The role of soft surgery concept for residual hearing preservation during cochlear implantation

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Introduction: Preservation of residual low-frequency hearing in cochlear implant recipients is achievable and desirable for many reasons. Its importance cannot be underestimated in the light of the added benefit of hearing in noisy conditions, better music quality and more natural sound. Hearing preservation means that the neural structures in the cochlea remain undamaged and give recipients the chance to benefit from future therapies and technologies.

The concept of electrical and acoustic stimulation involves electrically stimulating the nonfunctional, high-frequency region of the cochlea with a cochlear implant and applying a hearing aid in the low-frequency range. The principle of preserving low-frequency hearing by a "soft surgery" cochlear implantation could also be useful to the population of children who might profit from regenerative hair cell therapy in the future.

Material and methods: 14 profoundly hearing impaired children with some residual hearing who underwent cochlear implantation using a modified "soft surgery" protocol at the ENT clinic of MMA - Sofia. For our study we defined functional residual hearing as at least one threshold better than or equal to 75dB HL at 250, 500, or 1000Hz. Pre-implant and post-implant pure tone thresholds and pure tone averages (PTA) were calculated from unaided audiograms for 250, 500, and 1000Hz. Hearing preservation was determined as average loss of less than 20dB for the 3 tested frequencies. All audiometric testing was performed using calibrated audiometers in a double-walled sound booth using insert earphones for unaided testing. Post-operative audiograms are obtained 6 months after operation at the time of fitting after processor switch on.

Surgical Technique: Each child received a perioperative, weight appropriate dose of intravenous dexamethasone of 0.25 mg/ kg. A standard mastoidectomy was performed through postauricular incision. A standard bony well for the internal processor was created. Cochleostomy was performed manually and its size limited to the needed for the electrode array. The surgeon avoided suctioning of perilymph, bone dust or blood entering the cochlea. The electrode array was then inserted to the manufacturer's recommended depth into the scala tympani with its natural curvature directed away from the cochlear partition. The cochleostomy was sealed with a small amount of connective tissue. The receiver was seated in position before opening the endosteum of the cochleostomy. The periosteum was then closed completely over the receiver/stimulator and the electrode. Soft tissues were closed in the standard way.

Results: Complete hearing preservation was achieved in 6/14 patients (42.8%), while 8/14 (57.2%) had worse preservation or no response at the limits of the audiometer. The pre- to post-operative low frequency PTA had a mean reduction of 16.5dB.

Discussion: The most important factor contributing to possible cochlear damage during or after the surgery is mechanical damage during electrode insertion including fractures of the osseous spiral lamina, disruption of the basilar membrane, tearing of the lateral spiral ligament, and leakage of traumatized blood vessels. This causes secondary intracochlear fibrous tissue formation and loss of residual hearing. That is not necessarily the case anymore. In fact, we are seeing considerable preservation of acoustic hearing with standard electrodes. It is primarily due to minimally traumatic surgery and the new atraumatic electrode design. At the time of implantation, very few patients lose all their residual low-frequency hearing. The cause of this loss is still unknown; some hypotheses suggest an immune reaction to the electrode, loss of afferent spiral ganglion neuron synapses at the hair cell related to the combination of acoustic amplification and electrical stimulation, or even an initial injury from noise-induced hearing loss.

Steroids have been shown to reduce noise-induced cochlear damage and hearing loss and to speed up recovery after noise trauma. However, their efficacy has been controversially discussed due to a lack of adequate clinical trials. A single-shot intracochlear glucocorticoid application appears to be a promising method for reducing progressive hearing loss caused by electrode insertion trauma due its long-term effects, such as reduction of inflammatory processes. Further in vitro studies with otoprotective drugs believed to bring new perspectives on an improved rate of hearing preservation are promising.

While residual hearing preservation has been observed in adults, it is not as well documented in children. This study is the result of reviewing our pediatric cochlear implant population to quantify residual hearing preservation using a standard length array with full insertion. We found that most pediatric patients in our study had some preservation of hearing and nearly half had complete preservation of hearing following cochlear implantation with full-length arrays. This observation raises the possibility that refinements in surgical technique and electrode design may allow reliable residual hearing conservation with full length cochlear implant array insertions.

Conclusion: It has been suggested that even very limited preserved residual hearing below 500Hz could be sufficient to significantly improve speech perception outcomes. However, minimizing the impact of cochlear implantation on residual hearing remains challenging, as damage to the cochlea can worsen or destroy this residual hearing in the majority of patients. In response to the desire to preserve residual hearing, special focus has been placed on the "soft surgery" technique. Residual hearing is very important for the use of electroacoustic stimulation.

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