Middle-term cochlear implant use in case of asymmetric hearing loss and single-sided deafness: A retrospective single-centre cohort study

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August 30, 2022

Abstract

Key points: (no abstract required) * Cochlear implant effectiveness in asymmetric hearing loss and single-sided deafness is well established, but rarely covered by health care systems. * Continuation of wearing the implant beyond the first year could be considered as an indirect indicator of subjective benefit. * Percentage of cochlear implant abandon at 5-years post-implantation was very low in patients with asymmetric hearing loss and single-sided deafness. * High education level, low audibility and good unaided speech perceptions scores of the contralateral acoustic-hearing ear were positive prognostic factors of CI use. * The low percentage of non-users is an additional strong argument to recommend cochlear implantation in patients with asymmetric hearing loss and single-sided deafness, on the ear with a profound hearing loss, especially in case of frail contralateral acoustic-hearing ear.

KEY POINTS

- Cochlear implant effectiveness in asymmetric hearing loss and single-sided deafness is well established, but rarely covered by health care systems.
- Continuation of wearing the implant beyond the first year could be considered as an indirect indicator of subjective benefit.
- Percentage of cochlear implant abandon at 5-years post-implantation was very low in patients with asymmetric hearing loss and single-sided deafness.
- High education level, low audibility and good unaided speech perceptions scores of the contralateral acoustic-hearing ear were positive prognostic factors of CI use.
- The low percentage of non-users is an additional strong argument to recommend cochlear implantation in patients with asymmetric hearing loss and single-sided deafness, on the ear with a profound hearing loss, especially in case of frail contralateral acoustic-hearing ear.

INTRODUCTION

The effectiveness of cochlear implantation in case of asymmetric hearing loss (AHL) and single-sided deafness (SSD) was well established in several studies with a short-term (˜1-year) follow-up. By restoring binaural information, cochlear implant (CI) improves speech recognition in noisy environment, localization of sound sources, quality of life, and reduces cognitive load and incapacitating tinnitus for most patients. However,

cochlear implantation in SSD and AHL is rarely covered by health care systems around the world, only in case of incapacitating tinnitus in some countries. CI use over time would be another indicator of subjective benefit, but was rarely reported (1–3). Furthermore, most studies included AHL patients with sensorineural hearing loss criteria of unaided mean pure-tone average (PTA). The aim of our study was to evaluate the CI use in AHL and SSD with a follow-up of 5 years, and to look for reasons of abandonment. AHL candidates were patients with bilateral sensorineural or mixed severe-to-profound hearing loss on PTA, but asymmetrical aided speech perception scores (SPS).

METHODS

Study design

This was a retrospective single-center cohort study.

Participants

Patients were selected from the database of postlingually deafened adults who underwent a unilateral cochlear implantation from September 2011 to December 2018 in a referent tertiary center. Patients included had a severe-to-profound hearing loss on the ear to be implanted, with a PTA[?]70 dB (0.5, 1, 2, and 4 kHz) and an aided SPS<50% for disyllabic words at 60 dB SPL. SSD candidates had a PTA[?]30 dB and a SPS[?]90% on the acoustic-hearing ear. AHL candidates had an aided SPS[?]60% for disyllabic words on the acoustic-hearing ear, and an interaural SPS gap[?]40%. Patients were excluded in case of fluctuating hearing loss, surgical complication, device failure, reimplantation, or severe psychiatric problem during the first year after the cochlear implantation. Implant devices of the four companies were used. Written informed consent was obtained from patients (CNIL N°2126598).

2.2 Outcomes measures

Data including age, sex, education level, work situation, duration and etiology of hearing loss, hearing aid use and brand of the CI device were recorded. In case of lost to follow-up (n=6), patient was contacted to find out why and how long they were no longer wearing the implant. Hearing ability was evaluated before and 1, 3 and 5 years after implantation. PTA and unaided speech recognition using disyllabic words (Fournier lists) were tested with headphones at 60 dB SPL. Speech recognition in best-aided conditions was tested in free-field at 60 dB SPL, for the implanted ear (with contralateral ear masking), the acoustic-hearing ear, and in bimodal conditions using mono- (Lafon lists) and disyllabic words in quiet, and sentences (Marginal Benefit for Acoustic Amplification lists) in noise at a signal-to-noise ratio of +10 dB, signal and noise in front of the patient. Subjective evaluation of communication in noise was evaluated using the Abbreviated Profile of Hearing Aid Benefit (APHAB) questionnaire.

2.3 Statistical analysis

Statistical analysis was performed using GraphPad Prism[?] (Version 9.4.0). Values were expressed as mean +- standard deviation. Unpaired t-tests or mixed-effect analysis with a Tukey post-test were used for quantitative data, and Fisher's test for qualitative data. Significance was defined at a level of $p<0.05$.

3. RESULTS

Demographic data and audiometric evaluation of 72 patients (66 AHL, 6 SSD) are reported in Table 1. The mean follow up was 3 +- 1.8 years [1-7]. Only three AHL candidates did not use a hearing aid on the acoustic-hearing ear: two cases with mild hearing loss (PTA: 33 and 35 dB, respectively) and one vestibular schwannoma.

At 1-year post-implantation, 71 patients (97%) still used their CI all day long, only one patient became non-user due to the lack of subjective benefit (Figure 1). Of the 66 patients implanted for 3 years, 61 (92%) used their CI all day long. One patient aged 86-years at time of implantation deceased. One patient with a partial extrusion of the electrode array, refused the revision surgery and stopped to use the CI. Three patients became non-users due to the lack of subjective benefit. Of the 44 patients implanted for 5 years,

42 (95%) used their CI all day long. One patient aged 82-years at time of implantation deceased, and one patient became non-user due to the lack of subjective benefit.

In total, among the 72 patients, 42 used their implant at 5-years, 22 had a follow-up <5-years, 2 deceased, 1 had electrode extrusion, and 5 patients became non-users. For these 5 patients, 2 AHL patients had a no objective benefit (at 1- and 3-years after implantation), 2 SSD patients had no subjective benefit with SPS at 50 and 100% for disyllabic words at 1-year, and no reasons to explain the abandon, 1 AHL patient became non-user at 1-year, and refused to be tested.

Compared to users (Table 2), the non-users had a lower education level *($p<0.05$),* a lower PTA ($p<0.01$), and a higher unaided SPS of the acoustic-hearing ear ($p<0.05$). Aided SPS for disyllabic words for the acoustic-hearing ear, and in bimodal condition were similar between users and non-users.

Considering the evolution of the auditory performance in cochlear implant users, aided SPS of the implanted ear improved at 1-year post-implantation compared to pre-implantation scores in quiet, for both disyllabic (68 +- 31.9% *vs* 14 +- 18.2%,$p<0.0001$, Figure 2A*)* and monosyllabic words (57 +- 27.2% *vs* 13 +- 18.4 % respectively,$p<0.0001$), and sentences in noise (57 +- 30.9%*vs* 7 +- 14.7%, $p<0.0001$). These scores remained stable at 3- and 5-years post-implantation. For the acoustic-hearing ear, the PTA remained stable (data not shown). However, the unaided SPS for disyllabic words decreased ($p<0.05$, Figure 2B*),* but the aided SPS remained stable over time (disyllabic and monosyllabic words in quiet, sentences in noise, data not shown). In bimodal condition, aided SPS improved after implantation and remained stable between 1- and 5-years in both quiet (data not shown) and noise (Figure 2C).

The total APHAB score decreased at 1-year post-implantation compared to preoperative scores, (48 +- 16.8% *vs* 63 +- 17.2%,$p<0.0001$) , showing an improvement of the communication in noise, and then remained stable at 3- and 5-years post-implantation (data not shown).

DISCUSSION

This study shows a small rate of non-users at 1-year post-implantation among post-lingually deaf adults CI recipients (1.4 %), a percentage similar to that reported in the literature (4,5). At 5-years post-implantation, 4 out of the 6 patients with SSD still used their CI (67%). Among the 66 AHL patients with follow-up over 1 year, 2 patients abandoned the CI use and one refused revision surgery. Among the 40 AHL patients with a 5-years follow-up, only one patient became non-user (2.5 %). In the literature, after the first year post-implantation, the percentage of non-users varies among studies: 10% at 2-years post- implantation among 20 SSD patients (3), 4.4% among 114 SSD patients with a follow-up of 1.5 to 60 months (2), 9.8 % among 41 SSD and 0% among 37 AHL patients with a follow-up of 6 to 11 years (1), 19% among 28 SSD and AHL patients with a follow-up of 45 to 67 months (6). The reported main reasons of non-use were lack of perceived benefit, as in our study, and unrealistic expectations. It should be noticed that the long-term non-user rate in CI recipients for post-lingually bilateral profound deafness was in the same range (7.5 to 11%) than in SSD/AHL patients (2).

In our study, the risk factors of discontinuation of CI use were mainly a good unaided acoustic-hearing ear, but also a low education level.

In France, cochlear implantation was recommended only in case of bilateral severe-to-profound hearing loss, but SSD/AHL with incapacitating tinnitus has been added to the criteria since September 2021. However, some CI centers have added other off-label indications (7). Most patients included in our study have been implanted because of an identified ear disease, with a risk of progressive decrease of speech intelligibility of the acoustic-hearing ear. Thus, only 32% of our patients were implanted for an unknown etiology, whereas the unknown etiology is most common in cohort of adult CI recipients (8). It was decided to implant the ear with the profound hearing loss to avoid a long duration of hearing deprivation, and a long period with high listening effort and poor quality of life, and cognitive decline in older patients. The improvement of speech intelligibility in quiet and noise and of the subjective benefit in noise, on tests performed in routine practice, are in accordance with all prospective trials (4,9,10).

Due to the retrospective analysis, evaluation of severity of tinnitus using a self-assessment scale that could influence the wearing of the CI, was missing for many patients, so this variable was not analyzed. Datalogging was also not available for all brands.

CONCLUSION

This study confirms that SSD/AHL CI recipients obtained significant improvement of speech intelligibility in quiet and noise with a follow-up of 5 years. The low percentage of non-users is an additional strong argument to recommend cochlear implantation on the ear with a profound hearing loss, especially in case of frail contralateral acoustic-hearing ear, after trial of contralateral routing of signals (CROS) devices.

FIGURES LEGENDS

Figure 1 . Flowchart of the cochlear implant use in patients with single-sided deafness and asymmetrical hearing loss.

Figure 2 . **A. Speech perception scores of the cochlear implanted ear for disyllabic words in quiet.** Speech recognition was tested in free-field at 60 dB SPL, with a contralateral ear masking.**B. Unaided speech perception scores of the acoustic-hearing ear for disyllabic words.** Speech recognition was tested with headphones at 60 dB SPL. **C. Speech perception scores in bimodal conditions for sentences in noise.** Speech recognition was tested in free-field at 60 dB SPL in best-aided conditions, with speech and noise coming from the front at a signal-to-noise ratio of +10 dB. For the three figures, the box plots show the first and third quartile values and the central line, the median value; the whiskers indicate the non-outliers values for each group. Values were compared using mixed-effect analysis with a Tukey post-test. **: $p<0.005$, ***, $p<0.0005$,****: $p<0.0001$.

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