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Applications of artificial intelligence and electronic implants in the field of hearing disability

Ouannoughi Nora [1]

[1] University of Mouloud mammeri –Tizi-Ouzou, (Algeria)
Correspondence: nora.ouannoughi@ummto.dz

Abstract---Our study revealed the reality of applying artificial intelligence and electronic implants in the world of the deaf child, by analyzing how these technologies are employed in the early detection of hearing disability, improving the quality of auditory rehabilitation, and enhancing the cognitive abilities of children who suffer from hearing loss or deafness. In this research, we relied on the descriptive method due to its suitability for examining the phenomenon as it exists in reality and for achieving an accurate scientific description of specialists' experiences with this modern technology. The study was conducted during the period extending through December 2025, during which a rigorously designed scientific questionnaire was developed and distributed to a purposive sample of specialists, with the aim of gathering multidisciplinary professional opinions on the effectiveness of artificial intelligence and electronic implants in the field of hearing disability. The sample consisted of: 9 ENT specialists, 5 speech therapists, 8 experts in ear surgery and auditory implant procedures, 5 education specialists, and 3 audiology specialists. The results indicated that integrating artificial intelligence with electronic implants constitutes a fundamental step in enhancing the abilities of deaf children, by improving sound-signal processing, developing early diagnostic systems, and raising the quality of auditory perception compared to traditional methods. The study also highlighted the need to further develop the technical infrastructure and increase investment in these applications in order to keep pace with global advancements in the field of auditory rehabilitation.

Keywords---artificial intelligence, hearing disability, electronic implants.

I. Introduction:

The present era has witnessed a rapid advancement in the use of smart technologies, where modern technology—particularly electronic implants supported by artificial intelligence—has become a pivotal

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tool in enhancing communication for individuals with hearing disabilities. This progress has contributed to opening new horizons for speech-language pathology practices by integrating innovative technological solutions into auditory–linguistic diagnosis and rehabilitation, ensuring leadership, entrepreneurship, and the transition from empowerment to excellence among individuals with hearing impairments.

A. Problem Statement:

Despite the increasing spread of artificial intelligence technologies across various medical fields, their use in the context of hearing disability remains limited and lacks practical scientific evaluation. Previous studies highlight the need for developing more accurate diagnostic tools for early detection and more effective rehabilitative support (Ahmed Abdel-Moneim, 2003). However, the application of these tools in the environment of the deaf child has not yet been sufficiently explored in the Arab context.

Accordingly, the study raises the following central problem: To what extent are artificial intelligence applications and electronic implants effective in improving the abilities of the deaf child, and what obstacles and challenges do specialists face in employing these technologies?

Sub-Questions:

1. How have technological advancements contributed to improving the efficiency of electronic implants?
2. How are smart data and machine learning used to monitor implant performance and enhance auditory rehabilitation services?
3. To what extent do artificial intelligence techniques contribute to improving the ability of children with hearing disabilities to distinguish sounds and understand speech?

Significance of the Study:

The importance of this study stems from several scientific and practical considerations, most notably the relative scarcity of previous research addressing the intersection of artificial intelligence and auditory implants in deaf children. This makes the present study a valuable contribution to enriching scientific knowledge and advancing digital transformation in the field of auditory rehabilitation.

It also highlights the human and developmental role of technology in enabling deaf children to access a more equitable communicative and learning environment.

C. Objectives of the Study:

- To analyze the role of artificial intelligence technologies in improving the performance of electronic auditory implants, particularly cochlear and middle-ear implants.
- To identify the technical and sensory challenges associated with the use of artificial intelligence in the field of implant surgery.
- To explore artificial intelligence applications in automatically adjusting and optimizing auditory programming according to the needs of the deaf child.

D. Study Terminology:

Defining the Key Concepts of the Study:

a. Artificial Intelligence: Artificial intelligence was defined during the European Year of Youth 2022 as “a general term given to a set of technologies that allow machines or software to mimic human intelligence.” Accordingly, Artificial Intelligence (AI) is an advanced branch of computer science that aims to design and develop systems capable of simulating human intelligence and performing tasks that normally require complex cognitive processes, such as learning, analysis, and decision-making. AI involves the use of advanced algorithms and machine-learning techniques that enable machines to process data, recognize patterns, and adapt to changing conditions (Tahar, 2025, p. 16).

b. Hearing Disability: The World Health Organization (WHO) defines hearing disability as a partial or complete impairment in the ability to perceive sounds due to a malfunction in one of the components of the auditory system (the outer, middle, or inner ear, or the auditory nerve), where the hearing threshold exceeds 20 dB or more in one or both ears. This disability may be permanent or temporary, mild, moderate, severe, or profound, and it affects language acquisition to varying degrees (Al-Khatib, 2021, p. 29).

c. Electronic Implants: Electronic implants for hearing disability are considered one of the advanced medical technologies aimed at compensating for auditory function in individuals with severe to profound sensorineural hearing loss.

These implants represent a pioneering achievement in the field of speech-language pathology and auditory–linguistic rehabilitation, as they contribute to developing communication skills and accelerating the social, educational, and professional inclusion of individuals with hearing disabilities (Ahmed, 2023, p. 2509).

II. The Theoretical Framework

A. Artificial Intelligence.

1. Definition of Artificial Intelligence: Artificial intelligence is a branch of computer science concerned with developing software and hardware capable of simulating human behavior. It is well known that computers possess the ability to imitate certain functions of the human mind—such as performing calculations, processing numbers and letters, making simple decisions, and possessing remarkable capacities for storing and retrieving information. The field of artificial intelligence seeks to simulate some cognitive processes and logical reasoning abilities that humans perform (Hachmi Rachida, 2024, p. 50)

Artificial intelligence is considered one of the most significant fields of interactive computer-based learning. It refers to efforts to develop computerized information systems that think in a way identical to humans, enabling them to carry out real tasks in a coordinated manner or to use perceptual images and patterns to rationalize physical behavior. At the same time, these systems are capable of storing accumulated human experiences and knowledge and employing them in decision-making. AI systems use human knowledge stored in the form of facts, concepts, theories, and methodological exploration techniques within a virtual electronic repository referred to as the "Knowledge Base", which also contains the rules used by the system to make decisions.

Thus, the primary objective of artificial intelligence is to simulate human intelligence using advanced software, enabling the solving of non-routine problems, training on problem-solving, or making appropriate decisions based on well-reasoned logic and available alternatives—tasks that would otherwise require considerable human effort, even from an individual of above-average intelligence.

2. Characteristics of Artificial Intelligence: Artificial intelligence possesses numerous characteristics that make it a highly effective investment in many fields, including:

- AI applications integrated into devices and machines enable them to plan and analyze problems using logic.
- The ability to recognize voices and speech, and to move objects.
- AI-enabled devices can understand and accurately analyze inputs to provide outputs that efficiently meet user needs.
- The capability for continuous learning, where the learning process is automated and self-directed without supervision or monitoring.
    - The ability to process vast amounts of information.
    - The capacity to detect and analyze similar patterns in data more effectively than the human brain.
    - The ability to find solutions to unfamiliar problems using its cognitive capacities (Asma El-Sayed Mohamed, 2020, pp. 22-23).

3. The Importance of Using Artificial Intelligence Systems: Interest in artificial intelligence has become a major concern for the developed world. By the late 1970s, the impact of AI research began to appear in a wide range of fields, including programming techniques, mathematics, genetic engineering, geology and petroleum exploration, medicine, commerce, psychology, and many others. A significant focus also emerged on applied artificial intelligence, which contributed to the development of numerous areas such as expert systems, natural language processing, speech recognition, computer vision, automated programming, robotics, and several additional domains. Machine learning and deep learning are also among the most important AI applications currently implemented across various fields such as media, medicine, electronics, and computer systems. These technologies can likewise be employed in educational programs and platforms to improve and develop the learning process. AI can further support personal learning and self-development through tools such as learning machines, logic modules, self-correction, and self-programming. Consequently, the education system—as both a concept and an outcome—will undergo significant transformation as a result of applying the principles of the Fourth Industrial Revolution. Education will increasingly focus on experiential and sensory learning to meet the needs of the industrial sector and the growing demands of artificial intelligence technologies (Asma El-Sayed Mohamed, 2020, pp. 29-30).
Here is a precise, fluent, and academically polished English translation of the full text:

B. Hearing Disability.
1. Definition of Hearing Disability: The term hearing disability is a broad concept that covers a wide range of hearing loss degrees, ranging from deafness or severe loss that impedes the processes of speech and language, to mild loss that does not prevent the use of the ear in understanding speech and learning language. Hearing disability includes both deafness and hard of hearing, and its range extends from mild hearing loss, through moderate hearing loss, to profound hearing loss (Al-Faiz, 2009, p. 15).
Definition of "Deaf": According to Adel Abdallah, a deaf person is an individual whose hearing impairment prevents them from sequentially processing linguistic information through hearing, whether or not they make use of hearing aids (Abdallah, 2024, p. 534).

Rachad Abdel-Aziz defines a deaf person as someone who cannot use the sense of hearing at all in daily life, and thus loses the ability to acquire language (Abdel-Aziz, 2009, p. 187).

Easterbrooks (1997) states that the term "deaf" has multiple definitions, yet they all point to hearing loss that negatively affects educational performance, to a degree that becomes severe enough to hinder the child's ability to process linguistic information for communication through the auditory sense, whether or not amplification devices or hearing implants are used.

Fatima Abdel-Samad asserts that individuals with hearing disabilities are those who have a deficiency in auditory ability, with the severe degree requiring the acquisition of a special language different from that of the majority of people. Therefore, they require specialized services (educational, psychological, social, and health-related), which vary depending on the degree of impairment and the time at which it occurred (Abdel-Samad, 2003, p. 11).

2. Classifications of Hearing Disability
a. Based on Age at Onset: Hearing disability is classified according to the age at which impairment occurs as follows:

- **Congenital hearing impairment:** This refers to cases in which the individual is born with hearing loss from the moment of birth. (Saeed, 2005, p. 176)
- **Post-lingual deafness:** According to Saeed Abdel-Aziz, this refers to cases of deafness that occur after the child has already acquired speech and language. In such cases, the child's pronunciation or speech is not affected (Saeed, 2005, p. 176).

- **Pre-lingual deafness:** Madjdi Ibrahim notes that this category includes cases of hearing loss that occur at birth or at an early age before speech and language development. It is believed that the critical threshold for this type of deafness is around the age of three. In this case, the child's ability to speak is affected, as they are unable to hear spoken language in a way that allows for proper acquisition and learning (Ibrahim, 2003, p. 435).

b. Based on the Site of the Lesion: According to Abdel-Moutalib Al-karyouti (2001, pp. 201–202) and kahtan Al-Zahir (2005, pp. 120–121), types of deafness are classified medically based on the nature of the impairment affecting the auditory system, as follows (Al-karyouti, 2001, pp. 201-202) (Al-Zahir, 2005, pp. 120–121):

- **Conductive deafness:** This type occurs when disorders of the external auditory canal or eardrum, or damage to the conductive parts of the middle ear—such as the malleus, incus, or stapes—prevent the transmission of sound waves carried by air to the inner ear, and consequently prevent their arrival to the brain.

  Conductive hearing loss is usually mild to moderate. The patient typically does not lose more than 40 decibels except in rare cases.

  This type of deafness can often be treated through surgical procedures to remove middle-ear effusion, repair the eardrum, or replace the stapes. Treatment may also include antibiotics for ear infections under specialized medical supervision, and hearing aids (such as amplification devices) are often beneficial.
- **Sensorineural deafness:** This type results from damage to the inner ear or deterioration of the auditory nerve transmitting impulses to the brain. As a result, sound waves cannot reach the inner ear regardless of their intensity, or they may reach it distorted, preventing the brain's auditory centers from converting them into neural signals and interpreting them.

  Causes include viral or microbial infections occurring before or after birth, and certain ototoxic medications.

  This type is difficult to treat due to the direct damage to sensory and neural fibers.
- **Central deafness:** This type results from dysfunction in the auditory centers of the brain, which prevents proper interpretation and discrimination of auditory stimuli. It is one of the most challenging types to treat.
- **Mixed deafness:** This type combines characteristics of both conductive and sensorineural deafness. It is difficult to treat due to the overlap of causes and symptoms; even if the conductive component is treated, the sensorineural deficit usually remains.
- **Hysterical deafness:** This type arises from exposure to severe psychological stress or traumatic emotional experiences.

c. Based on Severity of Hearing Loss: This is the physiological perspective, which classifies hearing disability based on the degree of hearing loss. A person who loses up to 24 decibels is considered within the normal range.

From this perspective, hearing disability is divided into several categories, ranging from 25 dB to over 90 dB—that is, from very mild or slight hearing loss to extremely severe hearing loss that prevents the individual from hearing spoken language around them.

According to Adel Abdallah, Radi Al-Wakfi, and Issam Nimer, these categories are as follows (Abdallah, 2024, pp. 362–464) (Al-Wakfi, 2004, pp. 320–324) (Nimer, 2000, pp. 20–22):

- **Slight hearing loss**: Ranging from 25–40 dB. Individuals in this category fall between those with normal hearing and those who are hard of hearing. They generally do not encounter major difficulties in using their hearing to learn speech and language.
  - **Mild hearing loss:** Ranging from 41–55 dB. Individuals experience some difficulty hearing conversations around them, especially when voices are soft, which leads to communication challenges. However, they can still rely on their hearing, although they may need louder speech, repetition, or a quiet environment.
  - **Moderate hearing loss:** Ranging from 56–70 dB. Individuals face more pronounced communication difficulties, requiring the use of hearing devices—such as various types of hearing aids—and auditory training to achieve acceptable communication.

- **Severe hearing loss:** Ranging from 71–90 dB. Individuals in this category cannot hear most sounds or auditory stimuli even at close range, resulting in significant speech disorders. They require specialized programs and services to learn speech and language. These individuals are considered deaf from an educational standpoint.
- **Profound hearing loss:** Exceeding 90 dB. Individuals in this category are entirely unable to learn language through hearing, even with amplification devices. Therefore, they must learn alternative communication methods, primarily manual communication systems such as sign language and finger spelling, in addition to total communication approaches.

Turkington and Sussman (2000) also classify hearing loss levels as follows:

Table (01): Turkington and Sussman's Classification of Hearing Loss Levels

Type of Hearing Loss	Degree of Hearing Loss
Complete Hearing Loss	100 dB
Profound Hearing Loss	More than 91 dB
Profound Hearing Loss	More than 91 dB
Moderate Hearing Loss	56–69 dB
Mild-to-Moderate Hearing Loss	| 41–55 dB
Slight Hearing Loss	26–40 dB

C.Assistive Technology.

1. Definition of Assistive Technology: Assistive technology refers to any program, system, or device—whether a standard product, modified, or customized according to need—used to enhance, maintain, or improve the functional abilities of children or individuals with disabilities. This definition encompasses both hardware and software.

2. The Role of Assistive Technology in Empowering and Integrating Children with Hearing Disabilities in Education and Society: Assistive technology supports access to information for children and individuals with hearing disabilities and enhances their ability to communicate effectively. This, in turn, strengthens their participation, inclusion, and overall quality of life.

Below is an overview of examples of assistive technology that facilitate the integration of deaf and hard-of-hearing children into education and society by supporting their communication abilities. These are divided into two categories: devices and applications.

a. Devices:

- **Individual Hearing Implants:** These devices have revolutionized the ways in which hearing-impaired children perceive amplified sounds. The primary purpose of hearing implants is to deliver and amplify sound to the ear. They can be used for peripheral hearing loss, which may be conductive (middle ear), sensorineural (inner ear), or mixed, and can range in severity from mild to profound. Hearing implants can be used from as early as three months of age in cases of hearing loss, depending on several criteria such as the individual's age, the degree and nature of hearing loss, and, in some cases, the design and placement of the device according to the user's preference.

  The forms, sizes, techniques, and methods of using hearing aids vary widely, as illustrated in the accompanying images (Arab Council for Childhood and Development, 2018, pp. 95–97).

If you want, I can continue and translate the applications/software section as well to complete the overview of assistive technology.

The images illustrate some of the diversity and variety among behind-the-ear hearing aids, in-the-ear hearing aids, and eyeglass-mounted hearing aids. Other types also exist, such as bone-conduction hearing aids and implanted bone-anchored hearing devices.

From a technical perspective, advancements have reached the use of Smart Bluetooth technology and wireless communication, which allow for remote adjustment of hearing devices and simultaneous calibration of both ears. Updates in the microphones of hearing aids now enable sound amplification without background noise, ensuring that sound reaches the ear clearly from all directions. Technical progress has also made it possible to shift inaudible frequencies into the audible range in cases of severe hearing loss, compensating for some frequencies more than others.

- **Cochlear Implant:** Nancy Chitz (2015) describes cochlear implant technology as "the most significant technological change for deaf children from an educational and social perspective." This technology is used in cases of severe hearing loss in which conventional hearing aids are ineffective, with the goal of delivering sound directly to the auditory nerve. The procedure involves surgically implanting a series of electrodes into the cochlea to stimulate the auditory fibers, which then transmit signals to the brain.

  Cochlear implants consist of multiple internal and external components, as illustrated in the image.

  The internal components include a receiver/internal processor coil and a set of electrodes that transmit signals to the inner ear. The processor, surgically placed behind the mastoid bone, contains a magnet that later attaches to the external device. It also includes an antenna that receives the transmitted signals. The external component consists of a speaker and speech processor, connected by a wire and transmission coil (Arab Council for Childhood and Development, 2018, pp. 97–98).

Cochlear Implant System

The technology of cochlear implant components is advancing rapidly, encompassing both internal and external parts. These developments have enabled users to perceive speech with clarity approaching normal hearing.

- **Personal Amplification Systems:** These can be divided into two categories:
  - **Assistive Listening Devices (ALD):** These devices are designed to be used alone or in conjunction with a hearing aid. They transmit the desired sound signal directly to the listener's ear, unaffected by room noise or the acoustic properties of the environment, allowing the listener to perceive sound as if in ideal conditions. Both the speaker and the listener wear a unit roughly the size of a cigarette pack. The signal is typically transmitted via infrared or frequency modulation (FM).

  These systems include a microphone for the speaker, an amplifier, and a receiver for the hearing-impaired individual. They can be used for one-on-one communication, such as in lectures or personal interactions. For individuals whose hearing loss is associated with central auditory processing issues, conventional hearing aids are often less effective, while personal assistive listening devices are significantly more effective due to the superior signal-to-noise ratio they provide, which substantially reduces background noise, though not entirely.

- **Telephone Amplifiers:** Some hearing-impaired individuals communicate more effectively on the telephone when their device is equipped with an amplified handset. The amplifier built into the phone can be adjusted to an appropriate volume. Portable amplifiers also exist, small enough to fit in a pocket or purse. These amplifiers are often integrated into the handset itself, performing the same function; however, not all phones are designed for portable amplifiers, though phone adapters can be purchased to facilitate use.

- **Group Listening Systems:** Group listening systems benefit individuals with severe hearing loss and can also assist those with mild hearing loss who accept their condition. They aim to improve the ability to hear clearly without background noise, especially in crowded environments and classrooms, where factors such as distance, echo, and ambient noise can limit or prevent clear understanding of speech or auditory signals. Nancy Chitz (2015) categorizes these systems into four main types:
  - **Audio Loops**: Audio loops consist of a microphone, amplifier, and a long wire surrounding the seating area. Sounds are captured and transmitted via magnetic fields through wires installed under floors and around walls. Hearing aids equipped with telecoil switches pick up these magnetic signals and convert them back into sound.
  - **Frequency Modulation (FM) Systems:** In this system, transmitters broadcast sound using methods similar to radio broadcasting. The listener uses a personal receiver to deliver the sound directly to the ear. FM systems are easy to install and can transmit signals up to 300 feet.
  - **Amplitude Modulation (AM) Systems:** AM systems operate on the same principle as FM systems but are more prone to interference.
  - **Infrared Systems:** Infrared systems are a modern type of group listening device. They convert sound into infrared light waves, which are then received by infrared receivers used by listeners and converted back into sound. These systems are easy to install and free from interference, but their range is limited to line-of-sight, and infrared waves cannot pass through obstacles such as walls or corners. These devices can also be affected by some sources of light (Arab Council for Childhood and Development, 2018, pp. 98-100).

Alert Robot

- **Personal and Laptop Computers:** The use of personal computers has grown steadily since their invention in the late 1930s, revolutionizing communication and daily task performance for all people. Personal computers have become essential devices in most homes and schools, opening new pathways for deaf and hard-of-hearing individuals to communicate both among themselves and with the hearing community. Computer technology has begun to promote equality by providing both deaf and hearing individuals faster access to information.

  Studies, such as Rogers (1998), indicate that deaf and hard-of-hearing individuals in the United States began using the Internet in the same way as their hearing peers. They navigated the web, used email, sent text messages and blogs, and communicated via video conferencing. Additionally, deaf individuals started sharing videos on YouTube. These developments reduced communication barriers, enabling deaf people to participate in conversations, share texts and blogs, and access information. Details on accessibility and computer-based applications will be discussed in the software and applications section.

- **Vibrating, Tactile, and Visual Alert Devices:** These devices rely on light sources, magnification, and tactile vibrations to support communication for deaf and hard-of-hearing individuals through vision, touch, or sound. Visual signals have been developed to alert deaf and hard-of-hearing individuals to doorbells, telephones, alarms, smoke detectors, and wake-up devices. Tools have also been designed to alert deaf parents when their infants cry.

In the Arab region, the Asdaa Association for the Advancement of Deaf and Hard-of-Hearing People in Alexandria designed a device called the "Alert Robot"(as shown in the image). This device vibrates when it detects the sound of a doorbell using a sound sensor, waking deaf or hard-of-hearing individuals and alerting them to someone at the door. The robot is also equipped with a camera screen that allows the person to see who is outside. The door can then be opened automatically by a sound produced by the deaf or hard-of-hearing person, which is detected by the sensor, triggering the automatic opening mechanism (Arab Council for Childhood and Development, 2018, pp. 100-101).

b. Software and Applications: With advances in computer, device, and phone technology, several services, programs, and applications are now available to support communication for deaf and hard-of-hearing individuals. Some of these tools rely on computers, televisions, video phones, video messaging services, or video message interpreters. These programs and applications allow individuals to communicate face-to-face from any location using sign language, spoken language, or shared documents.

Programs such as Skype or WhatsApp enable people in distant locations to use the Internet from anywhere in the world for face-to-face communication through sign language, speech, or shared documents, greatly benefiting deaf and hard-of-hearing individuals. The following are examples of such programs and applications:

- **Closed Captioning Technology:** Tarek Al-Rais (2015) describes closed captioning as a technology or service that displays text on a television, computer screen, or other display devices to provide additional or explanatory information for individuals who cannot access auditory content. This technology is similar to the subtitles on foreign films, translating spoken language into written text for deaf individuals. The term "closed" indicates that the captions are not available to all viewers, but only to those who subscribe to the service or use compatible decoding or receiving devices.

In 1990, the U.S. Congress passed the Television Decoder Circuitry Act, requiring all televisions 13 inches or larger sold in the United States to be equipped for this service. However, this service is not yet available in Arab countries.

- **Speech-to-Text Technology:** Programs such as real-time translation and speech-to-text applications were designed to facilitate communication and note-taking for individuals who require additional or alternative support to access spoken communication. The transcription is performed by professionals known as speech-to-text captioners, who use shorthand software to convert speech into written text. The shorthand is then transformed into full text, which can be displayed on a computer or separate LCD screen for multiple users. The resulting text can be saved, printed, or shared with the recipient, offering an alternative mode of accessing spoken communication. These professionals typically include individuals who have chosen this career path, such as sign language interpreters trained in multiple disciplines, court reporters who also provide live captions, and trained caption writers skilled in software applications and typing shorthand that displays words and phrases for the deaf or hard-of-hearing user. These shortcuts reduce the number of keystrokes needed, allowing captioners to provide as much spoken information as possible in text form. Although the transcription is not always literal, it sufficiently conveys the intended meaning (Arab Council for Childhood and Development, 2018, pp. 102-103).

3. Examples of the Most Important Electronic Implants:

a. Cochlear Implant (L'implant cochléaire):

- An electronic device implanted internally.
- Stimulates the auditory nerve.
- Indicated for individuals with profound bilateral sensorineural hearing loss who do not benefit from conventional hearing aids.

Recommended for children before the age of two.

Modern models include:

- MED-EL
- Advanced Bionics
- Nucleus Profile / Nucleus 718
- MRI wireless compatibility.

This is a product from the company Rondo3 - MED-EL.

b. Bone-Anchored Implant (Bone Conduction Implant):

- A device for transmitting sound via bone conduction.
- Titanium implant or magnet placed through the skin in the temporal bone.

Components:

- Implant + abutment
- Magnetic unit through the skin
- External sound processor (pre-fitted for the jaw)

Users: Individuals with external and middle ear injuries (conductive or mixed hearing loss).

Examples: Ponto, Ponto 3 – featuring advanced digital processing technologies and wireless connectivity options (Bluetooth).

c. Middle Ear Implant:

- An active implant including a Floating Mass Transducer (FMT)
- Implanted in the middle ear or on the ossicular chain.
- Consists of two parts: a bone-anchored part and an external component.

Example: Vibrant Soundbridge – MED-EL (VORP 503)

4000

Products from the company Cousound for hearing impairment, currently available in Algeria and imported by the company Pramedical, available for purchase in various regions of Algeria, including Setif.

The Sky CI M is a sound processor from Phonak (Sonova), and it is the first processor specifically designed for cochlear-implanted children.

It works with the HiRes Ultra 3D cochlear implant system from Advanced Bionics, the sister company of Phonak.

- Présentation Sky CI M – Phonak
- Advanced Bionics Sky CI M Overview
- Phonak Sky M Family Brochure (PDF)

The goal is to provide personalized treatment: "according to the needs and preferences of each patient."

That is: not a "one-size-fits-all device," but rather an analysis of the hearing condition + the patient’s lifestyle + preferences + sound environment.

III. Practical Aspect

A. Methodology.

In our study, we relied on the descriptive method, as it is one of the qualitative research models aimed at describing phenomena as they exist in reality. It was chosen because it is the most suitable for the topic of the impact of artificial intelligence in the field of electronic implants, particularly for individuals with hearing impairments.

B. Study Location and Duration.

The study was conducted during the period from December 2024 to June 2025.

Questionnaires were distributed and data were collected in four Algerian provinces: Boumerdès, Tizi Ouzou, Béjaïa, and Bouira, due to the availability of specialized medical and educational centers in the field of hearing impairment.

C. Study Sample

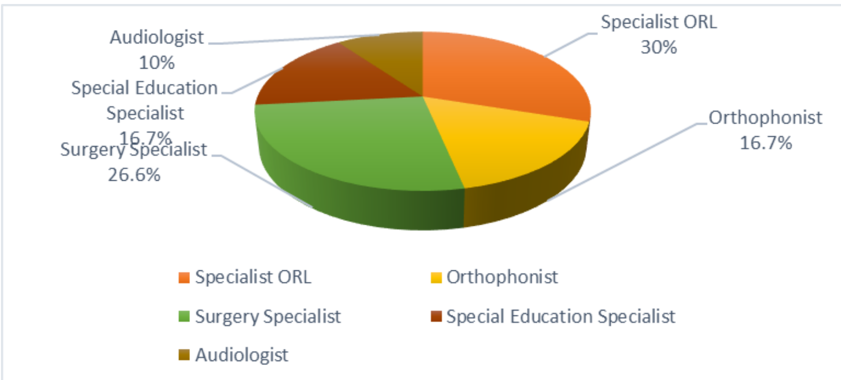
The study sample included 30 specialists, distributed as follows:

Table (02): Study Sample

Sample	Frequency	Percentage
ENT Specialist	9	30%
Orthophonist	5	16.7%
Surgery Specialist	8	26.6%
Special Education Specialist	5	16.7%
Audiologist	3	10%
Total	30	100%

Source: Prepared by the researcher based on the outputs of the SPSS system

Figure (01): Study Sample



Source: Prepared by the researcher based on the outputs of the SPSS system.

D. Tools Used

The questionnaire was adopted as the primary tool for collecting data and information. It was designed with regard to the validity and reliability of the survey. It was distributed to specific groups of specialists, including doctors, orthophonists, and experts in the fields of artificial intelligence and audiology.

They unanimously agreed on its suitability and clarity of its items. Its reliability was also verified using Cronbach's alpha coefficient, which reached 0.81, indicating high reliability, suggesting that it can be trusted as a study-specific tool.

The questionnaire was structured in the following way:
First Section: Related to the general information of the specialist (specialization, experience, category, etc.).
Second Section: Electronic implants and their technologies. For example:
- How would you assess your level of knowledge regarding recent developments in the field of electronic implants?
- Do you consider that integrating artificial intelligence into hearing implant systems represents a qualitative leap in auditory rehabilitation?
- In your opinion, what are the main areas where artificial intelligence contributes within implant systems?

Third Section: Application of artificial intelligence techniques in the field.
- Difficulties that hinder professional coordination in this field.
- Lack of digital training among some specialists.
- Absence of a unified protocol.
- Weak technical equipment.

Fourth Section: Artificial intelligence and its impact on auditory rehabilitation.
- Have AI-based systems contributed to improving the efficiency of auditory processing after implantation?
- Have you noticed differences in the speed of auditory and speech rehabilitation between users of traditional implants and users of smart systems?
- What is your opinion on the effectiveness of Remote Fitting in terms of accuracy and therapeutic outcomes?

From an orthophonist's perspective, do the smart technologies integrated into implants help improve:
- Auditory awareness?
- Sound discrimination?
- Speech production and language comprehension?
- Do you think that using smart applications connected to the implant (APP) contributes to supporting orthophonic rehabilitation programs?
- Do you support integrating AI-based digital training content into rehabilitation sessions?

This was a presentation of some of the questions for each section of the questionnaire.

E. Presentation and Analysis of the Study Results

Through analyzing the statistical data extracted from the field questionnaire directed to workers in the audiology sector, specialized physicians, and orthophonists, it becomes clear that there is a general positive trend toward integrating artificial intelligence technologies in developing and employing electronic implants for the benefit of children with hearing disabilities.
The results reflected an increasing awareness among practitioners of the importance of these technologies in improving auditory performance, personalizing orthophonic rehabilitation, and enhancing linguistic and communicative understanding in accordance with the individual characteristics of each child.
1- From the perspective of audiologists: The results of the first statement indicate that 60% of the sample strongly agreed on the effectiveness of artificial intelligence in improving the performance of electronic implants by adapting them to the needs of each child, while 20% agreed to a moderate degree, and 20% disagreed. The mean score reached (3.22) with a standard deviation of (0.30), which is higher than the hypothetical mean.

These results indicate a strong conviction among audiologists of the role of artificial intelligence in enhancing the self-regulation and precise calibration of implants, so that their settings align with the nature of hearing loss and the level of auditory perception of each child. This result is consistent with studies such as Svirsky (2020), which confirmed that artificial intelligence algorithms enable the implant to adapt to changes in the auditory environment, improving sound quality and speech comprehension among implanted children.

2- From the perspective of ENT specialists: The results of the second statement showed that 50% of respondents strongly agreed that the use of smart technology enhances the ability of implants to transmit auditory information clearly, contributing to raising children's attention levels and reducing negative behaviors resulting from poor communication, while 23% moderately agreed, 17% weakly agreed, and 10% rejected the idea.

The mean score reached (3.45) with a standard deviation of (0.40), reflecting a positive medical trend toward integration between technology and auditory–neural functions.

This trend is explained by the specialists' understanding that artificial intelligence contributes to analyzing auditory signals and converting them into clearer neural patterns, which supports the neuro-auditory effectiveness of the cochlear implant and reduces behavioral disorders associated with auditory comprehension difficulties.

3- **From the perspective of the orthophonist (speech and language specialist):** The results of the third statement show that 50% of the sample strongly agree on the necessity of training deaf children using artificial intelligence programs specialized in auditory and linguistic rehabilitation, while 17% moderately agreed, and 10% rejected the idea. The mean score reached (3.96) with a standard deviation of (0.343), indicating a high awareness of the importance of integrating artificial intelligence with orthophonic practice. The orthophonist views these technologies as a means to personalize therapeutic sessions through auditory and interactive simulation programs that help the child develop auditory perception and speech skills individually. These results agree with what was indicated by Khosravi & Kermani (2019) regarding the effectiveness of artificial intelligence in remote auditory rehabilitation through smart interfaces that allow audio-visual interaction and support continuous orthophonic follow-up.

4- From the perspective of special education: As for the results of the fourth and fifth statements, they showed that 43% of the sample believe that artificial intelligence technologies are capable of simplifying and analyzing auditory information for children with hearing disabilities through sound processing and reshaping it in understandable ways, while 33% moderately agreed and 20% rejected the hypothesis. The mean score reached (3.13) with a standard deviation of (0.24).

These results indicate that the majority view artificial intelligence as a tool that helps compensate for auditory comprehension difficulties resulting from hearing loss by adapting auditory and linguistic content to match the child's cognitive and linguistic abilities.

This educational–linguistic dimension shows that employing artificial intelligence in orthophonic programs is not limited to technical support, but extends to enhancing verbal interaction and developing communication skills to ensure the child's integration into various daily and educational situations.

Based on the above, it can be said that the results of the study confirm a unified professional and scientific orientation toward investing in artificial intelligence as a developmental tool in the field of electronic implants, whether from the perspective of auditory medicine, orthophonia, or the educational–rehabilitative dimension.

It appears that the integration among these fields represents a fundamental axis in building a comprehensive model for supporting children with hearing disabilities, one that relies on artificial intelligence to personalize auditory programming, improve linguistic performance, and enhance communicative interaction, in line with modern trends in intelligent orthophonic rehabilitation.

F. Discussion of the Results

The results of the study indicate a clear positive trend among specialists in the fields of audiology, orthophonia, and special education toward integrating artificial intelligence technologies in the design and development of electronic implants intended for individuals with hearing disabilities. This trend reflects professionals' awareness of the importance of employing artificial intelligence as a supportive tool to improve the quality of life and auditory–verbal communication for this population.

The results highlighted that artificial intelligence effectively contributes to personalizing auditory settings in accordance with the degree of hearing loss and the individual response patterns of each child, which allows for a more accurate auditory experience adapted to their communicative needs. This integration also enhances auditory and linguistic attention skills and reduces compensatory or isolating behaviors resulting from weakened auditory communication.

In addition, specialists' opinions showed great appreciation for the role of artificial intelligence in developing orthophonic rehabilitation programs, especially those based on auditory simulation and verbal interaction, which support auditory and speech rehabilitation in a more dynamic and personalized manner. The use of natural language processing techniques and smart audio encoding also contributes to facilitating the comprehension of auditory content and improving the discrimination of meanings and phonetic segments among implanted children.

These results are consistent with recent scientific literature, where Svirsky (2020) confirmed the prominent role of artificial intelligence in improving cochlear implant responses among children through the autonomous adaptation of auditory parameters. Raine et al. (2021) also pointed to the effectiveness of smart predictive models in adjusting implant parameters in accordance with changes in the auditory environment. Khosravi & Kermani (2019) demonstrated that artificial intelligence opens new horizons in remote auditory rehabilitation through interactive audio–visual interfaces that support continuous and personalized orthophonic intervention for each case.

Accordingly, it can be said that the results of the current study confirm the integration of artificial intelligence with modern orthophonic practice in the field of auditory implant rehabilitation, enhancing the effectiveness of therapeutic care and contributing to the development of rehabilitation practices that are more responsive to the individual needs of people with hearing disabilities.

G. General Conclusion

The results of the study showed a clear positive trend among specialists in audiology, orthophonia, and auditory medicine toward employing artificial intelligence technologies in developing electronic implants for the benefit of children with hearing disabilities.

The statistical data indicated that the use of artificial intelligence effectively contributes to improving implant programming settings by adapting auditory responses to the individual characteristics of each case, which positively impacts the quality of auditory perception and central auditory processing.

The results also revealed that integrating artificial intelligence into orthophonic practices represents a qualitative addition in the field of auditory–linguistic rehabilitation, as it enables the design of interactive training programs based on machine learning algorithms and natural language processing, contributing to enhancing auditory discrimination, sound recognition, and verbal production skills among implanted children.

Accordingly, it can be concluded that artificial intelligence constitutes a supportive component of modern orthophonic programs and contributes to the transition from traditional rehabilitation models to digital diagnostic and training approaches that rely on continuous adaptation to the auditory and linguistic performance levels of each child.

IV. Conclusion

The study confirms that the use of artificial intelligence in the field of orthophony—especially in the design and programming of electronic implants—represents an advanced research and applied direction toward improving the care provided to children with hearing disabilities.

The integration between intelligent systems and orthophonic practice enables the specialist to accurately analyze auditory and linguistic data, and to determine performance levels through digital assessment tools that allow for the objective monitoring of the development of auditory and linguistic abilities.
The research also highlights the need to develop professional competencies among orthophonists in dealing with artificial intelligence interfaces, particularly in the areas of auditory processing, speech perception, verbal training, and language analysis. This ensures evidence-based practice and a data-driven approach.

Accordingly, the current findings open new horizons for applying artificial intelligence as a supportive diagnostic and rehabilitative tool in orthophonic practice, with the aim of enhancing the quality of services provided to children with hearing disabilities and improving their communicative competence.

Recommendations:

Based on the findings obtained, the study recommends moving toward the following:

1. Conducting experimental studies to measure the effectiveness of AI-supported orthophonic programs in developing auditory and linguistic skills in cochlear-implanted children.
2. Developing a digital orthophonic protocol based on deep learning algorithms to monitor auditory and linguistic progress in real time.
3. Analyzing the impact of AI-supported remote orthophonic care on the quality of auditory rehabilitation compared to traditional in-person approaches.
4. Developing intelligent assessment tools to measure auditory performance and verbal production using speech-recognition technologies and spectral voice analysis.
5. Conducting training-based studies on integrating artificial intelligence into university and professional orthophonic training programs, with the aim of enhancing practitioners' competencies in using smart digital systems for diagnosis and rehabilitation.

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