THE PARTICULARITIES OF AUDITORY PERFORMANCE EVALUATION IN BIMODAL HEARING REHABILITATION – COCHLEAR IMPLANT AND HEARING AID

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ABSTRACT

Introduction Cochlear implantation is the standard intervention for hearing and speech rehabilitation of the patients with bilateral severe and profound hearing loss. The concomitant usage of a hearing aid in the contralateral ear offers a better sound localization and speech understanding in complex noise situation. **Materials and methods** The study group included twelve patients, adults and children, implanted in our cochlear implant centre, who still wear a hearing aid in the opposite ear. For all the subjects we considered the age at the implantation, the aetiology and the onset of the hearing loss, pre- and postimplantation audiological evaluation with the cochlear implant and with the hearing aid. **Results** The free field pure tone thresholds with the cochlear implants are superior to those with the hearing aid in the opposite ear. The cochlear implant offers a better audition for the high frequencies comparing to the reverse situation of the hearing aid. **Discussions:** The particularity of the auditory performance evaluation in bimodal rehabilitated patients – cochlear implant in one ear and hearing aid in the opposite ear is represented by the necessity to create a particular audiological evaluation algorithm adapted to that situation. **Conclusions** The results of the present study suggest an advantage of cochlear implant usage in conjunction with a hearing aid in the opposite ear. The cochlear implant alone performs better than the hearing aid alone, and the bimodal condition is superior to the cochlear implant alone. The bimodal hearing rehabilitation requires a regularly auditory re-evaluation to establish the limit line between the benefit / less benefit of bimodal hearing.

Key words: bimodal hearing, cochlear implant, hearing aids

INTRODUCTION

Cochlear implantation has become the standard intervention for providing improved communication benefits to individuals with bilateral severe and profound hearing loss. In early stages of this technology, cochlear implantation was offered as a treatment to individuals with deafness that derived essentially no speech understanding from conventional amplification. As the evidence for enhanced speech recognition accumulated, coupled with technological advances, it became apparent that individuals with cochlear implants received benefits superior to those of many individuals with severe and profound hearing losses who used acoustic amplification [1].

It is well recognized that people with normal hearing combine auditory information from both ears to locate the sources of sounds, and to understand speech in complex listening situation. The benefits of binaural hearing are associated with three primary binaural mechanisms: the head shadow effect, binaural squelch and binaural summation [2]. In the case of patients with a unilateral cochlear implant and a hearing aid in the contralateral ear presents potentially a different situation in that acoustic and

electrical signals which offer different intensity levels, spectral information and quality must be integrated [3, 4].

As an increasing number of patients with audible residual hearing undergo cochlear implantation, interest has grown in examining the advantages of bimodal stimulation. There is recent evidence pointing to binaural advantages for better speech recognition in quiet and noise as well as to improved sound localization and functional performance when a hearing aid is used in conjunction with a cochlear implant [3, 5, 6, 7].

Ching et al. (2006) recommended bimodal device fittings as standard care, in the absence of contraindications, in adults and paediatric unilateral cochlear implants recipients who have residual hearing in the non-implanted ear [6]. The decision on the part of the recipient to continue hearing aid use in the non-implanted ear and on the part of the audiologist to recommend a bimodal fitting may be affected by several factors including patient's experience with hearing aids, costs, aesthetics, comfort, clinician's experience and clinical resources such as the additional time required for fitting both devices (personal communication).

The main concerns of the clinician might be that signal interference may occur when electrical and acoustic stimulation is combined [4]. Research indicates that prolonged periods of profound deafness without auditory stimulation result in changes in both the peripheral auditory pathways and the cortical areas of the brain [8, 9]. An enhanced understanding of the potential advantages of bimodal hearing is particularly important in view of the recent trend towards bilateral implantation [5, 10].

In this study, we assessed the hearing performances of twelve cochlear implanted patients who still wear a hearing aid in the opposite ear and tried to address the advantage of cochlear implant usage in conjunction with a hearing aid in the opposite ear. The study is intended to be a first step in a larger investigation aimed to offer support for clinical decision-making related to bimodal fitting.

MATERIALS AND METHODS

We realized a retrospective case series review. The study group was selected from the total number of patients implanted in our clinic in the eleven-year period, from 2000 to 2011. The selection criteria were the usage of a hearing aid in the contralateral ear after the adaptation to their cochlear implant. The database was built from the recordings of the audiological assessment of the patients during the clinical sessions in the cochlear implant centre. We extracted information as the age at implantation, severity and duration of hearing loss, deafness aetiology, audiological pre-implant evaluation: pure tone audiometry and speech recognition tests in unaided condition and with one side or bilateral hearing aids. The post-implant evaluation involved the free field pure tone audiometry with the cochlear implant and with the hearing aid. We considered for our study the hearing threshold levels identified in the last fitting session which corresponded to the best auditory rehabilitation level for the patient. The data were statistically processed.

RESULTS

The study group included 12 patients (two adults and ten children) with cochlear implant who still use a hearing aid in the opposite ear.

The age at the implantation varied between 2 years and 10 months to 53 years (Fig. 1), with an average of 8 years and 2 months.

The aetiology of the hearing loss was autoimmune in one case, genetic associated with malformation in one case, genetic in two cases, caused by ototoxicity in three cases and unknown in four cases (Fig. 2). The onset of the hearing loss was prelingually in 25% of the cases, perilingually in 33 % of the cases

and postlingually progressive in 42 % of the patients (Fig. 3).

The levels of free field pure tone thresholds determined with the cochlear implant and with the hearing aid were compared (Fig. 4).

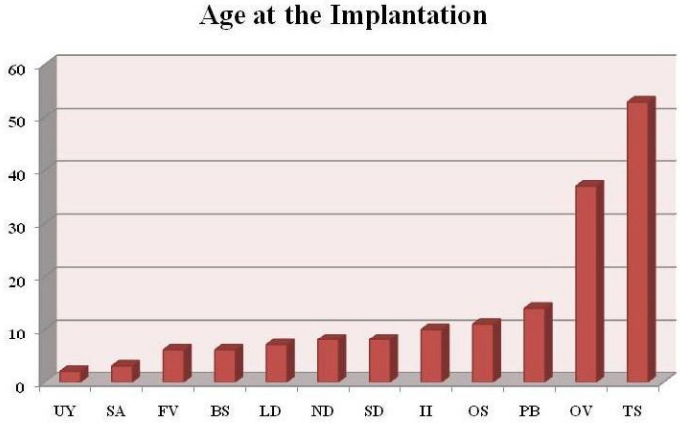

Fig. 1. The age distribution of the patients at the moment of cochlear implantation

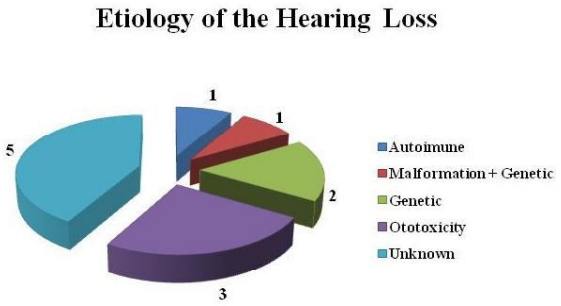

Fig. 2. The aetiology of the hearing loss

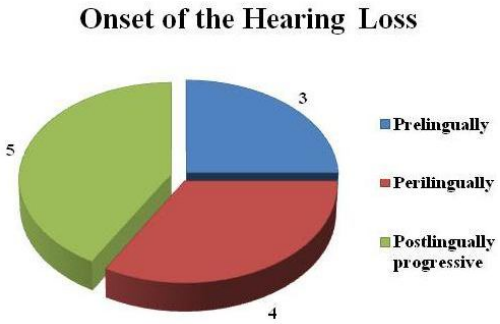

Fig. 3. The onset of the hearing loss

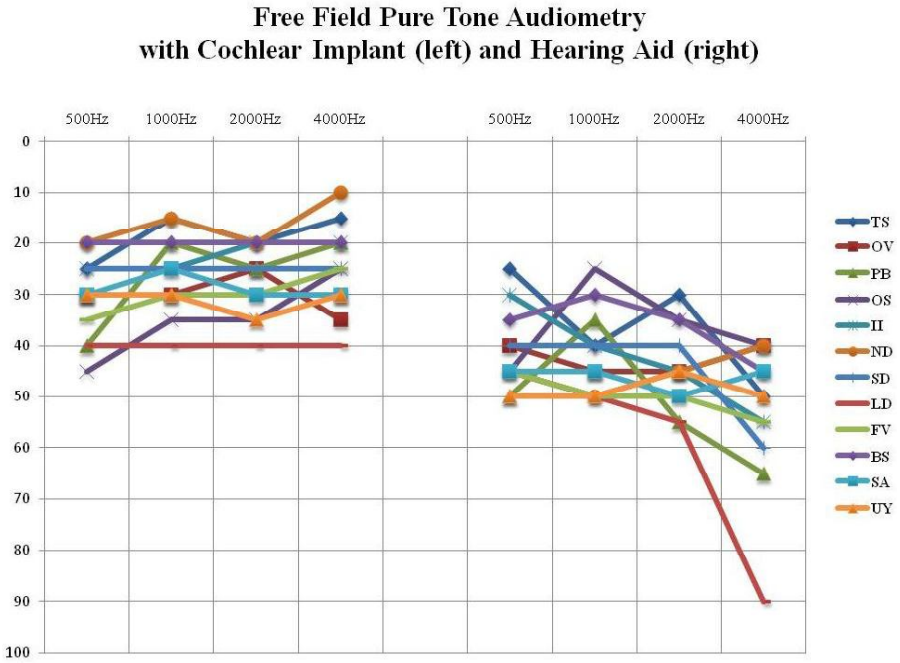

Fig. 4. Comparison between free field pure tone audiometry with cochlear implant (left) and hearing aid (right)

The final results show that all the patients in our study were still wearing a hearing aid in the contralateral ear in the moment of the last cochlear fitting session. Considering the last hearing threshold levels in free field measured in two conditions, we can see that the pure tone free field thresholds with the cochlear implants are superior to those with the hearing aid in the opposite ear. The majority of free field thresholds with the cochlear implant were situated between 15 dB HL to 35 dB HL compared to those with the hearing aid which belongs to the interval 30 dB HL – 55 dB HL. We can also see a decreasing trend of the auditory levels from the low to the high frequencies in the implanted ear comparing to the reverse trend for the hearing rehabilitation of the ear with the hearing aid, where there is a better amplification in the low frequencies. We compared the auditory level of the nonimplanted ear before the cochlear implantation and after different periods from the implant's switch on. In our group, these measurements showed the same levels in headphones pure tone audiometry and in free field audiometry with the hearing aid, proving no degradation of the hearing in the nonimplanted ear.

DISCUSSIONS

The advantages of binaural hearing are not available to a person who wears a cochlear implant in only one ear, but may be possible if a hearing aid is used with a cochlear implant in contralateral ear (bimodal hearing). Fitting a hearing aid is non-invasive and helps to preserve the residual hearing abilities in the non-implanted ear by providing acoustic/auditory stimulation.

Similarly to others reported researches [11], our results suggest that hearing aids can lead to improvements whereby acoustic information at low frequencies is combined with high-frequency envelope information, compensating for limitations in the cochlear implant signal processing. This electro-acoustic benefit clearly depends on the patient's amount of residual usable low frequency hearing.

The particularity of the auditory performance evaluation in bimodal rehabilitated patients – cochlear implant in one ear and hearing aid in the opposite ear is represented by the necessity to follow an audiological evaluation protocol. The lack of a standard protocol in this clinical setting may have negatively impact on patient's ability to combine a cochlear implant and a hearing aid, particularly for those patients who could complain that sounds are unbalanced when both devices are used. The bimodal hearing loss rehabilitation requires a good "loudness balance" for binaurally combined acoustic and electric hearing.

The mandatory audiological evaluation should include the free field pure tone audiometry and speech audiometry with the cochlear implant and with the hearing aid. Also mandatory should be the periodic evaluation of the air and bone conduction thresholds in nonimplanted ear. That offers the possibility of monitoring the hearing loss thresholds in the nonimplanted ear and to discover at the right time a progressive hearing loss which would need a new device adaptation. Although the cochlear implantation protocol allows normal visits after reaching normal thresholds with the cochlear implant, the audiological evaluation should be done regularly at 3 or 6 months, precisely to evaluate the nonimplanted ear.

Another particularity of auditory performance evaluation in bimodal rehabilitation consists in the determination of the global speech intelligibility with the cochlear implant and with the hearing aid. Although the usage of the hearing aid offers a good amplification for pure tones, the speech evaluation with it could indicate a severe

alteration in speech intelligibility and further the "jamming" of global speech performance. In that moment should be done a reconsideration of its usage.

Of course, the testing methodology for speech intelligibility includes the list of words or sentences. It is an easy methods for the evaluation of the patients with the postlingually onset of the hearing loss, but difficult to use in the case of prelingually or perilingually deafness, especially in very young children. In that cases, can be use a close-set word identification task according to their level of speech recognition and acquisition or the auditory frequency discrimination with visual reinforcement.

CONCLUSIONS

The results of the present study suggest an advantage of cochlear implant usage in conjunction with a hearing aid in the opposite ear. The cochlear implant alone performs better than the hearing aid alone, and the bimodal condition is superior to the cochlear implant alone. Given the proven advantages of an implant and controlateral hearing aid over a unilateral cochlear implant, the benefits of bilateral implantation must be demonstrated relative to an implant and a hearing aid combination rather than a single implant if the cost effectiveness of bilateral implantation is to be established. The bimodal hearing rehabilitation requires a regularly auditory re-evaluation to establish the limit line between the benefit / less benefit of bimodal hearing.

REFERENCES

1. NIH Consensus Development Program. 1995. Cochlear implants in adults and children. NIH Consensus Statement Online. Retrieved February 28, 2007 from: http//www:consensus.nih.gov/1995/1995CochlearImplants100html.htm.
2. Mencher GT, Davis A. Bilateral or unilateral amplification: Is there a difference? A brief tutorial. Int J Audiol. 2006; 45: 3-11.
3. Mok M, Grayden D, Dowell RC, Lawrence D. Speech perception for adults who use hearing aids in conjunction with cochlear implants in opposite ears. J Sp Lang Hear Res. 2006; 49: 338-351.
4. Blamey P, Dooley GJ, Parisi ES. Monaural and binaural loudness measures in cochlear implant users with contralateral residual hearing. Ear Hear. 2000; 21: 6-17.
5. Ching TY, Incerti P, Hill M. Binaural benefits for adults who use hearing aids and cochlear implants in opposite ears. Ear Hear. 2004; 25: 9-21.
6. Ching TY, Incerti P, Hill M, van Wanrooy E. An overview of binaural advantages for children and adults who use binaural/ bimodal hearing devices. Audiol Neurotol. 2006; 11: 6-11.
7. Holt RF, Kirk KI, Eisenberg LS, Martinez AS, Campbell W. Spoken word recognition development in children with residual hearing using cochlear implants and hearing aids inopposite ears. Ear Hear. 2005; 26: 82S-91S.
8. Hardie NA, Shepherd RH. Sensorineural hearing loss during development: Morphological and physiological response of the cochlear and auditory brainstem. Hear Res.1999: 128; 147-165.
9. Shepherd RK, Hardie NA. Deafness-induced changes in the auditory pathway: Implications for cochlear implants. Audiol Neurotol. 2001; 6: 305-318.
10. Perreau AE, Tyler RS, Witt S, Dunn C. Selection strategies for binaural and monaural cochlear implantation. Am J Audiol. 2007; 16: 85-93.
11. Kong YY, Stickney GS, Zeng FG. Speech and melody recognition in binaurally combined acoustic and electric hearing. J Acoust Soc Am. 2005: 117; 1351-1361.