Fluctuating Hearing Loss in the Only Hearing Ear: Cochlear Implantation in the Contralateral Deaf Side

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Abstract

Objective. To investigate the hearing performance of adult patients presenting unilateral deafness with contralateral fluctuating hearing loss who received a cochlear implant on the deaf side.

Study Design. Case series with chart review.

Setting. University tertiary referral center.

Subjects and Methods. Preoperatively and at 6 and 12 months postoperatively, 23 patients underwent pure tone audiometry and speech audiometry with disyllabic and monosyllabic words in a quiet environment and sentences in quiet and noisy (signal-to-noise ratio \(+10\, \text{dB SPL}\) environments under best-aided conditions. The Abbreviated Profile of Hearing Aid Benefit (APHAB) inventory was evaluated preoperatively and at 6 and 12 months postoperatively.

Results. No difference was found between pre- and postoperative tests for disyllabic and monosyllabic words. For sentences in quiet and noisy environments, a difference between pre- and postoperative performance was present at 1 year (\(P = .002\) and \(P = .02\), respectively). In a noisy environment, a difference was present at 6 and 12 months postoperatively as compared with the preoperative value (mean \(\pm\) SD: 6 months: 42% \(\pm\) 7.1% vs 61% \(\pm\) 6.5%, \(P = .016\)). A significant improvement in the APHAB score was found at 6 and 12 months postimplantation (Friedman’s 2-way analysis of variance by ranks, \(P < .001\)). The number of years of hearing deprivation of the deaf ear was not correlated with performance.

Conclusion. When incapacitating fluctuating hearing loss occurs in patients presenting a contralateral deaf ear, a cochlear implant is indicated in the latter ear, significantly improving performance in noisy conditions and allowing a better quality of communication to be achieved.

Keywords

Ménière’s disease, immune-mediated inner ear disease, cochlear implant, SSD, APHAB, fluctuation
benefit from immunosuppressive treatments; however, there remains a high rate of treatment failure, and these cases often progress to unilateral or bilateral deafness.

In our experience, in both Ménière’s disease and immune-mediated inner ear disease, the hearing fluctuation and the necessity to undergo specific treatment cycles are determining factors in the decrease in quality of life as well as the difficulty in adapting to conventional hearing aids. Furthermore, as the disease progresses, severe to profound deafness might be present on one side with contralateral hearing fluctuation, resulting in a significant decrease in speech intelligibility. The loss of binaural advantages and the difficulty in achieving sufficient and stable hearing gain with conventional hearing aids lead to great difficulties in hearing and understanding speech, especially in noisy environments, as well as in sound localization. Indeed, in France, the official guidelines for cochlear implants (CIs) include patients who still have sufficient speech discrimination in one ear but present a degree of hearing fluctuation in the contralateral ear that leads to a major impairment of communication.

The aim of the present study is to retrospectively examine the hearing performance of adult patients presenting unilateral severe to profound deafness with contralateral fluctuating hearing loss who received a CI on the deaf side, to determine the benefit of CI on hearing and its impact on subjective auditory quality-of-life measures.

Materials and Methods

A retrospective chart review was carried out on adult patients who received a CI in a university tertiary referral center between 2008 and 2015. Data were collected on demographics, characteristics of the hearing loss, audiometry, associated symptoms, and the eventual medical treatments. All participants provided written informed consent allowing retrospective analysis of their data for this study, which is in line with the reference methodology of the CNIL (Commission Nationale de l’informatique et des libertés; National Committee for Information and Liberty) and the CCNE (Comité consultatif national d’éthique; National Consultative Ethics Committee).

The inclusion criteria were presence of unilateral severe to profound hearing loss with or without fluctuation, contralateral mild or moderate hearing loss with hearing fluctuation, and absence of retrocochlear pathology. All patients who previously underwent surgical or chemical labyrinthectomy were excluded.

Preoperatively and at 6 and 12 months postoperatively, all patients underwent pure tone audiometry, as calculated per American Academy of Otolaryngology—Head and Neck criteria, and free field speech audiometry with disyllabic and monosyllabic words in a quiet environment and MBAA sentences (marginal benefit from acoustic amplification) in quiet and noisy environments under best-aided conditions (ie, with the contralateral hearing aid, if used). Tests were performed in a soundproof cabin with speech and noise coming from the front of the patient and at a fixed signal-to-noise ratio for the tests in noise (+10 dB SPL).

The Abbreviated Profile of Hearing Aid Benefit (APHAB) inventory was administered preoperatively and at 6 and 12 months after CI activation. This questionnaire was used to quantify everyday life problems associated with hearing impairment.

Statistical Analysis

Results are reported as means (95% CI). Because of the relatively small sample of subjects, nonparametric tests were used. The Wilcoxon paired signed rank test was used to analyze the difference between pre- and postoperative pure tone audiometry of the contralateral ear to eliminate the influence of the contralateral ear on hearing performance evaluation. Friedman’s 2-way analysis of variance (ANOVA) by ranks, followed by post hoc Wilcoxon paired signed rank test with a Bonferroni-adjusted P value, was used for audiometric data comparison among preoperative and 6- and 12-month postoperative scores. To investigate the influence of the duration of hearing deprivation of the implanted ear on postoperative speech perception scores, the Spearman correlation coefficient (r) was calculated, and ANOVA was used to test the slope of the linear regression line. A P value <.05 was considered statistically significant. All statistical analyses were performed with SPSS 22.0 for Windows (IBM, Chicago, Illinois).

Results

Twenty-three patients were included in the study (12 males and 11 females). Mean ± SD age at implantation was 55 ± 15 years (range, 22-77 years). The mean duration of hearing deprivation of the implanted ear was 5.1 ± 3.9 years (range, 1-14 years). In all cases, a retrocochlear etiology of hearing loss was ruled out by magnetic resonance imaging (MRI) before cochlear implantation. The mean follow-up after cochlear implantation was 32 ± 26.9 months (range, 12-120 months), and at the last follow-up, all patients wore the CI all day.

For disyllabic and monosyllabic tests, no difference was found among preoperative and 6- and 12-month postoperative speech perception scores in a quiet environment (Friedman’s 2-way ANOVA by ranks, P = .15 and P = .57, respectively; Figure 1). Concerning sentences in quiet and noisy (signal-to-noise ratio +10) environments, a significant difference was found between pre- and postoperative performance for both conditions (P = .002 and P = .02, respectively, Friedman’s 2-way ANOVA by ranks; Figure 1). In a quiet environment, this difference was found at 1 year postimplantation (79% [95% CI, 66.8%-91.3%] vs 96.6% [93.5%-99.7%], P = .008, Wilcoxon paired signed rank post hoc test, Bonferroni-adjusted P value = .017). No difference was found between preoperative and 6-month postoperative performance for sentences in a quiet environment (79% [66.8%-91.3%] vs 87.5% [76.9%-98.1%], P = .12). In a noisy environment, an improvement was achieved at 6 months (42% [27%-57%] vs 61% [46.9%-74.1%), P = .016) as well as at 1 year postimplantation (42% [27%-57%] vs 77% [65.9%-88.3%], P = .015). The number of years of hearing deprivation of the deaf ear was not correlated with...
postoperative performance with CI (Spearman correlation, 
\( P = .6 \) and \( P = .25 \) for monosyllabic words and sentences in 
a noisy environment at 1 year, respectively; data not shown).

After implantation, 4 patients presented major hearing fluctuation 
of the nonimplanted ear that required further fitting of CI until hearing stabilized at 1 year postimplantation. No difference was found in the pure tone audiometry of the fluctuating ear between preoperative and 1-year postoperative evaluation in the whole study group (64 dB [95% CI, 58.3-70.3] vs 68 dB [58.8-77.2], \( P = .2 \), Wilcoxon paired signed rank test). Before cochlear implantation, 17 of 23 patients were aided with a conventional hearing aid on the contralateral fluctuating side. These patients did not meet the classic criteria for cochlear implantation in France since, preoperatively, they reached a discrimination \( \geq 50\% \) in free field speech audiometry at 60 dB. Of these 17 patients, 13 reported a benefit but experienced hearing difficulties under noisy conditions, and 4 were not satisfied in either quiet or noisy conditions and did not routinely use their hearing aid. Nevertheless, 2 patients among the 13 who had a benefit from wearing it abandoned their hearing aid after cochlear implantation; thus, at 6 and 12 months postoperatively, 11 patients were in the bimodal stimulation condition and 12 in CI-only condition.

The APHAB questionnaire was administered to all patients implanted after 2011 (12 subjects) preoperatively and at 6 and 12 months postoperatively. A significant improvement in total score was found at 6 months as compared with the preoperative score, and this was still present at 12 months (Friedman’s 2-way ANOVA by ranks, \( P = .002 \), post hoc Wilcoxon paired signed rank test). Postoperative improvements were detected in 2 of the 4 APHAB test subscales at 6 months—ease of communication and background noise (Friedman’s 2-way ANOVA by ranks \( P = .004 \) and \( P = .019 \), respectively) but not for reverberation or aversiveness (Figure 2). There was no difference in APHAB scores at 6 months and 1 year postoperatively.

**Discussion**

This study showed the benefit of cochlear implantation in a population characterized by asymmetric hearing loss and hearing fluctuations in the better ear. These patients are therefore handicapped by the fluctuation of the hearing threshold and by the asymmetry of their hearing.

The difficulty of hearing rehabilitation for patients with fluctuating hearing loss is well acknowledged.\(^{12}\) For these patients, the sensation of fullness, the reduced dynamic range, and the lower word recognition scores are only some of the obstacles in the fitting of hearing amplification, which can be challenging for most audiologists,\(^{8}\) even though several solutions have been proposed. McNeill et al\(^ {13}\) introduced an interesting approach in a study of 40 patients with Ménière’s disease who were aided with hearing prostheses. The authors experimented with a self-regulating amplification system that the patient could fit and use with a portable programmer. This hearing aid system was useful for 70% of the patients because it allowed them to test their hearing and adjust the aids as hearing levels fluctuated.

The population in the present study presented hearing fluctuation in the better-hearing ear, with profound hearing loss in the contralateral ear, representing de facto asymmetric hearing loss or, in some cases, unilateral deafness. Patients presenting unilateral or asymmetrical hearing loss do not benefit from binaural cues, such as interaural time and level difference, present in persons with normal hearing. These patients experience a substantial handicap in their daily lives, especially when a background noise is present. Contralateral routing of signal and bone conduction hearing aids have been used in patients with asymmetric hearing loss and may successfully rehabilitate the hearing impairment with good results.\(^ {14,15}\) These solutions allow an improvement of the discrimination in noise and slightly in
silence, but when hearing fluctuation in the better-hearing ear is significant, the fitting of the ipsilateral and contralateral device remains difficult.

Van de Heyning et al first proposed cochlear implantation in a cohort of patients presenting single-sided deafness and incapacitating tinnitus, documenting that hearing performance achieved with a CI is superior to the monaural condition. Moreover, in the case of contralateral moderate hearing loss, a bimodal stimulation resulted in improvements in speech recognition, localization, and everyday functional abilities.

In the case of asymmetric hearing loss, cochlear implantation was recently proposed by Firszt and Arndt, who reported evidence of successful binaural rehabilitation with CI in these patients, with a documented improvement in speech comprehension and localization ability, confirming that bilateral input to the auditory system enhances the potential for binaural processing. Compared with those with unilateral hearing loss, patients with hearing fluctuation, as described in the present study, are at an even greater disadvantage because the better ear does not have normal hearing. However, our study confirms that these patients have an evident benefit from a CI, even in the case of contralateral fluctuations. The results show that cochlear implantation leads to a significant advantage in comprehension of sentences in a quiet environment at 12 months post-implantation and in noisy conditions as early as 6 months postimplantation, and these results remain stable at 12 months.

This is reflected in the results of the APHAB questionnaire, which shows an improvement in the overall score and in the subscales of ease of communication and background noise. We did not find any difference in quality of life between patients who were in bimodal stimulation and patients who had CI only, probably due to the small sample size. The benefit of CI was independent of the duration of total hearing loss. We can hypothesize that hearing deprivation does not influence the performance if a contralateral stimulation is still present. This is in accordance with recent data showing that duration of sound deprivation in one ear has limited value in predicting speech recognition outcomes of cochlear implantation in that ear and that outcomes of cochlear implantation are more closely related to the period of time for which the brain is deprived of auditory stimulation from both ears. The etiology of the hearing loss could also account for the performance regardless of the duration of hearing deprivation. In the contralateral fluctuating ear, no significant difference was found between pre- and postoperative hearing thresholds; therefore, the influence of hearing fluctuations on the CI results could not be assessed for these patients. However, because of the sensation of hearing fluctuation, several patients abandoned their conventional hearing aids, being satisfied by the stable benefit achieved with restoration of contralateral hearing by the CI.

The excellent performance of CI in patients with Ménière’s disease and immune-mediated inner ear disease with severe bilateral deafness was already demonstrated in several studies, but as in this study, the positive or negative influence of cochlear implantation on other symptoms, such as dizziness and tinnitus, has not been proven. In some patients, vertigo was subjectively improved, but since videonystagmography was performed only preoperatively, we cannot conduct a thorough analysis of the improvement of vertigo. We describe what patients reported, which is probably due to the status of the contralateral ear (hearing still fluctuating and so still in an active phase of the disease). The small sample size is a limitation of the present study, with the fact that it is a retrospective review.

The findings of the present study explore a clinical question concerning the indications and timing of cochlear implantation in patients with asymmetric hearing loss, who do not meet the conventional inclusion criteria for CI in most countries, because criteria are based on speech intelligibility in quiet conditions. However, in this population, the good performance recorded in the preoperative setting in a quiet environment is not present in a noisy environment. In addition, we have to consider (1) the great disability caused by the continuous hearing fluctuations in the only hearing ear, which cannot usually be documented by audiometric evaluation, and (2) the discomfort of continuous treatment that these patients receive to stabilize hearing thresholds. This condition can represent an early indication for cochlear implantation in the deaf ear that can be proposed to the patient as soon as his or her level of communication is insufficient, especially in noisy conditions. In fact, CI could have a beneficial role in preventing a period of total deafness among these patients should the hearing in the fluctuating ear ultimately drop to nonuseful levels.

Conclusion

Unilateral or bilateral fluctuating hearing loss represents a major obstacle in rehabilitation with conventional hearing aids. When one side has profound hearing loss and the other side has fluctuating hearing, the patient becomes a good candidate for a CI, which will allow the difficulties in noisy conditions to be overcome and a better quality of communication to be obtained with stable results over time.

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Author Contributions

Francesca Yoshie Russo, substantial contributions to the design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; Daniele De Seta, substantial contributions to the analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in
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