Analysis of factors affecting hearing preservation after cochlear implantation.

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Introduction:

It is generally accepted that cochlear implants (CI) may be offered to individuals who have little potential for speech understanding, due to the limited benefits of acoustic stimulation using a well-fitted HA, although the definition of "limited benefits" has been altered many times over the last 20 years. Originally, only those patients who had very little residual hearing and who showed no demonstration of sound awareness using HAs were considered to be candidates for cochlear implantation. Gradually, the criteria for implantation have been expanded to include patients with residual hearing (Di Nardo et al. 2007). This change in the criteria of qualification was supported by the observation that implanted patients performed better than individuals who used HAs and had comparable hearing loss. The opinion that preservation of any residual hearing must be an aim of all CI surgery has recently been expressed by authors reporting on the use of combined electric acoustic stimulation (EAS) (Skarzynski et al. 2007, James at al. 2005). Although preservation of hearing has been extensively reported, there are large individual differences in the degree of hearing loss after cochlear implantation (Skarzynski et al. 2002, Kifer et al. 2004, James et al. 2005).

Cochlear implantation may introduce damage to functional cochlear structures of inner ear and cause subsequent degeneration of neural tissue. Electrode insertion has the potential to trigger several mechanisms of cell death, including necrosis and different forms of programmed cell death (apoptosis). Therefore hearing preservation achieved after cochlear implantation may be influenced by a number of factors related to the demographic characteristic of the sample, electrode design or surgical technique. Factors influencing the preservation of residual hearing following cochlear implantation or reimplantation are still a matter of debate.

Objective:

The objective of the study was to assess hearing preservation in a large group of patients in order to identify factors that may be associated with the preservation after the insertion of the electrode to the inner ear.

Material and Method:

The study is a retrospective analysis of data of patients with residual hearing selected from the entire group of patients implanted at the Institute of Physiology and Pathology of Hearing from 1992 to 2008. Patients were older than 5 years of age and with preoperative hearing threshold better than 120 dB at all frequencies: 125, 250 and 500 Hz in the ear selected for surgery were included to the study. The criterion of age was implemented in order to obtain data from tonal audiometry. Audiometric testing was performed with the use of Madsen Itera, Madsen Midimate 622, Madsen Orbiter, Siemens SD50, according to ANSI standards (ANSI, Katz, Kramer).

According to the acceptation criteria, 550 patients were qualified to be included in the group: 331 females (60%) and 219 males (40%). The right ear was implanted in 64% of the female population and 60% of the male population. The age range of patients selected for the group was 5 to 77 and 2 months, with the average age was 25.68 years. Children younger than 19 years of age made up 32% of the group. In 50% of the group the etiology of hearing impairment was unknown; in 17% - genetic

(35 delG mutation); in 7% - meningitis; in 13% - ototoxicity; in 3% - head trauma; in 5% - rubella; in 5% - prematurity. Patients were implanted with different systems from 3 companies: Med-El, Cochlear, Advanced Bionics, with the use of the following different electrodes: C40, C40+, C40+Flex, C40+M, N22, N24R, N24RCA, N24RST, N24M, HF Helix. The electrode was inserted through a cochleostomy in 57% of patients, through the round window in 43% of patients.

Variables like gender, age at the surgery, etiology, degree of hearing loss, surgical technique and type of electrode were analyzed with the use of general linear model.

Results:

The results obtained in this large group of patients show the advantage of the round window over the cochleostomy approach in hearing preservation. This is manifested in significantly smaller threshold deterioration after the surgery for all frequencies; with $p<0,0001$ for 250, 500 and 1000 Hz and $p<0,001$ for 125 Hz. (Figure 1)

Age is the second factor associated with hearing preservation; changes in post operative threshold at 125, 250 and 500 Hz are significantly smaller for patients implanted before 19 years of age, with $p<0,0001$ for 125, 250 Hz and $p<0,001$ for 500 Hz. Fig. 2.

Discusion and Conclusion:

Results obtained from this large cohort of patients confirm that hearing can be preserved to a large extent after insertion of the cochlear implant electrode. The round window approach demonstrates an advantage over cochleostomy in hearing preservation. This can be explained by known potential problems with cochleostomy, such as (a) perilymph loss and acoustic trauma caused by drilling; (b) formation of new bone within the cochlea, caused by the presence of bone dust; (c) the risk of osseous spiral lamina injury; and (d) damage due to infection, which may cause the formation of fibrous tissue. Some authors have used temporal bone studies to address these issues and have demonstrated the supremacy of the 'round window' approach over cochleostomy in preventing trauma to cochlear structures (Adunka et al. 2004)

Additionally, implantation before 19 years of age improves the likelihood of hearing preservation. This finding is in line with the observation made by Kiefer et al. (1998) that hearing preservation was superior in children compared with adults. One can speculate that this outcome is facilitated by higher plasticity of the inner ear in children or because any peripheral hearing loss in the operated ear might be compensated for by a gain in hearing induced by maturation of the auditory pathway (Kiefer et al. 1998).

**References**


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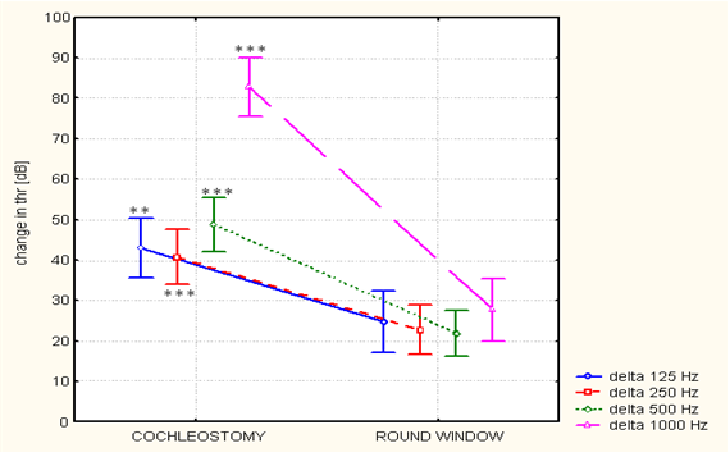


Fig. 1. Changes in pre- and postoperative threshold at frequencies 125, 250, 500 and 1000 Hz for two surgical techniques: cochleostomy and round window approach.

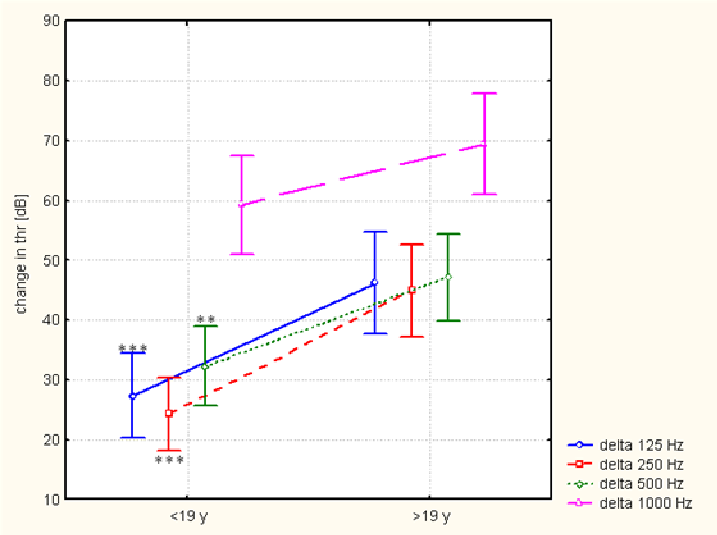


Fig. 2. Changes in pre- and postoperative threshold at frequencies 125, 250, 500 and 1000 Hz for patients implanted before and after 19 year of age