

How Does Cochlear Implantation Affect the Contralateral Vestibular System?

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Abstract: Cochlear implantation has been performed for 16 years by investigators at Semmelweis University. During this period, different types of cochlear implants have been used and, in 30% of cases, hearing was observed to be restored in the nonimplanted ear. In addition to contralateral hearing improvement, significant improvement was observed in the caloric responsiveness of the nonoperated labyrinth. The preoperative median value of the average slow-phase velocity of the caloric test increased, and the increase was statistically significant on the contralateral side. The reason for this caloric response improvement is unclear, although possible explanations are brain plasticity or presently obscure trophic influence on the vestibular system. Whereas the role of brainstem function in the improvement of the contralateral ear's caloric response remains unclear, it is also possible that hearing impulses affect the labyrinth. Clearly, the influence of cochlear implants on vestibular function requires further investigation to explain the improvement of contralateral vestibular responsiveness.

Key Words: cochlear implantation; contralateral hearing; vestibular function

During the last decades, cochlear implantation has become the treatment of choice for profoundly deaf adults and children who obtain little or no benefit from conventional hearing aids. A few patients with a cochlear implant have only some auditory sensations, but the star patients are able to understand conversations without lip reading and can even use a telephone or enjoy music. There are many factors contributing to a patient's postoperative performance: etiology of deafness, age, social background, individual differences of cochlear nerve populations, technical details of surgery, speech processing, and the like. With increasing numbers of patients and newer generations of implants, however, implanting teams have more to report on various aspects of cochlear implantation [1].

Although many patients with profound bilateral sensorineural hearing loss have an associated weak or non-functional vestibular system, sometimes the vestibular system remains intact. Cochlear implant candidates

may also have normal vestibular function. Several authors have reported the preoperative and postoperative vestibular function in cochlear implant patients, but the changes of caloric responsiveness are rare topics for research papers. We previously reported our experiences with different cochlear implants and vestibular function changes of the implanted side [2-4]. In this study, we describe contralateral changes in hearing and vestibular responsiveness.

PATIENTS AND METHODS

Since 1985 at Semmelweis University, cochlear implantation has been a routine operation for total deafness. During this period, 135 cochlear implantations were performed on 119 patients. Of these patients, 60 were male, and 59 were female; 68 were adults and 51 children. The mean age was 28.6 years (22 months to 68 years). Intracochlear implantation was performed in 101 ears (including reimplantations), and extracochlear promontory and round window implantation was performed in 34.

Seventy-seven patients were prelingually deaf, whereas the others had postlingual deafness. The cause of deafness was unknown in 42%, and the other patients were deaf because of purulent meningitis, skull-

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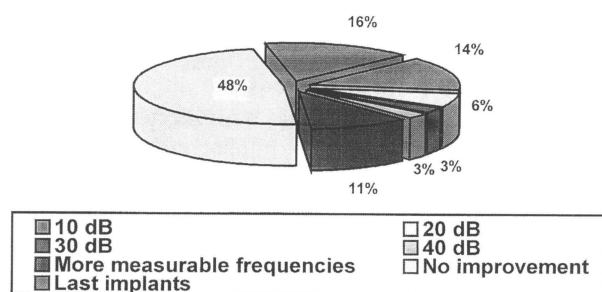


Figure 1. Hearing improvement of contralateral ear.

base fracture, ototoxic drug administration, viral infection, and revision stapes surgery.

Every patient's hearing was measured before the implantation. Most of them were completely deaf, but none had usable hearing. Each patient's hearing threshold was routinely checked 3 months postoperatively and, after that, every 3 months. The hearing examinations were performed on both the implanted and the contralateral side. Sixty patients had detailed vestibular examinations before the operation. The rest were young children or were not cooperative during the performance of vestibular examination.

In all patients (except children younger than 5 years), the vestibular system was examined prior to surgery. The method of detailed vestibular examination was reported previously [5,6]. During the last 5 years, we have examined totally deaf patients by the computer-based electronystagmography (ENG) system. This system includes software for numerical analysis of nystagmus, especially slow-phase velocity. All postoperative examinations after implantation were made by the computerized ENG system. Changes of the average slow-phase velocities (ASPVs) of caloric nystagmus were statistically analyzed.

RESULTS

Contralateral hearing improvement was measured in 41 cases in the year after implantation. Seventeen patients experienced 10 dB of hearing improvement, and 7 patients experienced a 20-dB improvement (Fig. 1). Three patients each experienced 30- and 40-dB hearing improvement and, in 11 patients, more measurable frequencies could be observed on the threshold audiogram. These results indicate recovery of hearing in a previously totally deaf ear. Most of these hearing improvements could be seen in patients using newer types of implants (MedEl Combi 40, 40+), but three patients had earlier types of implants (Nucleus, Hortman, Bánfai). One patient underwent bilateral implantation, the

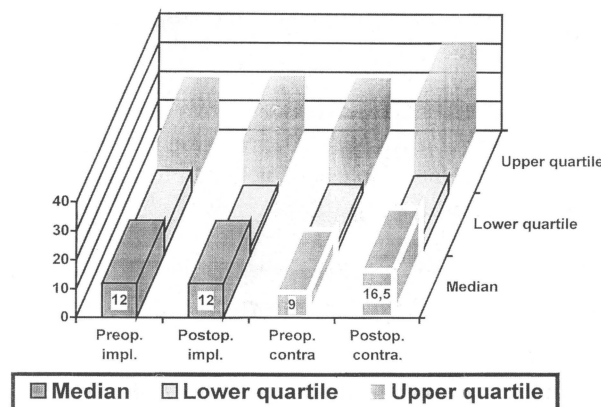


Figure 2. Average slow-phase velocity (ASPV) changes in caloric responses after cochlear implantation on the implanted and the contralateral side. (*Preop. impl.* = preoperative ASPV of implanted side; *Postop. impl.* = postoperative ASPV of implanted side; *Preop. contra.* = preoperative ASPV of contralateral side; *Postop. contra.* = postoperative ASPV of contralateral side.)

first operation in 1999 and the second 1 year later. Her hearing and speech discrimination are excellent without lip reading.

No hearing improvement was measured in 57 patients and, in 19 cases (last implants), there was insufficient time after surgery to control hearing.

A normal vestibular system was observed in 25% of patients preoperatively. Bilateral loss of function was found in 47%. Unilateral canal paresis was registered in 15%, and directional preponderance—a characteristic of central vestibular lesions—was found in 13% of cases. Postoperatively, only 10 patients had mild vertigo lasting 3–4 days. Vestibular function was checked after the operation. Postoperatively, the labyrinth function changed in 60%; in 40%, the vestibular function remained intact. In 28% of patients, the vestibular responsiveness of the operated ear decreased, whereas in 32%, the postoperative vestibular responsiveness improved on the implanted side. The bilaterally implanted patient had unilateral weakness and severe unsteadiness, which disappeared after surgery (normal, symmetrical caloric responses and normal results in the Romberg and blind walking tests).

What follows is a detailed discussion of our most recent 10 patients in whom pre- and postoperative vestibular examinations were similarly performed by the computer-based ENG system. The postoperative testing was performed from 4 to 30 weeks after surgery and did not reveal any spontaneous nystagmus or abnormal statokinetic test results. The preoperative median value of the ASPVs of the caloric test in 10 patients was 11 degrees per second (lower quartile, 5.5;

upper quartile, 18.0), and the postoperative mean value of ASPVs was 18.0 degrees per second (lower quartile, 6.0; upper quartile, 30.0). The increase is statistically significant. Between the preoperative and postoperative ASPV values, a significant correlation can be found. The ASPV value changes are not significant on the operated side but are significant on the contralateral side (Fig. 2). The correlation between preoperative and postoperative ASPV values is not significant on the operated side but is on the contralateral side. The values demonstrate the increase in the slow-phase velocity, meaning that the caloric responsiveness improved on the contralateral side.

CONCLUSIONS

On several occasions, we reported our observation of contralateral hearing improvement after cochlear implantation. The improvement may be explained in several ways (e.g., a presently obscure trophic influence of the efferent olivocochlear system in regeneration of the inner ear cells' afferent innervation or the plasticity of the brain). Chronic electrical stimulation on one side may affect both ears and might result in regeneration of auditory pathways. However, the underlying mechanism remains obscure in cases of contralateral hearing improvement after cochlear implantation. It is advisable to check the threshold every 3 months because there is continuous improvement in some patients. If a combination of cochlear implant, hearing aid, and lip reading were provided, 90–100% speech discrimination could be achieved in most affected patients. In our opinion, bilateral cochlear implantation is indicated only if contralateral hearing improvement cannot be demonstrated 6 months after the initial operation; therefore, at least half a year's waiting time is required between the two implantations.

In most of our cases, atraumatic surgical technique during electrode insertion avoided diagnosable impairment of any vestibular responsiveness of the operated ear. The reason for the caloric response improvement is not clear. In a few patients, the function improved not

only in the operated ear but in the contralateral ear. Possibly, this contralateral improvement was caused by brain plasticity or presently obscure trophic influence on the vestibular system. The mastoidectomy, being a part of cochlear implantation, might change the responsiveness of the horizontal canal to caloric stimuli on the operated ear but not on the contralateral side. The role of brainstem function in the improvement of contralateral caloric response is not yet clear. It is also possible that the influence of hearing impulses affects the labyrinth. Clearly, the influence of cochlear implants on vestibular function requires further investigation if we are to understand the improvement of contralateral vestibular responsiveness.

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