to their peers; however, these children in some aspects of language development demonstrate delay compared to their peers. Therefore, it is essential that training and rehabilitation centers for children with cochlear implant to provide language and speech educational programs for these children.[19] Nonverbal skills: there was a significant difference between nonverbal skills of children using cochlear implants and hearing aids with normal children. Cochlear implants surgery or the use of hearing aids alongside Auditory-Verbal rehabilitation can lead to the development of nonverbal communication skills of children in social interactions.[20] Speech, including the average length of speech, the richness of vocabulary, and the number of words and grammatical content in children with

Table 1: List of studies conducted in Iran

Skills	Numbers of participants	Types of studies	Main results	Reference
Basic ToM	18 CI children, 18 normal children	Descriptive and cross-sectional	Hearing impairment has influence on basic theory development in CI children. Age of implantation and gender had no effect on development of ToM	[17]
Lexical diversity and syntactic complexity	10 CI children, 10 normal children	Case-control	There was no significant difference in all measures between children with CIs and hearing age peers. Duration of hearing experience after CI is an important factor for acquiring speech and language abilities	[18]
Language development	35 CI, 35 children normal hearing	Cluster random sampling	The findings of the present study indicated that although the CI children had high scores in the scale of language development. In addition, there was a positive and significant correlation between age and language development	[19]
Nonverbal skills	20 CI, 20 with hearing aids, 20 normal hearing	Case-control study not a random sample	Nonverbal communication skills in hearing impaired children with CI are better than hearing aid users with severe to profound HL, also in comparison with these children, they have better social communication and act the same as normal hearing children in some skills	[20]
Speech	15 CI, 15 normal hearing, 15 hearing-impaired	Descriptive, cross-sectional	Significant differences between the speech quality of children with CIs and children with low-quality show that deaf CI has had a huge impact on speech and language development of children	[21]
Auditory skills	8 CI with ANSD, 8 CI with SNHL	Cross-sectional analytic study	There were no significant dissimilarities among the auditory skills of the children with ANSD and their matches which indicate that the CI results in the synchronous neural activity provided a coherent electrical stimulation; therefore, the hearing function will be improved	[22]
Theory of mind and executive functions	10 normal, 10 deaf, 10 CI	Cross-sectional comparative	Based on findings, cochlear-implanted and deaf children have lower performance in ToM and executive function compared with normal hearing children	[23]
Speech intelligibility in farsi speaking	11 CI children, 11 HA children	Cross-sectional study	Despite the fact that HL in CI children was sever to profound, in comparison to HA children, their speech clarity did not show a significant difference. It shows that children with high levels of HL, with use of appropriate audio equipment have the potential ability to reach high levels of communication skills	
Phonological awareness	8 normal, 8 CI	Cross-sectional study	The visual - auditory test for the use of the images, for the assessment of phonological awareness skills in children with CIs are more suitable and hearing test for the assessment of phonological awareness skills in a more sophisticated level, is useful	[24]
Improvement of hearing performance	95 children IC	Study up-follow cohort	The mean and the median of the auditory performance of the children who had undergone the CI showed a significant difference 6 months, 1 year, and 2 years after the implantation. Moreover, a statistically significant relationship was observed between the independent variable of the type of HL and the auditory performance score	[15]
Speech intelligibility	40 CI, 20 normal	Cross-sectional	Speech intelligibility in children with normal hearing was better than children with CI or hearing aids	[4]
Auditory perception	In each group 16 individuals	Descriptive-analytic study	Average scores auditory perception in children with CIs was significantly higher than children with hearing aids, auditory perception in children with normal hearing, it was better than children with hearing aids and CIs	[25]
Comprehension and expression of passive verbs	10 CI, 10 normal	Cross-sectional	There was a significant difference between normal and children with HL in terms of the rate of comprehension and using passive verbs. The results show the significant delay in comprehension and using passive verbs, which may be due to a delay in diagnosis of the HL, delay in receiving rehabilitation trainings, loss of lingual age, and inefficient CI devices	[26]

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Skills	Numbers of participants	Types of studies	Main results	Reference
Auditory, language and speech skills	8 CI with ANSD, 8 CI children with SNHL	Cross-sectional analytic study	Significant correlation was shown between the age of HL diagnosis and the score levels in three developmental skills. All children were lingered in the investigated skills compared to normal hearing children; however, there was no significant difference between the CI children with and without ANSD	[22]
Phonological awareness	12 CI children, 12 children with hearing aids	Descriptive-analytic study	Results showed that the means of scores of children with CIs in rhyme task were significantly greater than the children with hearing aids. However, in means of scores of phone deletion and nonword reading tasks were not significant different between two groups. CI with accessibility auditory inputs can facilitated the acquisition of phonological awareness skills in HL children	[28]
Reading skills	24 children with CI	Descriptive, cross-sectional	Reading skills were significantly correlated with both the age of surgery and the duration of CI use .Increased auditory input, provided by CI, improves language, and reading skills	[27]
Intonation production	25 CI, 50 normal hearing children	Cross-sectional	In cochlear-implanted group, mean speech base frequency was higher, and mean pitch alteration was lower than the control group. Mean experts scores in cochlear-implanted group were lower than the control group. There was a significant direct correlation between duration of time that the children had CI and perceptual judgment scores	[29]
Perception of intonation	25 CI, 50 children with normal hearing	Descriptive, cross-sectional comparative	The results showed that perception of question and statement sentences intonation had significantly differences between two groups. Perception of question and statement sentences intonation had significantly correlation with age at implantation and duration of implant use	[6]

CIs: Cochlear implants, ANSD: Auditory neuropathy spectrum disorder, SNHL: Sensorineural hearing loss, HA: Hearing aids, HL: Hearing loss, ToM: Theory of mind

cochlear implants, was compared with their peers. The results showed that the value of this parameter is significantly higher in normal children compared to children with congenital profound hearing loss. However, this difference becomes more pronounced with increasing age and hearing-impaired children show less progress in these indicators and even in variable "lexical diversity" show deterioration.[21] Auditory skills in children with auditory neuropathy spectrum disorder (ANSD) who underwent CI were similar to sensorineural hearing loss children who used this prosthesis.[22] In ToM and executive functioning, the performance of deaf, cochlear implant, and healthy children were compared together. The results of ToM demonstrated deaf children have poorer performance than healthy children and children with cochlear implant.[23] Speech intelligibility: the speech intelligibility compared between children with cochlear implant and children with moderate-to-severe hearing loss who use hearing aids. The performance was judged by 4 listeners, and no significant difference was observed between the two groups. In addition, phonological awareness in children with cochlear implant was lower than normal children.[24] Improvement of hearing performance (Development of auditory perception): this study showed the growth and development of auditory perception in children who benefit cochlear implant, so it is necessary to promote the awareness and trust of the society toward the success of this important treatment method. The study also showed that the type of hearing loss can help determine the candidates of cochlear implant.[15] Speech intelligibility: speech intelligibility in children with normal hearing was significantly higher than children with cochlear implant or those who use hearing aids, while there was no significant difference in speech intelligibility between children with cochlear implant and children with hearing aids.[4] Auditory perception: there was a significant difference between mean scores of auditory perception in children with cochlear implant, hearing aid, and children with normal hearing. The assessment of the mean score of different groups indicates that auditory perception in children with normal hearing is significantly better than children with cochlear implant or hearing aids. The auditory perception in cochlear implant was better than children who use hearing aids.[25] Comprehension and expression of passive verbs: there was a significant difference in comparison of the skills, including understanding and application of passive verb between children with cochlear implant with normal children. However, the main cause of this difference cannot be decisively attributed to loss of learning course, inadequacy of implant device, or lack of proper training and rehabilitation program. Probably, this significant difference could be the resultant of all of these factors.[26] Auditory, language, and speech skills: there was no meaningful difference in the level of verbal skills, receptive, and expressive language between children with ANSD who had cochlear implant and their peer children with other difficulties such as SNHL. Accordingly, the CI is an effective intervention in children with ANSD.[22] Reading skills: there was a relationship between the age at cochlear implants and duration of its usage with the score of

reading skills. In other words, with increasing duration of the cochlear implant use, overall score of reading increases by an average.[27] Phonological awareness: the score of cochlear implant group in rhyme recognition task was significantly higher compared to hearing aid group. However, there was no significant difference in the mean score of both groups in assignments of phoneme elimination and reading the nonwords. Since both groups of cochlear implant and hearing aid had better performance at reading the nonwords, it can be said that performing this task relies on visual skills, and these children are able to use phonological pathway to read nonwords.[28] Intonation production: children with cochlear implant had weaker intonation production than children with normal hearing. Therefore, cochlear implants have limitations in facilitating the intonation production.[29] Perception of intonation skills: the performance of the children with cochlear implant in perception of intonation of declarative and interrogative sentences was significantly lower than normal hearing group. Hence, it can be concluded that CI does not facilitate the perception of intonation. Nevertheless, the effect of cochlear implant is time-dependent in children.[6]

Discussion

The study of speech and language development in children with cochlear implant includes various aspects such as vocabulary development, grammar and syntax, phonology, the clarity of speech, speech intonation, reading ability, and ability to express sentences and explain events. In different studies, the impact of factors such as the child's age at the time of surgery, participation in rehabilitation programs, duration of rehabilitation services, family education level and the presence of other disabilities have been investigated in promoting auditory, speech, and language skills. According to the results of these studies factors including the child's age at the time of cochlear implant, participation in rehabilitation programs, its duration of usage and the absence of other disabilities have direct correlation with the speed of development of auditory, language, and speech skills in children with cochlear implant. In addition, the factors such as the level of family education and awareness by creating a favorable learning environment through providing positive reinforcement and encouraging children to participate in rehabilitation sessions indirectly accelerate the growth and development of language learning and can improve listening skills of children. Moreover, the number of children at home is noted as an important factor in language and speech development of children. Considering that the formation of auditory system begins during the first trimester of pregnancy and that normal children receive sensory stimulation, the auditory perception, language comprehension, and verbal skills manifest on their own during normal growth and normal developmental stages of children. It should be noted that the above skills despite CI do not develop in deaf children on their own. To further enhance the beneficial effects of cochlear implants, some factors such as proper age for language learning, holding rehabilitation sessions and contribution of children and families during the training sessions should be taken into account in the selection of patients for surgery. Although in the past, children with associated disabilities were not considered as appropriate candidates for cochlear implants, but recent studies suggest that the power of concentration and learning is determinant factors in the selection of a child for surgery. Physical and movement conditions of children are not an important factor in decision-making except when it causes imbalance and influences the independent walking of children, thus early rehabilitation and educational interventions to children and families is essential.

Conclusion

Early detection of hearing loss and timely decision-making and implantation of cochlear as well as the duration of usage as the most significant factors can help deaf children to reach the level of normal peers in the ability of understanding and expression of verbal language and other skills. Cochlear implant in the first 2 years of life and even before the 12 months decreases hearing age from the calendar age to the minimum possible level and provides sufficient hearing experience in critical period of language learning for speech and language learning so that the language ability and capability of a deaf child will be similar to a hearing child. When the children receive cochlear implant with considerable delay after 24 months of age, it will be difficult to compensate for the distance between hearing age and calendar age. Furthermore, the language ability of such children will be different from hearing children of the same age. In addition, other factors such as individual differences, the hearing level before surgery, the use of hearing aids and social status, higher socioeconomic level, the presence of residual hearing, lack of associated disabilities, the ability of nonverbal perception, memory, special collaboration of parents and parents' verbal communication, lack of learning disabilities, and environmental factors can have an impact on the evolution of speech and language in children with cochlear implant.

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Conflicts of interest

There are no conflicts of interest.

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