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ORIGINAL ARTICLE

Cochlear implantation in Timisoara

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OBJECTIVE: The most common indication for cochlear implantation includes profound/complete sensorineural hearing loss, with no benefit from a hearing aid, due to lesion in the cochlea.

STUDY DESIGN: Between January 2003 and December 2005 in the ENT Department of the University of Medicine Timisoara, 24 patients were fitted with cochlear implants. Devices used include: Combi 40+ (14), Pulsar CI 100 (8); and Tempo+ (1; Med-El, Innsbruck, Austria); and 1 Nucleus 24K (Cochlear Corporation, Lane Cove,. NSW, Australia). Patients were evaluated audiologically (pure-tone thresholds, vocal audiometry, electrocochleography, brainstem auditory evoked response, assessment of benefit offered by hearing aid) and psychologically and through medical examination, computed tomography scans of the temporal bone, and magnetic resonance imaging of the cochlea. Family history was also taken.

RESULTS: Postoperative rehabilitation started in our Speech Therapy Department 1 month after surgery, with additional evaluations at 3, 6, 9, 12, 18, and 24 months postoperatively and then every year. The evaluation methods were directed toward psychologic and logopedic criteria.

CONCLUSION: Cochlear implant is a well-known and largely accepted method for the treatment of profound sensorineural hearing loss.

Hearing loss, especially in children, is one of the most challenging pathologies in otolaryngology. Cochlear implantation is an excellent option in the treatment of patients with profound sensorineural hearing loss. This device restores sound perception through electronic equipment with 2 components: an inner processor implanted in the cochlea and an external processor that converts external sound into electric impulses to be transmitted to the inner processor. Screening, evaluation, early diagnosis, surgical treatment, and rehabilitation of children with profound sensorineural hearing loss raises different problems from those encountered with adults.

The ENT Department Timisoara became the second National Cochlear Implant Center in Romania since January 2003. Our continuing concern has been to offer the best chances to children with hearing impairment by improving early diagnosis and lowering the age of implantation. Because early diagnosis of hearing-impaired children must become a priority in Romania, we have introduced screening of newborns at risk. We also know age of implantation is crucial for the future development of children with profound sensorineural hearing loss. The cochlear implant will help these children both in speech development and in understanding. There remains debate whether all newborns should be screened for hearing impairment or if it is indicated only in newborns at considerable risk for congenital deafness (eg, those with family history of deafness, maternal disease during pregnancy [rubella disgravidia, toxoplasmosis, application of ototoxic drugs], low birth weight, prematurity, difficult delivery, obstetrical trauma, jaundice, meningitis, flu, or ototoxic drugs administered to the newborns.[1]

Screening consists of detecting otoacoustic response in the newborn. Absence of otoacoustic response indicates the need for further investigation, such as brainstem auditory evoked response (BAER). Many children diagnosed with hearing loss will benefit from a hearing aid. A cochlear implant is considered in patients with profound sensorineural hearing loss where there is no clear benefit from a hearing aid. The selection of patients for cochlear implantation was made on specific criteria: audiologic, medical, imaging, and psychologic.

The general indications for cochlear implantation include profound/complete sensorineural hearing loss, with no benefit from a hearing aid, due to a lesion in the cochlea. There are no clear prognostic factors regarding the outcome of patients with cochlear implant, but it is known that the longer the period of profound deafness, the poorer the results for the patient. Children born deaf receive the maximum benefit if they undergo implantation before the age of 4. If hearing loss occurs after the acquisition of speech, the results are far better, particularly if the period of deafness is less than one third of the patient's life[2].

MATERIALS AND METHOD

In the ENT Department of the University of Medicine Timisoara, 24 patients (12 boys) received cochlear implants between January 2003 and December 2005. Most procedures (n=22 [91.6%]) were performed in patients with prelingual hearing loss (mean age, 4.3 years). Two patients had postlingual hearing loss (8.4%); 1 patient with Cogan's syndrome and 1 with sensorineural hearing loss postmeningitis. Distribution of patients by age is shown in Figure 1.

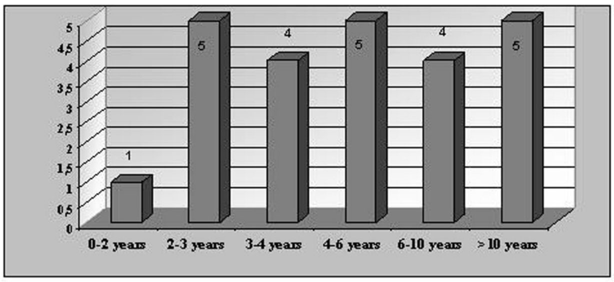

Figure-1: Age distribution

Several devices were used: Combi 40+ (14), Pulsar CI 100 (8); and Tempo+ (1; Med-El, Innsbruck, Austria); and 1 Nucleus 24K (Cochlear Corporation, Lane Cove,. NSW, Australia)(1). The etiology of deafness was investigated in every case (Figure 2).

Each patient was carefully evaluated. The audiologic evaluation included pure-tone thresholds, vocal audiometry, electrocochleography, BAER, and assessment of benefit offered by hearing aid. Medical examination determined general health status of the patient and investigated the external and middle ear. Imaging was of utmost importance; we ordered

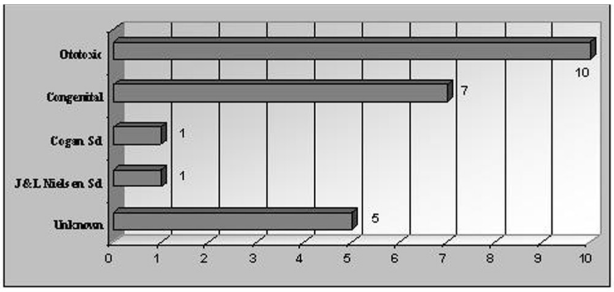

Figure-2: Distribution of patients by etiology.

computed tomography scans of the temporal bone and magnetic resonance imaging of the cochlea, inner ear canal, and acoustic nerve. The patient was evaluated psychologically, and the family was assessed for their ability to provide support during the entire rehabilitation process. We operated on children who would benefit most from a cochlear implant, including a 12-month-old boy—the youngest child with a cochlear implant in Romania.

The evaluation methods focused on psychologic and logopedic criteria and are listed in Table 1.

RESULTS

The average duration of the 24 operations was 3 hours. Tolerance to general anesthesia was very good, even in very young children; we found no differences in tolerance between the very young children and the older ones. We created a double flap in order to avoid flap necrosis, wound dehiscence, and implant extrusion. In each patient, we tried to maintain a very thin bone shell over the dura to avoid injury, reducing the risk of meningitis. In our statistics, we had no major complications, such as flap necrosis with extrusion of the implant, meningitis, or facial palsy. The only postoperative incident encountered was nausea and vomiting in the first 24 hours, but this happened only in children below the age of 3. Postoperative rehabilitation

Table 1. Postoperative evaluation methods

Test	Description	Age of child
LiP	Evaluates auditory perception for sounds, speech, and developing hearing capabilities in children with a cochlear implant	All ages (for young patients, only sound detection may be possible).
MTP	Demonstrates ability to identify different syllable patterns varying from 1 syllable to 2 syllables with different stresses to more than 2 syllables; demonstrates ability to identify words within correct syllable pattern	≥2 years
Closed-Set Monosyllabic Words	Demonstrates ability to identify familiar monosyllabic words. Results of this test are comparable internationally	≥3 years
Speech Perception Test for Hearing-Impaired Children	Demonstrates ability to identify coarticulated familiar words. It is not necessary that the child understand the meaning of the sentences. Results of this test are comparable internationally	≥4-5 years
Open-Set Monosyllabic Words	Demonstrates ability to recognize monosyllabic words	≥4-5 years
GASP	Demonstrates ability to recognize simple questions. Results of this test are comparable internationally	≥4 years
Questionnaires for parents and teachers		
MAIS	Assesses child's use of and confidence in the implant. The questionnaire also concentrates on the child's confidence in hearing and the growing capability to associate a meaning with a sound	All ages
MUSS	Assesses the child's control over his/her own voice, the creation of sounds which are similar to language, and his/her communication strategy.	All ages

LiP = Listening Progress Profile; MTP = Monosyllabic-Trochee-Polysyllabic GASP = Glendonald Auditory Screening Procedure; MAIS = Meaningful Auditory Integration Scale; MUSS = Meaningful Use of Speech Scale.

started 1 month after surgery, and progress was evaluated in our Speech Therapy Department at 3, 6, 9, 12, 18, and 24 months postoperatively and then every year.

The averages results obtained from linguistic tests were evaluated at 18 and 24 months for 16 and 20 patients, respectively (Table 2).

DISCUSSION

For centuries, people believed that only a miracle could restore hearing to the deaf. Forty years ago, scientists first attempted to restore normal hearing to deaf patients by electrical stimulation of the auditory nerve. The first experiments were discouraging because patients reported that speech remained unrecognizable. However, as researchers kept investigating different techniques for delivering electrical stimuli to the auditory nerve, the auditory sensations elicited by electrical stimulation gradually came closer to sounding more like normal speech. Today, a prosthetic device, called a cochlear implant, can be implanted in the inner ear and can restore partial hearing to profoundly deaf people. Some individuals with implants can now communicate without lip reading or signing, and some can communicate over the telephone. The success of cochlear implants can be attributed to the combined efforts of scientists from various disciplines including bioengineering, physiology, otolaryngology, speech science, and signal processing. Each of these disciplines contributed to various aspects of the design of cochlear prostheses. Signal processing, in particular, played an important role in the development of different techniques for deriving electrical stimuli from the speech signal.

Designers of cochlear prosthesis faced the challenge of developing signal processing techniques that would mimic the function of a normal cochlea.

Sound undergoes a series of transformations as it travels through the outer ear, middle ear, inner ear, auditory nerve, and into the brain. Hair cells and the basilar membrane are responsible for translating mechanical information into neural information. If the hair cells are damaged, the auditory system has no way of transforming acoustic pressure waves (sound) to neural impulses and that, in turn, leads to hearing impairment. The sound never makes it all the way to the brain because of this broken link. Hair cells can be damaged by disease (eg, meningitis, Meniere's disease), congenital disorders, and drugs among other causes. Damaged hair cells can subsequently lead to degeneration of adjacent auditory neurons, and if a large number of hair cells or auditory

Table 2.

Test	Possible answers (Average)	Chance score (Average)
LiP Test		
12 patterns	68%	30%
12 words	56%	6%
MTP Test		
6 patterns	66%	24%
6 words	49%	18%
3 patterns	88%	22%
3 words	81%	16%
Close Set Monosyllabic word	70%	15%
Close Set Sentences (Tyler-Holstand)	61%	10%
GASP Test	48%	2.5%

neurons throughout the cochlea are damaged, the diagnosis is profound deafness. Research has shown that the most common cause of deafness is the loss of hair cells rather than the loss of auditory neurons[3]. This was encouraging news for cochlear implant research because it meant that the remaining neurons could be excited directly through electrical stimulation. The science behind cochlear prosthesis is based on bypassing the normal hearing mechanism and stimulating the remaining auditory neurons directly.

Research has shown that the intelligibility of speech produced by children with cochlear implants improves over time[4-6]. Osberger and colleagues measured the intelligibility of 29 prelingually deafened children (ie, deafened before or during the development of speech and language skills) for 4 years after implantation[5].

Significant changes in speech intelligibility were not observed until after the children had worn their cochlear implant devices for at least 2 years. In fact, the mean intelligibility score of children with implants after 2.5 years of use was found to be higher than the mean score of children wearing hearing aids (with thresholds between 100 to 110 dB HL) for the same period of time.

It has also been shown that the speech perception abilities of children with implants improve steadily over time.[2,7,8] In a longitudinal study on the perception abilities of 39 prelingually deafened children, Miyomato and colleagues demonstrate a steady improvement on speech recognition performance for prelingually deafened children over a 3-to-4-year period of implant use.[7]

In addition, postlingually deafened children have been found to perform better on tests of open-set speech understanding compared with prelingually deafened children. Speech perception and speech production abilities of children with cochlear implants continue to improve over a 4-year period following implantation. Auditory performance is defined here as the ability to discriminate, detect, identify, or recognize speech. The factors responsible for such variability in auditory performance have been the focus of research for many years.[9-12] Some of the factors that have been found to affect auditory performance include number of surviving spiral ganglion cells, electrode placement and insertion depth, electrical dynamic range, and signal-processing strategy. There are also factors, such as patient's level of intelligence, which are unrelated to deafness but may also affect auditory performance.

In 1961, House, Doyle, and others separately described approaching the auditory nerve via the scala tympani. Simmons, 3 years later, placed an electrode directly into the modiolar segment of the auditory nerve through the promontory and vestibule and demonstrated that some tonality could be achieved. House and Michelson refined the clinical applications of electrical stimulation of the auditory nerve via the scala tympani implantation of electrodes.[12] In 1972, the first commercially available device was developed. It consisted of a wearable speech processor that interfaced with the House 3M single-electrode implant. In 1984, multiple-channel devices were introduced and became the approach of choice based on enhanced spectral perception and open-set speech understanding. Miyamoto and associates at Indiana University reported on 55 children who were born deaf or acquired hearing loss prior to age 3.[7] The average child in this group had 63% open-set speech understanding. Likewise, Gantz and colleagues at Iowa University, in a study of 54 implanted children, reported that after 4 years of use, 82% of prelingually deafened children achieved open-set word understanding[3]. Waltzman and associates at New York University reported on 14 children who were prelingually deafened, received cochlear implants prior to age 3 years, and had been followed for 2 to 5 years. Improvement in perception was found in all aspects of hearing.[13] All of these children had open-set speech discrimination, used oral language as their primary method of communication, and attended regular school. Current studies indicate that early implantation, before 6 years of age, is important for maximal auditory performance. These findings are consistent with the generally accepted theory that the shorter the period of auditory deprivation, the better the performance with any type of sensory aid. It has been shown that speech intelligibility following implantation is twice that typically reported for children with hearing impairments and continues to improve over time. It is also clear that speech produced by children with implants is more accurate than produced by children who use vibrotactile devices or hearing aids.

The results presented in our small study are encouraging both for operative and linguistic results emphasizing that the cochlear implantation is a safe procedure with very good results in severely hearing-impaired children.

CONCLUSION

The cochlear implant is a well-known and largely accepted method for the treatment of profound sensorineural hearing loss especially when the criteria of selection of the patients are fulfilled.

Cochlear implant in children older than 1 year causes no special problems compared with older children, when accomplished by a well-trained team. There is a trend toward implantation in very young children, ie, younger than 1 year. There is still debate regarding this issue, especially concerning the accuracy of the early diagnosis in the first 3 months, and the criteria for evaluating the benefit of a hearing aid in such young children.

We strongly believe that, in prelingual deaf children, it is recommended to perform implantation before the age of 4 years to enable children to enter into mainstream schooling by age 7 or 8 years. It is also of utmost importance that profoundly deaf children with cochlear implants be entered into a rehabilitation program.

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