

Tinnitus in Cochlear Implant Users: The Freiburg Experience

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Abstract: Cochlear implantation is a well-accepted method of aural rehabilitation in deaf or severely hearing-impaired adults and children. A majority of patients not only suffer from hearing impairment but from tinnitus. The high rate of preoperative tinnitus in adults (68.1%) stands in contrast to assumed lower rates in children. Unknown are such factors as how tinnitus develops in children, how they realize what tinnitus is, and whether the mechanism of development of tinnitus differs from that in adults, respectively. Electrical stimulation of the auditory pathway is followed by loss, or at least reduction, of tinnitus in most cases (75%). Also, the insertional trauma alone is able to stop tinnitus in some patients. Attention must be paid to the low risk of developing tinnitus postoperatively. No reports are available regarding tinnitus in children. Though younger children may not be able to report, some adolescent patients report preoperative or postoperative tinnitus (or both) that is reduced by electrical stimulation at the rates seen in adults. Further investigations are needed to define the mechanism of tinnitus development in children and to define optimal stimulation modes and rates for tinnitus reduction with best auditory performance.

Keywords: adults; children; cochlear implant; electrical stimulation; tinnitus

Tinnitus is a well-known complaint in hearing-impaired persons. We report here our experience with tinnitus in cochlear implant users. The majority of cochlear implant users suffer from tinnitus preoperatively. The aim of this study was to find out how the use of intracochlear stimulation influences tinnitus both in adult and adolescent patients, how often the insertional trauma leads to development or loss of tinnitus, and whether constant tinnitus influences performance, respectively.

Several authors reported relief of tinnitus from electrical stimulation, either intracochlear or through the

cochlear wall or round-window niche. The rate of tinnitus relief is up to 93% in the literature [1-3].

MATERIAL AND METHODS

Results regarding tinnitus were obtained from a questionnaire sent to each patient provided with a cochlear implant at the Ear, Nose, and Throat Department, University of Freiburg, and to parents of children, respectively. In this questionnaire, we asked whether patients suffered from tinnitus preoperatively or postoperatively (or at both times), whether changes occurred in tinnitus, and whether using the speech processor produced an influence.

All patients had a Nucleus (Cochlear Limited, Australia) device implanted (either CI22Mini or CI24M). The time of implant use ranged between 3 months and 4.5 years, as the Freiburg cochlear implant program began in 1993.

On a regular basis at the time of tuning of the speech processor, all adult patients perform speech tests including vowels, consonants, Freiburg numbers, and speech tracking in auditory and auditory-lip reading condition. Performance of each patient was assigned to

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three groups: Patients assigned to group I were able to perform speech tracking in auditory condition of at least 10 words per minute; those in group II were able to understand consonants in auditory condition alone of at least 10%; and those in group III were able to understand only vowels in auditory condition of at least 10%. Results of performance in adults were investigated in those patients whose tinnitus was not influenced by use of the speech processor.

RESULTS

Of a total of 210 patients (68% children, 32% adults), 61% (80 children [as reported by their parents] and 47 adults) reported their experience with tinnitus. Of the 47 adults, 32 (68.1%) had tinnitus preoperatively; 15 patients (31.9%) never had tinnitus.

Of 32 patients with tinnitus preoperatively, 6 (18.7%) had no tinnitus postoperatively. Of 28 patients with postoperative tinnitus, 18 (64.3%) had complete relief while using the speech processor, whereas 3 patients (10.7%) reported partial relief. Two patients developed a new tinnitus but also had complete relief in using their cochlear implant.

Only 10 patients reported no change of tinnitus postoperatively or while using the speech processor. Nine (the majority of these patients) suffered from progressive hearing loss. Eight patients performed in group I with an open-set speech understanding, and two patients were assigned to group II.

Of 80 reports (mean age, 8.1 years; range, 3.1–17.4 years), only nine children reported their experience with tinnitus. In this group, the mean age was 11.8 years (range, 5.25–16.8 years). Whether tinnitus was present in 32 children (mean age, 5.9 years; range, 2.5–13.4 years) was unknown; the remainder did not report tinnitus.

Three children reported preoperative and postoperative tinnitus, two children experiencing complete relief in using the speech processor. Six children developed tinnitus postoperatively: In one child, the condition lasted for 3 weeks, three children experienced relief when using the speech processor, and two children experienced tinnitus only when using the speech processor.

DISCUSSION

Tinnitus in Adult Cochlear Implant Users

The majority of patients (68.1%) reported tinnitus preoperatively. This incidence is consistent with results of other studies [4,5], in which 27%–85% of patients reported tinnitus. After cochlear implantation, six patients reported complete loss of tinnitus. This result

may be facilitated by the insertional trauma of intracochlear structures as they are described by O'Leary et al. in 1991 [6] after histological examinations of temporal bones with cochlear implants. Traumatic damage was found especially at the insertional site and along the basal turn. If, in these patients, tinnitus originates somewhere in the cochlea, the electrode insertion may destroy intracochlear structures, resulting in loss of tinnitus.

The use of intracochlear stimulation to reduce tinnitus is well-known. In our group of patients, most (75%) had a complete loss or experienced at least partial relief of tinnitus while using the speech processor. Only two patients reported a newly generated tinnitus after cochlear implantation (obviously also due to the insertional trauma) but had complete relief while using the speech processor. This finding is within the reported rates of up to 93% reduction of tinnitus with intracochlear stimulation [1–3]. However, not clear is how the type of stimulation mode and pulse rate of different devices influence the rate of tinnitus. Investigations by Hazell et al. [7] and Dauman et al. [8] favor a low-frequency stimulation rate. The use of different devices with slower stimulation rates (e.g., 3M/Vienna, Ineraid, CI22Mini) may explain reduction of tinnitus in those high rates. Up to now, no reports have addressed the effect on tinnitus reduction rate of fast stimulation rates, as in continuous, interleaved sampling stimulation mode. Further investigations will help to define an optimal stimulation rate for reduction of tinnitus with concurrent best performance.

Though tinnitus in hearing-impaired patients may influence the rate of speech understanding, that is not the case in cochlear implant patients. Of 10 patients with tinnitus that could not be influenced by use of the speech processor, most were excellent performers, suggesting that their tinnitus may not have originated in the cochlea but in other parts of the auditory pathway and that it does not influence speech perception.

Tinnitus in Adolescent Cochlear Implant Users

Until now, no reports have addressed tinnitus in children. Moreover, whether such reports are reliable is not clear. The fact of young age in the majority of children (younger than 8 years) can suggest that these children do not know whether they have some tinnitus or that they are not able to report it, representing the group of unknown tinnitus of 40%, with a mean age of 5.9 years. Even the group of children reporting no tinnitus may suggest that those children do not know the meaning of *tinnitus*, so the validity of these reports remains uncertain.

Of the nine children reporting their experience with tinnitus, tinnitus reduction during use of the speech

processor seems to occur at a rate similar to that in adults, suggesting similar mechanisms of tinnitus origin and reduction. Just after the cochlear implantation, one child reported tinnitus of 3 weeks' duration only, suggesting that the insertional trauma had generated the tinnitus, as in one adult patient reported by Tyler [4]. Two children reported tinnitus only when using the speech processor. This tinnitus may be due to intracochlear stimulation or may be induced by activating the central auditory pathway.

In general, tinnitus reduction is a common side effect of electrical stimulation after cochlear implantation. Some patients benefit from a complete loss of tinnitus after intracochlear electrode insertion. Nevertheless, the responsibility of surgeons is to alert patients to the minimal risk of developing a new tinnitus after implantation [4]. Even in patients in whom electrical stimulation had no influence on tinnitus, performance was excellent, suggesting sites of tinnitus origin other than the cochlea. Our results also encourage the use of extracochlear electrical stimulation as a mode of treatment for tinnitus in hearing patients.

In children, tinnitus has been a rare symptom until now. Long-term reports may help to define the origin and the mechanism of generating tinnitus in deaf-born or severely hearing-impaired children.

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