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ADAPTATION ISSUES OF CHILDREN WITH COCHLEAR IMPLANTS WITHIN THE FRAMEWORK OF GENERAL INCLUSIVE EDUCATION IN ARMENIA

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ABSTRACT

This article provides comprehensive information about hearing impairments, specialized methods for hearing restoration, such as cochlear implantation, as well as the goals, timing, stages, and age-specific features of auditory and speech rehabilitation after cochlear implantation.

It also highlights the factors that contribute to and hinder the social adaptation of children with cochlear implants (CI). The article discusses challenges in preschool and school education for children with CI, such as the lack of special technical tools to enhance the quality of education, insufficient awareness among educators and teachers regarding communication with children with CI, and the psychological aspects of their interactions with peers.

Keywords: *hearing impairments, cochlear implantation, auditory and speech rehabilitation, preschool education, inclusive schools, special technical means, individual education plan, psychological-pedagogical commission, regional center for psychological-pedagogical support*.

INTRODUCTION

Hearing is a crucial sense organ that plays a role in intellectual, emotional, and social development. Auditory perception results from the joint activities of the receptive auditory system and the brain's analytical and integrative systems. As the final link in the acoustic communication chain, hearing, along with the behavior it influences, is controlled and coordinated by many complex brain mechanisms (National Institute on Deafness and Other Communication Disorders, 2021; Vartanyan, 1981).

A global assessment of hearing impairment prevalence, published by WHO in 2012, reported that 360 million people (5.3% of the world's population) suffer from hearing loss, including 328 million adults (183 million men and 145 million women) and 32 million children (WHO, 2012). Hearing loss can result from inflammatory and non-inflammatory diseases of the middle ear (e.g., exudative otitis media, chronic suppurative otitis media, otosclerosis), the use of ototoxic drugs (e.g., antibiotics from the aminoglycoside group, loop diuretics, anticancer drugs), poor environmental conditions, infectious diseases such as measles, rubella, scarlet fever, and meningitis, exposure to loud noise and acoustic trauma, various vascular diseases leading to impaired microcirculation in the inner ear, pregnancy and birth complications (e.g., preeclampsia, hyperbilirubinemia, asphyxia, birth injuries, prematurity), and hereditary factors (Koroleva, 2012; Zabirova, 2012; Markova, Polyakov & Kunelskaya, 2008; Rosenblum, 1980).

In Armenia, 1 in 1,000 newborns is diagnosed with profound hearing loss, and by the age of five, two additional cases per 1,000 occur.

THEORETICAL BACKGROUND

There are different classifications of hearing impairments based on various criteria:

1. Depending on the causal factor:

- Hereditary hearing impairments, which are genetically determined (monogenic and multifactorial);
- Congenital hearing impairments;
- Acquired hearing impairments (resulting from diseases, injuries, or harmful effects).

2. By type of inheritance:

- Autosomal inheritance (autosomal recessive and autosomal dominant types);
- X-linked inheritance;
- Mitochondrial inheritance;
- Combined inheritance.

3. By the mechanism of sound signal processing:

- Conductive hearing loss (caused by an impaired sound conduction mechanism);
- Sensorineural hearing loss (caused by an impaired sound perception mechanism);
- Mixed hearing loss (involving both impaired sound conduction and perception in one ear).

4. By location of impairment in the auditory system:

- Peripheral hearing impairments (damage to the outer, middle, or inner ear, neurons of the spiral ganglion, or auditory nerve);
- Central hearing impairments (damage to the subcortical and cortical centers of the auditory system).

5. Depending on the location of the damage:

- Unilateral hearing impairment (affecting only one ear);
- Bilateral hearing impairment (affecting both ears).

6. By the dynamics of hearing loss:

o Progressive (thresholds increase by 10 dB or more at four frequencies from 0.5 to 4 kHz over five years);

o Stable.

7. By symmetry of hearing loss:

o Symmetrical;

o Asymmetrical (threshold differences of more than 15 dB between ears at two or more frequencies).

8. Depending on the onset period of the disease:

o Congenital;

o Prelingual (occurs before speech development);

o Post-lingual (occurs after speech development).

9. By degree of severity:

o Domestic classification of hearing loss (hearing loss for tones at 0.5–2 kHz):

▪ Mild hearing loss: average loss does not exceed 50 dB (perception of conversational speech at more than 1–2 meters, whispering speech near the ear);

▪ Moderate hearing loss: average loss from 50 to 70 dB (perception of conversational speech up to 1 meter, whispering speech not perceived);

▪ Severe hearing loss: average loss from 70 to 85 dB (perception of conversational speech is difficult, not always clearly perceived near the ear).

o International classification of hearing loss degrees (assessed in the speech frequency range of 0.5–4 kHz):

▪ Mild: average hearing loss from 26 to 40 dB (perception of conversational speech at 6–3 meters, whispering speech at 2 meters near the ear);

▪ Moderate: average hearing loss from 41 to 55 dB (perception of conversational speech at 3 meters near the ear, whispering speech not perceived);

▪ Moderate to severe: average hearing loss from 56 to 70 dB (perception of loud speech near the ear);

▪ Severe: average hearing loss from 71 to 90 dB (perception of shouting near the ear);

▪ Profound: average hearing loss over 91 dB (speech is not perceived).

o International classification proposed by WHO (2008) (assessed in the speech frequency range of 0.5–4 kHz):

▪ Normal hearing: average hearing loss up to 25 dB (no speech perception problems or very minor issues, perception of whispering speech);

- Mild: average hearing loss from 26 to 40 dB (distinguishing and repeating words spoken with conversational speech at a distance of 1 meter);
- Moderate: average hearing loss from 41 to 60 dB (distinguishing and repeating words spoken with loud speech at a distance of 1 meter);
- Severe: average hearing loss from 61 to 80 dB (perception of shouting near the ear);
- Profound, including deafness: average hearing loss over 81 dB (speech is not perceived).

(National Institute on Deafness and Other Communication Disorders, 2021; Shcherbakova, Yanov, Kuzovkov, Megrelishvili, 2014).

HISTORICAL REVIEW OF COCHLEAR IMPLANTATION

It is well known that hearing aids are widely used to improve auditory perception in children and adults with various hearing impairments. However, hearing aids do not always lead to significant improvement in speech perception for everyone. Due to a number of technical, physiological, and pathophysiological reasons, hearing aids provide minimal or no improvement in speech perception for individuals with severe sensorineural hearing loss and deafness (Tavora-Vieira & Rajan, 2020). Recent scientific advancements and the use of cutting-edge technology have made it possible to develop a new method to improve auditory perception in such patients - the method of multichannel cochlear implantation (CI). CI generally refers to the implantation of electrode systems into the inner ear to restore auditory sensation through direct electrical stimulation of the auditory nerve fibers.

The idea of assisting people with hearing impairments through CI emerged around 40 years ago in France. During surgery on the middle ear of a hearing-impaired person, an electrode was accidentally placed near the cochlea, connected to a power source, and the patient began to hear better. Doctors investigated this phenomenon, leading to the development of a new approach that improves speech perception for deaf and hard-of-hearing people (Carlson, et. al., 2020; Lorens, Polak, Piotrowska & Skarzynski, 2008; Litovsky & Parkinson, 2006; Lindbaek & Harris, 2005; Yanov, 2005; Mens, 2003; Trautwein, Sininger & Nelson, 2000).

In the Soviet Union, the first operation to implant a domestic cochlear device was performed in 1982, and since 1990, doctors at the All-Russian Scientific Center of Audiology and Hearing Aids of the Ministry of Health of the Russian Federation, led by Tavartkiladze, in cooperation with specialists from the company “Cochlear” (Germany), prepared and performed the first operation to implant a 22-channel Nucleos electrode. Since then, doctors at the center have been performing several such operations annually.

In 1995, the center's doctors developed and published the “Guidelines for Cochlear Implantation”. Today, other medical institutions in Moscow and St. Petersburg also perform such surgeries on both children and adults.

Sensorineural hearing loss is typically caused by damage to the inner ear, particularly the hair cells. However, despite significant damage to the sensory cells, most such patients retain auditory nerve fibers. These fibers, when directly stimulated by electrical current, are capable of sending signals to the brain, creating auditory sensations. This is the principle on which the CI operates - it essentially serves as an artificial inner ear.

Currently, tens of thousands of people worldwide use CI. Thus, cochlear implantation is gradually becoming a viable solution for hearing aids in individuals with severe sensorineural hearing loss and profound deafness.

The cochlear implant provides:

1. Restoration of auditory perception thresholds to 30-40 dB relative to normal hearing thresholds;
2. Significant improvement in the perception of everyday environmental sounds, such as knocking on the door, doorbells, engine sounds, car horns, phone ringing, dog barking, background music, etc.;
3. A psychological breakthrough into the world of sounds. The subjective loudness of everyday sounds perceived through the implant typically far exceeds that of similar sounds perceived even through optimally fitted hearing aids. As a result, deaf and hard-of-hearing individuals describe their experience as “I started to hear”;
4. The vast majority of those who undergo the operation improve their ability to understand others through a combination of enhanced hearing ability and lip reading.

The primary indications for CI are bilateral profound sensorineural deafness, with an average hearing perception threshold at 500 Hz, 1000 Hz, and 2000 Hz above 110 dB, or a lack of significant improvement in speech perception with hearing aids in cases of severe bilateral sensorineural hearing loss, with an average hearing threshold above 90 dB.

The age range for CI is quite broad: the minimum age is 1-2 years, which is determined by the development of the cochlea to the minimally required size. The maximum age is limited by the individual's overall health and the need for a long (several years, at least more than a year) rehabilitation period.

In addition to the above, the following conditions must also be met:

1. The presence of intact auditory nerve fibers;

2. The absence of cochlear obliteration;
3. The absence of retro cochlear pathology;
4. The absence of serious comorbid somatic diseases;
5. No cognitive impairments in the patient;
6. The absence of pathologies in the brain's cortical or subcortical structures;
7. No psychiatric disorders;
8. Strong support from parents (for children) or relatives (for adults), and their readiness for a long post-operative rehabilitation period involving sessions with audiologists and deaf education specialists.

Another criterion for CI is the effectiveness of hearing aids. If a person can recognize around 30-40% of words with a hearing aid, CI is only recommended if the prognosis is excellent. CI is confidently recommended when the individual correctly recognizes fewer than 5% of words and there are no contraindications.

To determine the potential effectiveness of cochlear implantation for an individual, one cannot rely solely on the average hearing threshold.

Studies have shown that neither the average threshold, the etiology of deafness, nor the age at which surgery is performed are decisive factors in post-operative speech comprehension for implant recipients. However, there is a strong correlation between the duration of deafness (from the time of hearing loss to implantation) and the results of implantation: the shorter the period, the faster the patient's progress in auditory training. Another important factor is whether deafness occurred before or after the development of speech. In the latter case, speech recognition progress after implantation is faster and more significant.

These two factors are so significant for predicting the results of CI that, for a long time, only recently deafened individuals whose deafness occurred after speech development were selected for implantation. Indeed, the prognosis for such patients is the most favorable.

CI implantation has been performed in Armenia since 2004 at the Erebouni Medical Center.

REHABILITATION

Auditory and Speech Rehabilitation After CI is a process aimed at restoring hearing and developing speech in people with profound hearing impairments who have received a CI system. CI allows a person with hearing loss to perceive sounds by converting sound signals into electrical impulses that stimulate the auditory nerve. However, the implantation itself is only the first step toward full auditory and speech integration. The rehabilitation stage, which helps patients adapt to their new hearing abilities and learn how to use them, is equally important.

The main goals of auditory and speech rehabilitation after CI are:

1. **Learning to perceive sounds.** The patient must learn to recognize and differentiate environmental sounds, such as speech, music, and noise.
2. **Development of speech skills.** For those who lost their hearing before acquiring speech (prelingually deaf), it is crucial to learn to understand and produce words and phrases.
3. **Improving quality of life.** Restoring hearing and speech enables a person to integrate into society, communicate freely, and lead an active lifestyle.

The duration and stages of auditory and speech rehabilitation may vary depending on the patient's age, the time of implant placement, and prior hearing experience. Rehabilitation typically occurs in several phases:

1. **Implant activation period (4 weeks after surgery).** During this time, the CI is connected and adjusted, and sound signals begin stimulating the auditory nerve. However, sound perception remains unclear and requires adaptation.
2. **Adaptation and initial training period (first 6 months).** During this time, the patient learns to distinguish sounds. Children and adults with different hearing experiences adapt differently: children learn to perceive and pronounce new sounds, while adults with hearing loss recover familiar sounds.
3. **Active rehabilitation period (from 6 months to several years).** This is a period of intensive work with speech therapists and other professionals aimed at developing hearing and speech. The duration depends on the patient's initial condition: it may take several years for children, while adults usually progress faster.
4. **Final stage (ongoing support).** Even after completing the main rehabilitation, patients continue exercises to maintain their hearing and improve speech skills.

Age-specific features of rehabilitation

- **Children.** Auditory and speech rehabilitation in children, especially those born with congenital deafness, requires a special approach. The earlier the child receives the implant (the optimal age is before 1 year), the faster and more effective the hearing and speech training will be. At this age, the brain is most plastic, and the ability to adapt is greater. Early intervention allows children to learn to recognize sounds and develop speech at nearly the level of their peers.
- **Adults.** Rehabilitation in adults who lost their hearing later in life usually progresses faster since they already have established auditory and speech skills. They relearn familiar sounds. However, for adults with congenital deafness or those who lost hearing at an early age, the process can be longer and

more demanding. In such cases, CI is considered less effective (Lenarz, James, Cuda, & European Cochlear Implant Users, 2020).

Auditory and speech rehabilitation after CI is a lengthy but essential process requiring patience, effort, and cooperation with qualified specialists. The success of rehabilitation largely depends on the patient's age, pre-implantation hearing condition, and the quality of the rehabilitation itself. Early CI and systematic work on developing hearing and speech allow patients to effectively adapt to the world of sounds and achieve a high degree of social integration.

The goal of rehabilitation is to achieve a level of hearing and communication that enables patients to integrate freely into society. Auditory and speech rehabilitation also includes the development of gross and fine motor skills, perception of the surrounding world, attention, memory, thinking, and emotional and volitional spheres.

In Armenia, for over 20 years, the "Mutual Assistance Center" has been conducting auditory and speech rehabilitation for children with CI. It is the only certified rehabilitation center whose specialists work using the Harutyunyan's method. This method has provided optimal results in auditory and speech development for cochlear implant patients for over two decades.

The attendance of children with cochlear implants in preschool institutions plays a significant role in their development and social integration. CI gives children with severe hearing loss the opportunity to hear sounds, but successful use of these opportunities depends not only on rehabilitation but also on creating special conditions in the environment where the child develops and learns. Attending kindergartens is one of the key stages in the process of adapting such children to the world of sounds, speech, and communication.

One of the main tasks for children with CI in preschool institutions is creating a rich linguistic environment. It is important that the child is surrounded by speech, as this allows for more active development of auditory perception and speech communication skills. In kindergarten, children constantly encounter conversational speech from peers and educators, which stimulates their auditory development and improves their understanding and reproduction of sounds.

Preschool institutions should create favorable conditions for children with CI, including:

• minimizing noise in the group, so the child can better perceive speech and orient themselves in the sound environment.

• using visual cues to support understanding of spoken words.

• special programs and methods aimed at developing auditory and speech skills and educating children with hearing impairments.

Socialization is another important aspect of attending preschool for children with CI. In kindergartens, children learn to interact with peers, work in groups, and share emotions and impressions. A key goal is for children with implants to fully participate in play and educational activities, promoting their emotional and social development.

Through constant interaction with other children, a child not only learns to perceive speech but also understands it in various contexts, which is essential for successful integration into society. In group work and play, the child acquires communication skills, develops self-confidence, and the ability to express their thoughts and desires.

Despite the many advantages of attending preschool institutions, children with CI face several challenges:

1. **Adaptation to noise.** The background noise level in a kindergarten can be quite high, making it difficult to perceive speech through the implant. This can lead to fatigue and decreased concentration in the child.
2. **Need for an individual approach.** Children with implants often require additional support from educators. This requires educators to have special knowledge and skills in working with children with hearing impairments. It is important that educators understand the characteristics of these children and can adapt teaching and communication methods.
3. **Psychological adaptation.** The socialization process can be difficult for children with CI, especially if they feel "different" due to the need to wear a device. This can affect their self-esteem and interaction with other children.
4. **Lack of experience among peers in interacting with children with implants.** Some children may not immediately understand what a CI is, which can lead to misunderstandings or even the isolation of the child with the implant. It is important to explain to children that the implant helps their peer hear and to teach them to respect others' differences.
5. **Insufficient knowledge of educators in technical matters (handling the speech processor, replacing batteries, etc.).**
6. **Insufficient awareness of educators regarding communication with children with CI (use of gestures or exaggerated speech).**

EDUCATION AND SOCIALIZATION

Attending preschool institutions by children with CI is an important stage in their development, socialization, and integration into society. Creating a linguistic environment and educator support play a key role in successfully adapting these children. However, difficulties related to speech perception in noisy environments and psychological barriers require special attention from both parents and educators.

By overcoming these obstacles, children with implants can fully participate in the lives of their peers and gain the necessary skills for further development.

Education in Inclusive Schools. Children with hearing impairments who have undergone CI are considered individuals requiring special educational conditions. A person in need of special educational conditions is defined as someone who faces learning difficulties due to issues with speech and language, communication, hearing, vision, intellectual (mental), emotional, behavioral, motor, or other problems, requiring special conditions for mastering the general education curriculum.

Most children with CI who have completed rehabilitation are typically ready to attend inclusive schools by the time they begin school. Readiness assessments for school are conducted by the school, a psycho-pedagogical commission, and/or a regional center for psycho-pedagogical support. The school submits a request to the psycho-pedagogical commission, after which an evaluation team is formed. The team consists of at least two educators (a special education teacher and a social worker) and one psychologist from the regional center for psycho-pedagogical support. If necessary, other teachers and specialists may be involved. The assessment is carried out in the first, fourth, and ninth grades, as well as on request from the school, if needed.

The assessment process consists of two stages:

- Conversations with teachers and parents.
- Comprehensive assessment of the child using a set of standards appropriate for each age group.

Based on the results, the evaluation team provides a comprehensive description of the child and determines the level of support required. The assessment of the child's educational needs is conducted free of charge. If a student is assessed and recognized as having special educational and developmental needs, an **Individual Learning Plan (ILP)** is developed. This document is based on the national and subject-specific educational standards, the curriculum, and the need for special learning conditions. It outlines the annual goals, objectives, and actions needed to achieve them (including support services).

The development of an ILP is a collaborative process involving the student, the parent or legal representative, the student's teachers, and specialists providing educational and psychological support. The ILP is developed for one academic year. If the educational institution lacks specialists to provide necessary support, they are invited from the regional center for pedagogical and psychological support serving the school.

Special Technical Tools for Improving the Quality of Education for Children with CI. To enhance the quality of education for children with cochlear implants (CI) in educational institutions, particularly during preschool and school activities, special technical tools are used to help children better perceive speech and sounds. These devices and technologies adapt the auditory environment and provide clearer speech perception in noisy or acoustically challenging conditions. Below are some of the most effective technical solutions:

1. **FM Systems (Frequency Modulation Systems)** – One of the most popular and widely used tools to improve speech perception for children with CI in the classroom or group setting.

- **How it works**: The teacher or adult wears a microphone that transmits their voice directly to the child's CI via a radio frequency signal. This reduces the impact of background noise and reverberation, allowing the child to focus better on the teacher's speech.
- **Advantages**: These systems significantly improve speech understanding at a distance and in group work situations where there are many background sounds.

2. **Digital Microphones and Sound Amplification Systems** – These can be used alongside audio systems to transmit sound to the child's device, improving the quality and clarity of speech.

- **Application**: These microphones can be used in classrooms and groups so that all spoken material is clearly audible to children with CI.
- **Advantages**: The teacher or speaker doesn't need to raise their voice, and their speech is transmitted clearly and directly to the child's device, reducing acoustic distortions.

3. **Interactive Whiteboards with Audio Support and Multimedia Systems** – These can be helpful for children with CI as they combine visual information with speech. Visual aids (texts, images, videos) help compensate for potential gaps in auditory perception that may still occur even with a CI. Children can follow the material easily, receiving information through multiple channels simultaneously. (These are **not yet used in Armenia**.)

4. **Noise-Cancelling Systems** – These can be used to reduce the level of background noise in classrooms or group settings, creating better acoustic conditions for speech perception. Reducing background noise helps children with CI to understand speech better, especially in large rooms or groups with many children. (These are **not yet used in Armenia**.)

5. **Speech-to-Text Software** – Programs that convert spoken language into text in real time can be helpful for children with CI, especially if they struggle with understanding speech in noisy environments. These systems act like subtitles, providing a textual version of what is said. Children can read and listen simultaneously, improving material comprehension and overcoming potential hearing difficulties in challenging acoustic environments. (These are **not yet used in Armenia**.)

6. **Speech Rehabilitation Applications** – Specialized programs and apps designed for speech rehabilitation and the development of auditory skills in children with CI are available. These apps help train sound perception, speech skills, and auditory memory. The programs can be integrated into the educational process or used as additional tools for home practice. Here are some popular apps for

speech rehabilitation for children with cochlear implants:

- **Lingraphica** – A series of apps designed for speech therapy and rehabilitation, supporting the development of auditory and speech skills.
- **Cochlear CoPilot** – An app from Cochlear that includes programs for speech rehabilitation and training to improve hearing and speech.
- **Auditory Workout** – An app for children developed by a speech therapist that helps improve auditory perception, attention, and concentration.
- **SoundTouch Interactive** – An app with interactive tasks to enhance auditory perception and language development.
- **Hearing First** – A platform with educational materials and apps for children with CI, focused on speech and auditory development.

Unfortunately, **these apps do not support the Armenian language and are not used in Armenia**.

These technical tools play a key role in providing quality education for children with cochlear implants. They help overcome barriers in speech perception, improve conditions for speech and hearing rehabilitation, and promote the successful integration of children into the educational environment.

CONCLUSION

Cochlear implantation is a life-changing technology that restores hearing in individuals with severe to profound hearing loss. However, successful auditory and speech integration depends on comprehensive rehabilitation, educational support, and assistive technologies.

Key Challenges and Recommendations:

1. Limited use of assistive technologies – Armenian schools lack advanced tools like noise-canceling systems and speech-to-text software. Government support is needed to integrate these technologies into the education system.
2. Insufficient technical training for educators – Many teachers lack knowledge about CI devices. Professional development programs should be introduced.
3. Need for specialized communication training – Teachers and caregivers should be trained in gesture support, speech modulation, and nonverbal communication to enhance interaction with CI users.
4. Psychological adaptation – Children with CIs may experience social stigma or self-esteem issues. Schools should promote awareness programs to foster peer understanding and inclusivity.

Providing inclusive education for children with CIs requires a multi-faceted approach, combining modern technology, professional training, and social support. Government intervention and professional community engagement are crucial for enhancing the quality of education and overall well-being of CI users in Armenia.

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