

Preoperative evaluation, surgical procedure, follow up and results of 150 cochlear implantations

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Abstract

Background: The cochlear implantation is among the most important achievements of medicine and biotechnology in the last 20 years, because it allows individuals who had never heard or had lost their hearing to perceive sound and improve their quality of life. Selection criteria for candidates are strict and are evaluated in each individual by a scientific committee specially trained for implantations which includes Ear Nose and Throat (ENT) surgeon, audiologist, psychiatrist and speech therapist.

Patients and methods: In our department, the first cochlear implantation was performed in 1995. During the last ten years more than 250 individuals have been evaluated due to profound hearing loss and 170 of them were found to be suitable candidates for cochlear implantation. One hundred and fifty (150) have already been operated and most of them are children with congenital hearing loss. No major or permanent complications were recorded in any of our 150 patients. Activation and fitting/mapping of the cochlear implant is initiated three weeks post-operatively. Regular follow-up and mapping of the implant are held, more frequently in children, along with specialized speech therapy. Each new mapping is evaluated according to the record of the patient with regard to the acoustic perception of sounds and speech and the discrimination of individual elements of phonation based on a protocol that we have created for the needs of Greek language.

Results: Speech discrimination (AHEPA Hospital protocol), before the Implantation, at the activation of the cochlear implant and till 4 years of the follow-up showed that in our patients, we obtained better and faster results in post-speech acquisition adults with recent or chronic deafness and in children with congenital deafness operated before the 5th year of age, who underwent special preoperative speech therapy programme, fact which is in agreement with current literature. Patient satisfaction evaluated by "Sanders" psychometrics tests, was achieved in accordance to pre-operative expectations.

Conclusions: In our patients, we observed better and faster results in children with congenital deafness operated before the third year of age, in post-speech acquisition adults with recent deafness and in post-speech acquisition adults with chronic deafness but with auditory memory reserve. *Hippokratia 2007; 11 (2): 77-82*

Key words: *cochlear implant, cochlear implantation, surgical procedure of cochlear implantation, follow up of cochlear implantation, results of cochlear implantation*

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The first step to stimulate the hearing system electrically was made by Count Alessandro Volta in 1790. He placed spills in his ears and powered the apparatus with 50 Volts, obtaining this way an «enormous experience». In 1930 an important advance was made when researchers discovered that the feeling of hearing can be created by providing alternate electric current (AC) beside the ear and that the cochlea operates as commutator of the auditory (kinetic) energy into bioelectric¹⁻³. In 1957 Djourno and Eyries were the first who stimulated the auditory nerve in a deaf patient. The patient could identify a variety of frequencies⁴. In 1960 Dr William House initiates the research regarding implantation, with surgical approaches of the middle ear^{5,6}. In 1961 he implanted 3 patients which considered useful and pleas-

ant this "new" hearing⁷.

Many discoveries are ought to laboratories working on telephony, like Bell Laboratories and AT & T, who concluded that, by using 6-7 channels coding the frequencies, with telephone line, palpable speech can be created. In 1969 Dr. Graeme Clark (Melbourne, Australia) began the research of the first multi-channel intra-cochlear implant and continued his research with Nucleus Limited⁸.

Today the use of cochlear implant for hearing rehabilitation of deaf individuals is widespread all over the world with more than 100.000 users in the world^{9,10}.

The cochlear implant (Figure 1) is an electronic device that replaces the function of the damaged or ab-

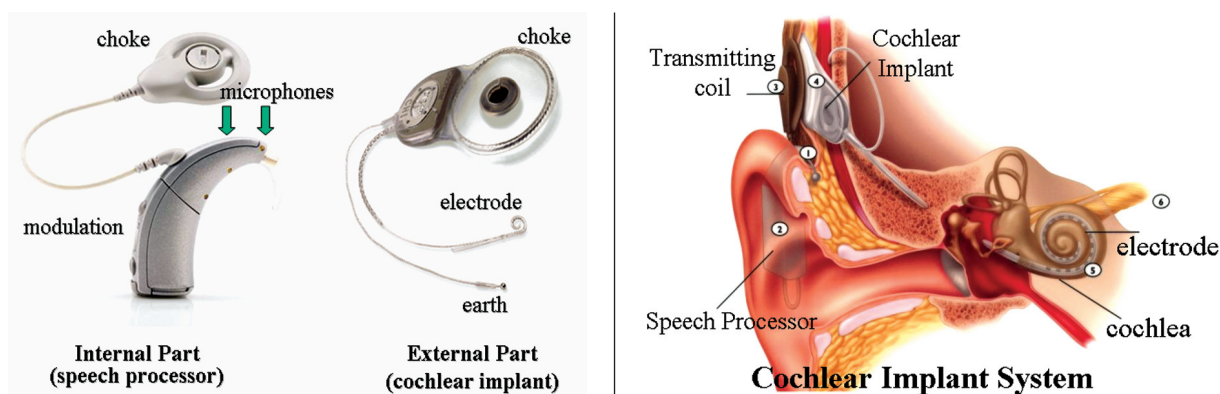


Figure 1. The latest cochlear implant system that we use in our CI Center. Cochlear's Nucleus Freedom™ system consists of the implant placed internally and the speech processor behind the ear

sent hair cells in the organ of Corti in the cochlea. An electrode array which is inserted in the cochlea during a delicate microsurgical procedure stimulates electrically the remaining auditory nerve fibres with codified sound information.

Cochlear Implants can be applied in adults and children with bilateral, severe to profound sensorineural hearing loss, who have not benefited by the use of powerful hearing aids and have not improved their oral communication skills by specific speech therapy. This is because early stimulation of the acoustic Central Nervous System, especially in pre-school ages, leads to improved acoustic memory and sound discrimination.

Indications and preoperative requirements for cochlear implantation include a complete medical history and physical examination, medical valuation, audiologic examinations, CT and MRI scans to evaluate the cochlea and the auditory nerve, psychological tests, speech evaluation and enrolment in oral education program.

Regular follow-up and mapping of the implant are held, more frequently in children, along with specialized speech therapy. Each new mapping is evaluated according to the record of the patient with regard to the acoustic perception of sounds and speech and the discrimination of individual elements of phonation based on a protocol that we have created for the needs of Greek language.

Material

A cochlear implantation program was initiated in the Otorhinolaryngology Department of Aristotle University of Thessaloniki in AHEPA University Hospital in 1995. Since that time, 250 candidates for cochlear implantation have been examined, out of which 170 suitable fulfilled the criteria for implantation and 150 were operated.

Sex distribution was 71 males and 79 females while the age of the patients was 1 - 73 years (Figure 2). The cause of deafness is demonstrated in Figure 3. Causes of deafness was congenital or of unknown etiology in

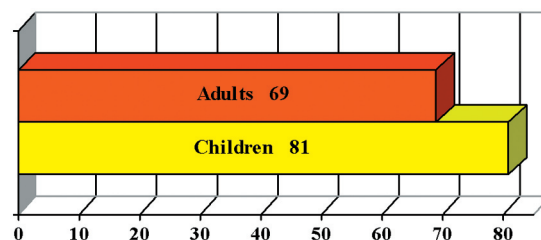


Figure 2. Age of 150 implanted patients

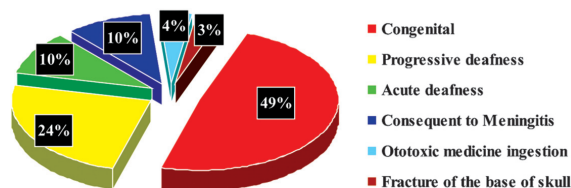


Figure 3. Cause of deafness in 150 implanted patients

children (73 cases) and consequent to meningitis during early childhood (15 cases), while in post-speech acquisition adults progressive deafness was incriminated (36 cases), along with acute deafness of unknown etiology (16 cases), deafness following ototoxic medicine ingestion (6 cases) and fracture of the base of skull and the labyrinths (4 cases).

Method

Evaluation of the candidates was performed according to a protocol created in our department that included patient medical history, general health check-up, ENT examination, audiometric evaluation, CT and MRI scans, psychological profile of the candidate, and logotherapeutic assessment. If the results were favorable concerning the exact localization of the defect, satisfactory excitability of the acoustic nerve, the mental capaci-

ties of the candidate, and the possibility of performing surgery, the patient was scheduled for surgery. Necessary prerequisites also included the patient's informed consent and that of his/hers entourage to undergo the operation and the necessary post-operative training, as well as realistic expectations of a satisfactory result.

Surgical approach

During the surgical procedure we use facial nerve monitoring (Amplaid MK12 with soft "implants")¹¹, specially in patients who have malformations of the middle ear, because the facial nerve may have an aberrant course.

In the beginning of implantations the method of choice was radical mastoidectomy.

Today we use two methods.

1. Radical mastoidectomy has been replaced by wide antrotomy with posterior tympanotomy.

The patient receives a general anesthesia, and his head is shaved over the post-auricular area. A posterior-superior auricular incision is made. The skin flap is elevated followed by the creation of a temporoparietal fascia flap. The temporalis muscle and overlying fascia are left intact. A subperiosteal pocket is created for positioning the implant induction coil and the ground electrode.

A mastoidectomy is performed. The horizontal semicircular canal is identified in the depths of the mastoid

antrum. The short process of the incus is identified in the fossa incudis. The facial recess is opened using the fossa incudis as an initial landmark, taking care to avoid injury to the chorda tympani and facial nerve.

The round window niche is visualized through the facial recess about 2 mm inferior to the stapes. Entry into the scala tympani is accomplished best through a cochleostomy created by drilling over the basal turn of the cochlea anterior and inferior to the annulus of the round window membrane.

A small fenestra slightly larger than the electrode to be implanted (usually 1 mm diameter) is created, allowing direct insertion of the active electrode array.

A bone bed well, tailored to the device to be implanted, is created and the induction coil is fixed to place with periosteal flaps.

The electrode array is then carefully inserted through the fenestra into the scala tympani of the cochlea. The ground electrode is tucked into the sub-periosteal pocket. The wound is closed in three layers. Thorough haemostasis is achieved and no drains are placed.

2. An endoaural approach for the cochleostomy and consequently a small posterior tympanotomy for access of the electrode (Figure 3).

During the operative procedure, after insertion of the electrode and before suturing of the surgical incision, telemetry is used to verify the correct placement of all electrodes, their resistances and the average electrode

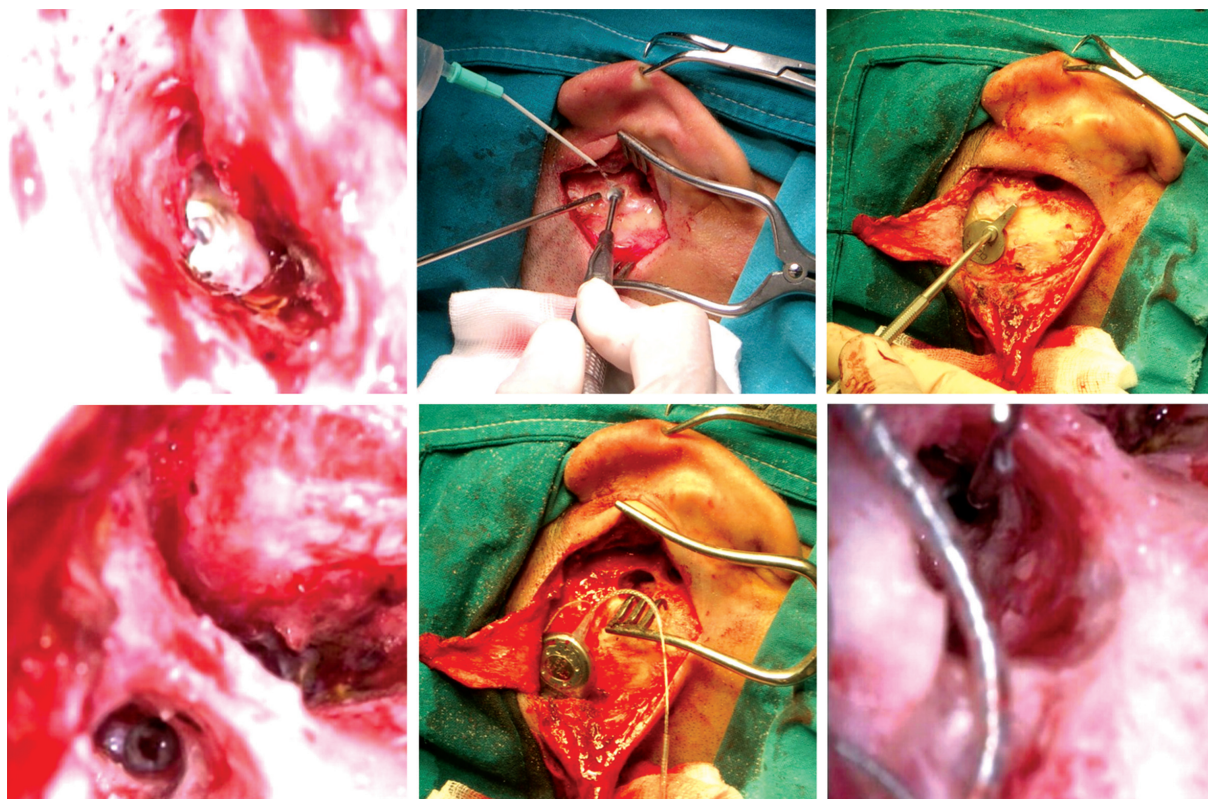


Figure 4. Steps of the surgical procedure with the second method of the endoaural approach

voltage values (AEV). Following that, acoustic pathway function is assessed by electrically detecting the stapedius muscle reflex, the Electrical Auditory Brainstem Response (E.A.B.R) and the Neural Response Telemetry (N.R.T.) the electrical equivalent of electrocochleography, with a specific software developed in Zurich ENT department¹¹⁻¹⁴.

With the patient still in recovery at the end of the

cation. The adults fully regained their hearing immediately after the activation of the implant. In children the results were even more impressive as the acquisition of hearing followed by specialized logotherapeutic education led to acquisition of speech. Even from the first few months, a dramatic increase of passive and later active vocabulary was observed, a fact that was corroborated by speech discrimination testing (Figure 5) and “Sanders”

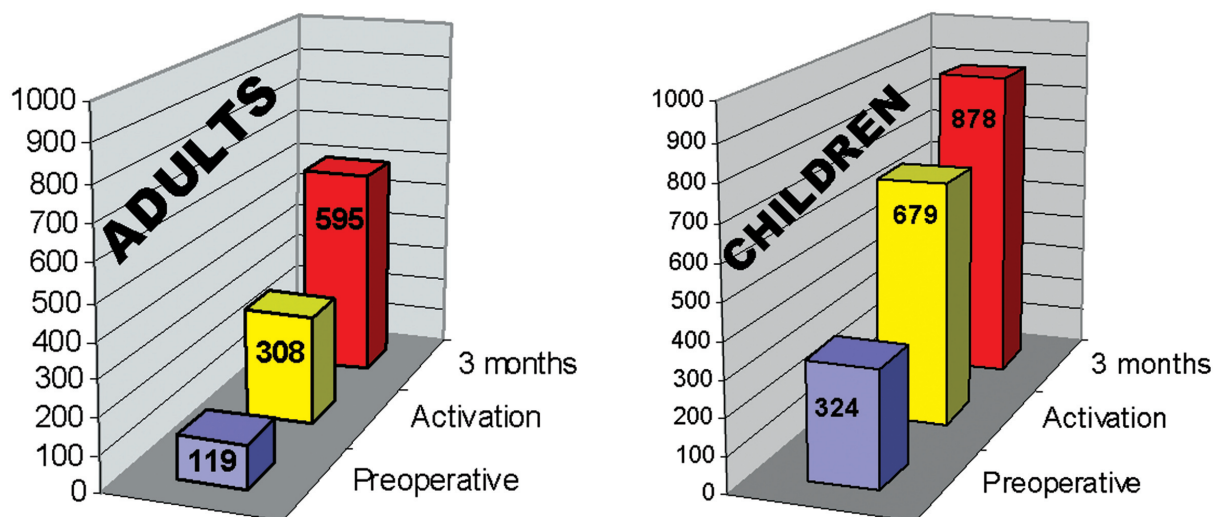


Figure 5. Results of speech discrimination (AHEPA Hospital protocol)

The average performance results in both categories are displayed (school-age children and adults with acquired deafness), in % of discrimination tests results, before cochlear implantation, during activation of the cochlear implant, and after 3 months follow-up.

operation, we know that the cochlear implant is functioning correctly, that the patient is perceiving hearing signals, and we possess valuable information concerning the E.A.B.R. and N.R.T. thresholds which will assist us in further fitting and mapping the cochlear implant, mainly in children.

With preoperative vaccinations (for Streptococcus Pneumoniae and Hemophilus Influenza) and antibiotic treatment during and after the implantation, especially in children, no serious infections complications have occurred. Three cases of transient delayed facial nerve paresis, with complete recovery of the neural function after 2 - 5 months were recorded.

The activation and adjustment, that is, the programming of the cochlear implant begins on average 2 weeks after the operation, followed by regular evaluations and fine-tuning which are more frequent in children. Each additional programming undergoes assessment based on the patient's performance in the auditory perception of sounds and speech, and the discrimination of the individual elements of phonation based on a protocol we have developed regarding the requirements of the Greek language.

Results

None of the 150 patients who underwent cochlear implantation suffered any major intraoperative compli-

psychometrics tests about quality of life (Figure 6).

We observed better and faster results in auditory performance and speech understanding in those children who had followed a primary special auditory and speech training. This is probably due to a better auditory memory reserve in these children.

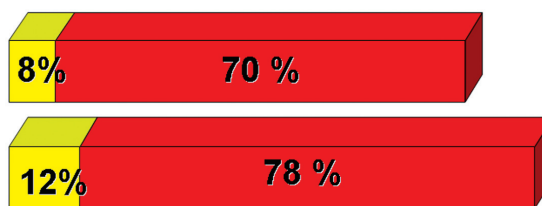


Figure 6. Results of psychometrics tests “Sanders” about quality of life, in 150 implanted patients, before cochlear implantation and after 3 months follow-up

The performance of the 9 homogeneous groups of cochlear implant users (Table 1), in the part of AHEPA Hospital protocol for identification (Figure 7) can be dividing in three main groups:

The first with excellent results is composed of prelingual or congenital deaf children with some benefits from hearing aid amplification and implanted during school, adults normally hearing in the past and recently totally deaf and adults hearing aid users in the past and recently totally deaf.

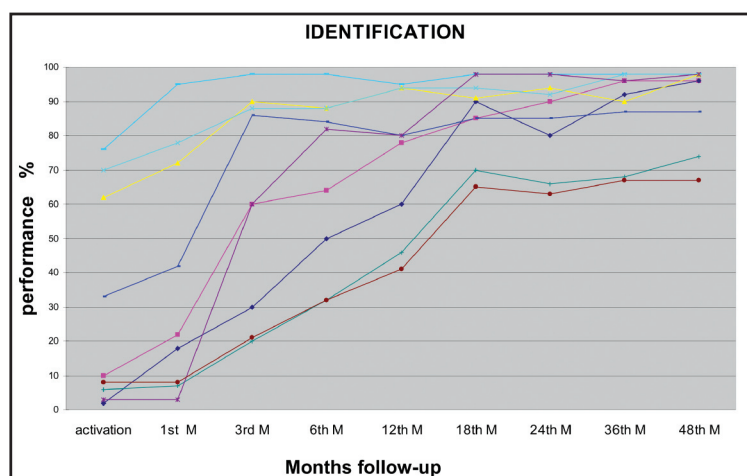


Figure 7: Follow up results of the nine homogeneous groups, in the part of AHEPA Hospital protocol for identification

The second group with good but delayed results is composed of prelingual totally deaf children implanted between 12 month and 5 years (pre-school age), prelingual totally deaf children implanted between 5 and 12 years age (school age), perilingual totally deaf children implanted between 3 and 5 years (pre-school age), perilingual totally deaf children implanted between 5 and 12 years (school age) and adults, normally hearing in the past and totally deaf over 10 years.

The third group of prelingually deaf implanted in adult age has delayed and sufficient results.

In the part for recognition of AHEPA Hospital protocol (Figure 8) we have:

The group that obtained excellent results is composed of perilingual totally deaf children implanted between 5 and 12 years (school age), adults normally hear-

ing in the past and recently totally deaf and adults hearing aid users in the past and recently totally deaf.

The group that obtained good but delayed results is composed of prelingual totally deaf children implanted between 12 month and 5 years (pre-school age) and adults normally hearing in the past and totally deaf over 10 years.

Sufficient results for all the other groups.

Discussion

The favorable results of cochlear implantation largely depend on the correct programming of the implant (fitting and mapping) in the post-operative stage. Programming is extremely specialized, complex, and crucial for the development of the abilities pertaining to auditory and expressive

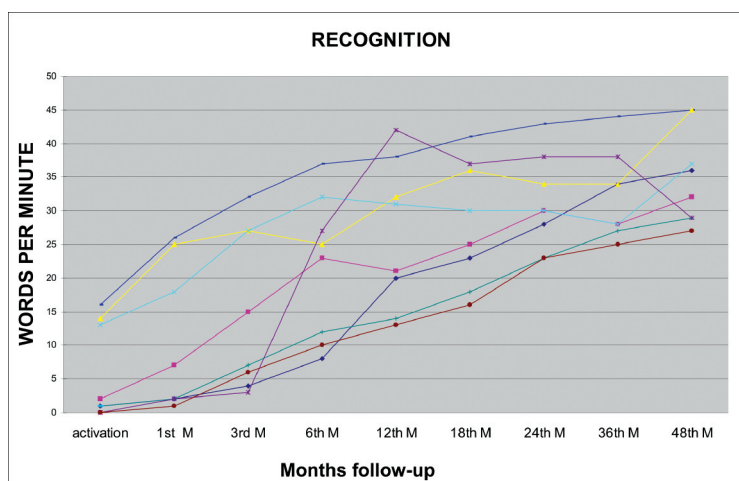


Figure 8: Follow up results of the nine homogeneous groups, in the part of AHEPA Hospital protocol for recognition

Table 1: The nine homogeneous groups of cochlear implant users, according to the age and the acoustic memory

■	Group 1. Prelingual totally deaf children implanted between 12 month and 5 years (pre-school age).
◆	Group 2. Prelingual totally deaf children implanted between 5 and 12 years age (school age).
◆	Group 3. Perilingual totally deaf children implanted between 3 and 5 years (pre-school age).
◆	Group 4. Perilingual totally deaf children implanted between 5 and 12 years (school age).
◆	Group 5. Prelingual or congenital deaf children with some benefits from hearing aid amplification, implanted during school.
◆	Group 6. Adults, normally hearing in the past and recently totally deaf.
◆	Group 7. Adults, hearing aid users in the past and recently totally deaf.
◆	Group 8. Adults, normally hearing in the past and totally deaf over 10 years.
◆	Group 9. Prelingually deaf implanted in adult age.

(speech) communication of the individual, and is based on the individualized tuning of specific parameters for each patient. In our department, from three speech coding strategies (SPEAK, CIS and ACE) we selected the Advanced Combination Encoders (ACE) strategy¹¹⁻¹⁴. We determine for each electrode the hearing threshold (T level) in base of NRT-Threshold and for the comfort level (C level) we evaluate stapedius muscle reflex and then we adjust the

parameters that influence the signal's profile, filtering, and the mode and shape of the final stimulus.

Adult patients with cochlear implant had very good to perfect speech recognition. Specifically, improvement was partial in the three months follow-up, but more spectacular after six months. The individual differences observed at the third month became less pronounced six months after cochlear implantation.

Performance was also observed to be dependent on the duration of deafness^{15,16}. Implant users with deafness lasting less than 5 years, presented rapid improvement and in several such cases communication without lip-reading was practicable at the third month following the first adjustment. Similar results were observed in users with longer-term deafness (over 5 years) following regular logotherapeutic intervention.

In children a number of demographic factors have been shown to influence performance results.

It is evident that earlier implantation yields superior cochlear implant performance in children, because we utilize the mental plasticity to create acoustic memory^{17,18}. That's why congenitally or prelingually deafened children implanted prior to age 3 years may yield improved results¹⁹⁻²¹.

Children using cochlear implants have acquired speaking and listening skills and have developed a spoken language system that is beyond what previously could be achieved with hearing aids. Those who are implanted before the third year of age and use oral communication have the best prognosis for developing intelligible speech and age-appropriate language abilities.

Conclusions

In our patients, we observed better and faster results in the following categories:

a) Children with congenital deafness operated before the third year of age, who underwent special preoperative logotherapy programs.

b) Post-speech acquisition adults with recent deafness.

c) Post-speech acquisition adults with chronic deafness. In these patients, despite the development of speech, sound perception after cochlear implantation is difficult, while in those patients with residual hearing the perception of sound is easier, possibly due to the continuing existence of auditory memory reserve.

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