Speech Audiometrical Results Before and After Reimplantation of Cochlear Implants

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Objectives: This study aimed to compare the audiological outcomes of cochlear reimplantation with those of the first cochlear implant (CI).

Design: A retrospective analysis was performed on the data of all CI recipi-ents who received the first CI at the age of 8 years or above and who were subsequently reimplanted on the same side. All participants who received their first implant after January 1, 2000, and who were reimplanted before January 1, 2021, were included. CI recipients who were unable to perform an open-set of Flemish monosyllable speech audiometry were excluded. The participants' clinical files were reviewed in terms of the cause of hear-ing loss, age at the first and second implantation, device types, the time between the first and second surgery, speech reception scores before and after reimplantation, and the reason for reimplantation.

Results: Reimplantation was due to device failure in 19 out of 22 patients, performance decrement in two patients, and medical reasons in one patient. The interval between the first and second CI ranged from 8 to 218 mo. Within-subject analysis showed the speech reception performance with the second CI to be significantly better than that with the first CI at all follow-up time points, with average within-patient gains of 17%, 16%, 12%, and 15% at 3 mo, 9 mo, 3 years, and the highest scores achieved, respectively. After reimplantation, the performance was better than the last results before reimplantation, and this was significant from 9 mo after reimplantation onwards. Three patients (14%) had a performance degradation with the second CI, which was probably owing to (1) difficulties in reimplantation surgery leading to a reduced number of active channels, (2) insufficient experience with the second CI as the reimplantation has been performed recently, and (3) advanced fenestral and retrofenestral otosclerosis.

Conclusions: The present study shows that speech reception performance after reimplantation yields faster and better results than the first implant. It takes a couple of months to get better results than those before the reimplantation. Only in a minority of participants, a small deterioration may be observed. It seems that soft failures in the absence of measurable technical abnormalities call for caution with regard to reimplantation.

Key words: Cochlear reimplantation, Outcomes, Speech audiometry, Cochlear implant.

Abbreviations: AB = Advanced bionics; ADL = Amplitude difference limen; CI = Cochlear implant; FDL = Frequency difference limen; LS = Loudness scaling; LVA = Large vestibular aqueduct; NA = Not applicable; NRT = Neural response telemetry; PS = Pitch scaling; PTA = Pure-tone average; SD = Standart deviation; SIT = Sentence identification test; SRS = Speech reception scores; VAS = Visual analog scale; WRS = Word recognition score.

(Ear & Hearing 2021;00;00–00)

INTRODUCTION

Cochlear implantation is a common treatment for pediatric and adult patients with severe to profound sensorineural hearing loss. Internal device failure is a known problem that requires explantation and implantation of a new device, called reimplantation. Wang et al. (2014) have shown that the historical cumulative revision rate for primary implants at all ages increases linearly by 1% per year.

Cochlear implant (CI) failures occur for different reasons, and they can appear in many different ways, ranging from limited to a full loss of functional benefit (Waltzman et al. 2004; Balkany et al. 2005; Roland et al. 2006; Zeitler et al. 2009).

While device failure is the most common cause of reimplantation, it is not the only cause. Reimplantation can also be performed for medical reasons, such as internal part and/or electrode migration, infections, wound complications, or to upgrade a new device that is thought to be more beneficial for the patient.

The first reimplantation reported in the literature was performed by Hochmair-Desoyer and Burian (1985) in two patients who had Vienna CIs (Technical University of Vienna, Vienna, Austria). The authors reported that the surgery was uneventful, with a positive audiological outcome. The first single-channel-to-multichannel conversion was reported by Gantz et al. (1989). The authors reported similar or better audiological results after reimplantation in all patients. In the following years, reimplantation was addressed by several authors with a focus on surgical success, audiological outcomes, or both. An overview of these reports is given in Table 1 in Supplemental Digital Content 1, http://links.lww.com/EANDH/A903, Jackler et al. (1989); Miyamoto et al. (1997); Rubinstein et al. (1998); Parisier et al. (2001), Fayad et al. (2004); Sunde et al. (2013), Yeung et al. (2018).

Most of these studies reported on a mixed population of children and adults and found that audiological findings either remained stable or improved after reimplantation. Deterioration after reimplantation has only been reported in a small number of patients. Some studies have compared the last scores before with those after reimplantation. The challenge is that these last scores with the first CI (CI_1) may have been low as a result of device failure. Therefore, better scores with the second CI (CI_2) do not necessarily indicate that reimplantation yielded comparable results to the best scores with CI_1. In addition, when young children were included, improved results after reimplantation may be attributable to age benefits in terms of linguistic development. Only three papers reported comprehensive audiological data on larger groups ($N \geq 15$) of adult patients only (Ray et al. 2004; Mahtani et al. 2014; Reis et al. 2017). None of these compared the course of the auditory performance after C1_1 and CI_2. In these three papers, speech audiometry was executed with sentences at 65 to 70 dB SPL presentation level. A possible weakness of this is that scores on sentences depend more on cognitive processing than scores on words, and that results at 65 to 70 dB presentation level are rather robust and not very sensitive to intervention (Vaerenberg et al. 2014). Because of this, possible impact of reimplantation on outcome may have been overlooked by these studies. For that reason, we undertook another retrospective

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study in adult CI recipients to compare audiological outcomes with those of the second device in a more fine-grained manner.

MATERIALS AND METHODS

Participants

A retrospective analysis was performed on data of CI recipients who were implanted after January 1, 2000, and were subsequently reimplanted before January 1, 2021. All native Dutch-speaking patients who received their first implant at the age of 8 years or above and were reimplanted after an interval of a minimum of 3 mo were included. The lower limit of 8 years was chosen to ensure that all participants were linguistically capable of conducting an open-set monosyllable speech intelligibility test. Written informed consent for this document review was obtained from all patients.

Procedure

The participant's clinical files were reviewed in terms of the cause of hearing loss, age at the first and second implantation, device types, the time between the first and second surgeries, speech reception scores (SRSs) before and after reimplantation, and the reason for reimplantation.

Reimplantation was classified based on the European consensus statement on cochlear implant failures and explantations (2005). We assigned a class based on the available data before explantation and another after analysis of the explanted device. Briefly, before explantation, device failure type B is defined by either a performance decrement (B2) or a device that is out of specifications during technical verification (B1). B2 reimplantations, also called "soft failures" were driven by a certain and progressive decrease in patient performance, the presence of aversive symptoms or intermittent function, even in the presence of normal device imaging and integrity testing results. In the case of both performance decrement and device out of specification, this is type C. After analysis of the explanted device, type C is defined by a confirmed technical failure or the clinical benefit of the new device, even in the absence of measurable device failure. Type D is used for medical reasons, such as infections or device migrations, or when no technical failure was found, and no clinical benefit was observed with the new implant.

The SRSs of the participants at several time intervals after surgery were compared. Hereafter, we refer to the test conditions CI_X_[Time], where

- X is 1 or 2, referring to the first or the second implant
- [Time] refers to the test moment after the implant where, for instance, [First] is the first test moment after switch-on, [Last] is the last test moment available, [3 mo] is approximately 3 mo after switch-on. In our center, we typically hook up the implant processor at 2 weeks after surgery and perform audiological tests at 1 mo, 3 mo, 9–12 months after surgery, and then once a year. The code CI_X_[Best] is used to refer to the best score ever obtained with CI_X.

The comparisons were as follows:

- Postoperative results at 3 mo, 9 mo, and 3 years after CI_2 and CI_1,
- CI_2_[Best] vs. CI_1_[Best],
- Postoperative results with CI_2 versus CI_1_[Last].

Outcome Measures

Speech audiometry was performed using a Flemish version of the Dutch open-set monosyllabic NVA Vlaams word lists (Wouters et al. 1994). Phoneme scores (SRSs) were obtained upon presentation of two lists of 12 words at 40, 55, 70, and 85 dB SPL. We used to calculate the weighted average of these four scores to summarize all the results. This average is called EaSI and is calculated as follows:

$$EaSI = \frac{SRS_{40} + SRS_{55} + 2 * SRS_{70} + SRS_{85}}{5}$$

where SRS_{40} stands for speech reception score (phoneme score) at 40 dB SPL presentation level.

Statistical Analyses

For the analysis of the data, in addition to descriptive statistics, paired-samples *t*-tests were used whenever parametric test assumptions were met; otherwise, the Wilcoxon signed-rank test was used to perform a within-subject comparison. The independent-samples t-test was used for the analysis of parametric data. One of the Pearson or Spearman coefficients was used for correlation analysis, depending on whether parametric test assumptions were met or not, respectively. The Shapiro-Wilk test was used to test for normality. The significance level was set at 0.05. IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY) was used for data analysis.

RESULTS

In the study period, a total of 1016 first CIs were placed in our center, 59 of which were explanted and replaced with a new device. Thirty-four of these patients received their first implant at the age of 8 years or above, and 12 were excluded as they were unable to perform the NVA speech list, either owing to their mother tongue or developmental delays. Therefore, 22 par-ticipants were included in this study.

An overview of the participants included in the study is presented in Table 1.

Fifteen (68.2%) female and seven (31.8%) male participants were included, with a median age of 28 years (Q1: 17.5, Q3: 56.25) at CI_1, and 35 years (Q1: 23.75, Q3: 60.25) at CI_2. The interval between the two surgeries ranged from 8 to 218 mo (median, 68 mo). The median time to obtain the best scores with CI_1 (59%) was 50.5 mo (Q1: 23.5, Q3: 80), and it was 69 mo (Q1: 14, Q3: 108.5) with CI_2 (71%). In addition to this, the median time needed to obtain significantly better scores with CI_2 than the best scores achieved with CI_1 was only 16 mo (Q1: 5, Q3: 39).

The decision to explant a CI is often challenging. Only in the case of a type C failure, with a proven device malfunction together with a performance decrement, the decision is straightforward. This occurred 19 times (86%) in the present study. Medical reasons (type D) for reimplantation are rare; in our series, only one out of 22 cases (5%). This CI recipient (P20) presented with edema 5 years after implantation. Despite conservative therapy, a skin lesion appeared several months after the extrusion of the electrode. In the case of soft failures (type B2), the decision is made after evaluation by the CI team, manufacturer, and patient (Balkany et al. 2005). This occurred in two participants (P5 and P19) in our study (9%), and these cases will be discussed in more detail later.

TABLE 1. Overview of the subjects

Subject	Age	Sex	Cause Of Deafness	CI_1	CI_2	Age at CI_1	Age at CI_2	Inverval Between CIs (mo)	Reason for Reimplantation	Post-Hoc Analysis of CI
P1	24	F	Perilingual unknown	AB HiRES90k HiFocus 1J	AB HIRES90K HiFocus ms	9	17	95	C	C
P2	64	F	DFNA9	AB HiRES90k HiFocus Helix	AB HiRES90k HiFocus Helix	50	52	31	C	C
P3	49	M	Toxoplasma	Nucleus CI24R CS	Nucleus CI24RE CA	32	37	60	C	NA
P4	69	M	Chronic Middle Ear Disease	MedEL Concerto Flex28	MedEl Synchrony Flex28	60	67	80	C	C
P5	69	M	Meniere	AB HiRES90k HiFocus 1J	AB HiRES90k HiFocus 1J	55	58	26	B2	C
P6	29	F	Congenital unknown	AB HiRES90k HiFocus 1J	AB HiRES90k HiFocus 1J	15	21	78	C	C
P7	82	F	Meniere	AB HiRES90k HiFocus 1J	AB HiRES90k HiFocus 1J	66	73	80	C	C
P8	87	M	Genetic (TMPRSS3)	AB HiRES90k HiFocus Helix	AB HiRES90k HiFocus Helix	73	76	27	C	C
P9	40	F	Congenital unknown	AB HiRES90k HiFocus 1J	AB HiRES90k HiFocus Helix	23	31	88	C	C
P10	26	F	Perilingual unknown	Digisonic SP20	Nucleus CI522	10	24	159	C	C
P11	30	M	Perilingual unknown	Nucleus CI24R CS	Nucleus CI24RE CA	12	18	69	C	C
P12	82	F	Postlingual unknown	AB HiRES90k HiFocus 1J	AB HiRES90k HiFocus 1J	65	70	58	C	NA
P13	32	F	MYO15A	AB HiRES90k HiFocus Helix	AB HiRES90k HiFocus Helix	16	24	99	C	C
P14	47	F	Congenital unknown	Nucleus CI24M	Nucleus CI24RE CA	27	32	67	C	C
P15	34	F	Congenital unknown	Digisonic SP20	Digisonic SP20	18	19	8	C	C
P16	55	F	Congenital unknown	Nucleus CI24M	Nucleus CI512	34	45	127	C	C
P17	49	F	Meningitis	Nucleus CI24R CS	Nucleus CI512	29	48	218	C	C
P18	31	M	Perilingual ototoxicity	Nucleus CI512	Nucleus CI24RE CA	22	23	22	C	NA
P19	38	F	LVA	Nucleus CI24R CS	Nucleus CI24RE CA	21	25	50	B2	C
P20	35	F	Congenital unknown	AB HiRES90k HiFocus 1J	Nucleus CI24RE ST	20	33	161	D	D
P21	78	M	Congenital unknown	Digisonic SP20	Digisonic SP20	66	71	66	C	C
P22	63	F	Congenital unknown	Nucleus CI24R CA	Nucleus CI24RE CA	47	52	56	C	C

AB, Advanced Bionics (Stäfa, Switzerland); MedEl (Innsbruck, Austria); Nucleus, Cochlear (Sydney, Australia); Digisonic, Oticon Medical (Smørum, Denmark).
LVA, large vestibular aqueduct; NA, not applicable.

Phoneme Scores

All within-subject SRSs (EaSI) differences are presented in Table 2 and Figures 1A, B.

The average CI_1_[Last] SRS (EaSI) was 49% (SD, 23%). On average, all CI_2 results were better than CI_1_[Last]. This was statistically significant for CI_2_[9 mo] and CI_2_[3 years]. On average, all participants had better CI_2 scores than those at comparable time points after CI_1 (Fig. 1). The benefit of CI_2 decreases over time, not since the results of CI_2 deteriorate; however, like those of CI_1 improved over time; hence, reducing the gap with CI_2. It is noteworthy that the best scores obtained with CI_2 were, on average, 15% better than the best scores with CI_1 ($p < 0.01$) within participants.

The variables such as age at CI_1 and CI_2, time interval between CI_1 and CI_2, etiology (Table 3), length of deafness before CI_1 were further analyzed to see any possible contribution on the outcomes. There was no effect of age at either CI_1 or CI_2 ($p > 0.05$).

Impact of Device or Brand Type

Nine (41%) subjects were reimplanted with the same implant (brand and model) as the first CI, while 11 (50%) with a different

TABLE 2. Within-subject SRS gains of CI_2 compared with CI_1

	CI_2 [3 mo]	CI_2 [9 mo]	CI_2 [3 yrs]	CI_2 [Best]
CI_2–CI_1_[Last]	7.5% ± 4.2	13% ± 4.3	8% ± 2.6	23% ± 4.9
CI_2–CI_1	17% ± 4.2	16% ± 3.6	12% ± 3.4	15% ± 3.2

Mean values are given ± SE of the mean.
The first row shows the differences between the different CI_2 results and CI_1_[Last]. The second row shows the differences between the different CI_2 results and the CI_1 results at comparable moments after implantation. See text for more details.

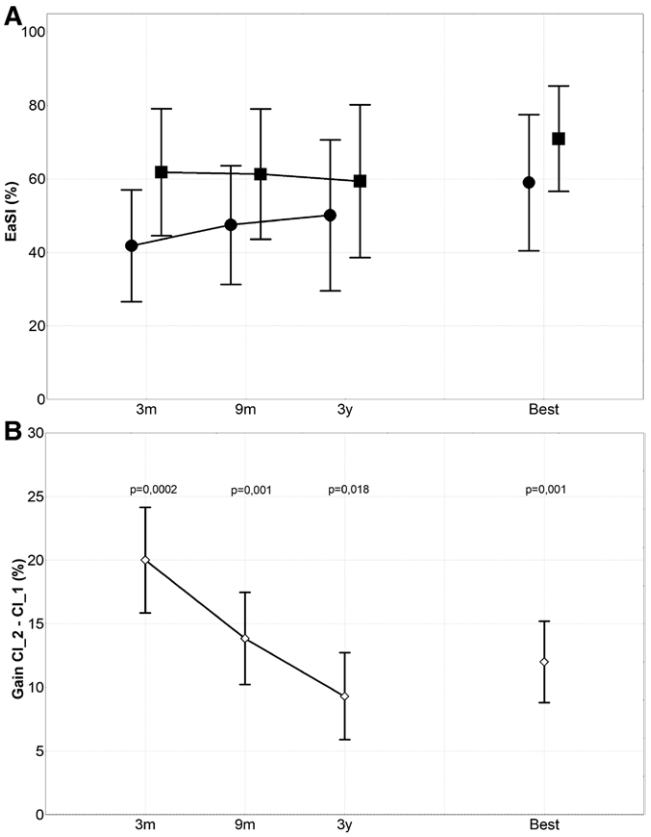

Fig. 1. A, Average group results after CI_1 and CI_2 (±SD). B, Average within-subject differences (±SE of the mean) in SRS between the CI_2 and CI_1 follow-up moments.

implant model of the same brand, and two (9%) with different brand implants. An independent-samples t-test was conducted to compare SRSs for both groups. There was no significant difference in the scores at any comparison for the users who have received the same brand & model implant as the first one and the users who have received either a different implant model of the same brand or another brand implant ($p > 0.05$).

Soft Failures

As said earlier, there were two soft failures (B2). P5 was a man who received his first CI at the age of 55 years. He was congenitally deaf unilaterally and developed a contralateral progressive hearing loss from the age of 51 years onward, due to Menière's disease. Surgery was uneventful; however, the results were not as expected with SRSs of 45–50% (Fig. 2). The man reported fluctuating performance over the course of a day, and this worsened over time. Tinnitus and loudness intolerance appeared when wearing the device for hours. Integrity testing by the manufacturer did not reveal any abnormalities. At a certain moment, wearing the processor became unbearable, and the SRS dropped from 47% to 30%. This is the moment that clinicians have proposed reimplantation. Explantation and reimplantation procedures were uneventful. An analysis of the explanted device showed no abnormalities. Immediately after CI_2, the performance was better than ever before, with an SRS of 71%. However, the participant developed loudness intolerance and invalidated tinnitus, which forced us to lower the maps and reduce the performance of SRSs by approximately 50–60%.

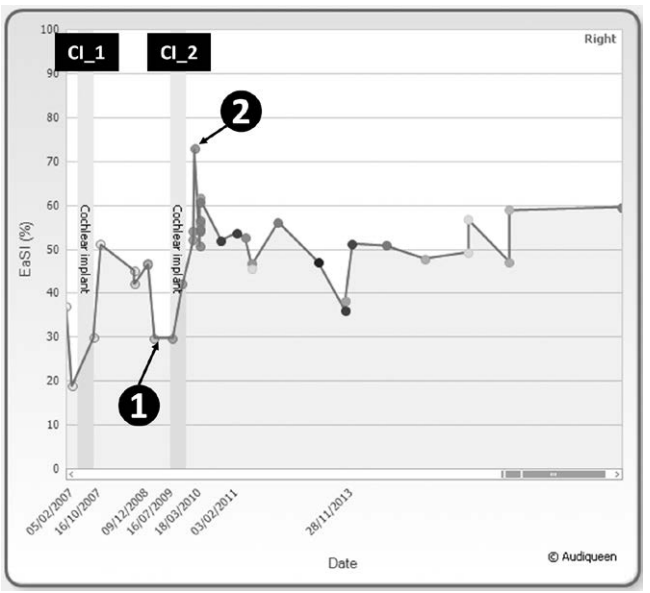

Fig. 2. Time evolution of the SRSs (EaSI) of subject P5. The SRSs after CI_1 were around 45–50%. At a certain moment (bullet 1), the SRS dropped to 30%. Because of this and other complaints (see text), it was decided to explant the device and implant a new device. Immediately after CI_2, the results were much better (bullet 2), but due to tinnitus and loudness intolerance, the map parameters had to be reduced and so did the outcome, with ultimate scores of 50–60%.

P19 was a woman who developed progressive deafness due to enlarged vestibular aqueducts. After an initial period of relatively good results, although never really as good as expected, performance progressively dropped from an SRS of 46–26% (Fig. 3). Integrity testing revealed no abnormalities. Nevertheless, it was decided to explant the device and place a new implant. An analysis of the explanted device did not reveal any abnormalities. Although the participant was quite positive soon after reimplantation, it took several years for the outcome to outperform the CI_1 result. More than 10 years after CI_2, the SRSs exceeded 70%.

DISCUSSION

This study aimed to investigate the audiological outcomes of reimplantation in comparison with the results obtained with the first CI. We did not focus on surgical or medical aspects, as this has been addressed in most of the existing literature, where it has been shown repeatedly that reimplantation has no major surgical impediments and that the second implant can be placed as easily as the first, without complications (Hochmair-Desoyer & Burian 1985; Gantz et al. 1989; Chute et al. 1992; Kileny et al. 1995; Saeed et al. 1995; Henson et al. 1999; Balkany et al. 1999; Alexiades et al. 2001; Hamzavi et al. 2002; Ray et al. 2004; Lassig et al. 2005; Côté et al. 2007; Kim et al. 2008; Gosepath et al. 2009; Van der Marel et al. 2011; Batuk et al. 2019). Histopathological animal studies have also shown that trauma to the cochlea after reimplantation is no more than that after initial implantation and that reimplantation can be performed with minimal or no additional damage to the vast majority of cochlear structures (Greenberg et al. 1992; Shepherd et al. 1995). Recent studies have shown that residual hearing can be preserved after reimplantation in electric-acoustic stimulation users, without additional trauma (Thompson et al. 2019).

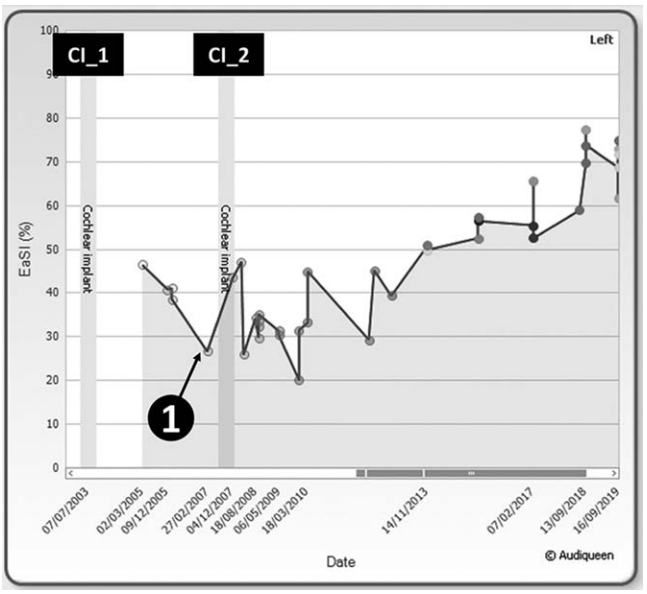

Fig. 3. Time evolution of the SRSs (EaSI) of subject P19. The SRSs after CI_1 were around 45–50% (the first data are missing, because in these days, we used to only measure SRS at 70 dB, so no EaSI could be calculated). At a certain moment (bullet 1), the SRS dropped to below 30%. It was decided to explant the device and implant a new device. After CI_2, it took several years for the results to outperform those of CI_1 and it was only after more than 10 years that scores exceeded 70%.

However, there are variable findings in the literature regarding the audiological outcomes after reimplantation. One challenge lies in the comparison of the results. Some studies compared the last test obtained just before reimplantation with the first postreimplantation test, some compared the highest scores achieved with both implants, and some studies compared prereimplantation with the most recent scores. The audiological results just before CI_2 may not be representative of CI_1 as CI_1 may be technically failing just before explantation, as confirmed by comparing CI_1_[Best] with CI_1_[Last]. The first results after reimplantation are also not necessarily representative of the outcome with CI_2, and neither are the most recent scores with CI_2. If children are included, as is the case in many reports (see Table 1 in Supplemental Digital Content 1, http://links.lww.com/EANDH/A903), SRSs may improve as a result of evolving linguistic skills rather than reimplantation. Therefore, we only included subjects who received their first implant after the age of 8 years and who were able to perform open-set monosyllabic speech audiometry.

In this study, we have compared CI_1 and CI_2 in a 3-year follow-up to answer the question: "Does reimplantation have a negative effect on speech perception?" The second implant gave equal or better outcomes than the first at all time points evaluated, namely 3 mo, 9 mo, and 3 years after surgery. This was also the case when the highest scores obtained with both implants were compared. This indicates that approximately all participants had better results after reimplantation than before. To the best of our knowledge, there are no other studies in the literature comparing the long-term follow-up results of both implants in adult patients. Birman et al. (2014) has made such a comparison in the pediatric group and concluded that SRS's did not change significantly after reimplantation. Similarly, Gosepath et al. (2009) also compared CI_1 and CI_2 [1-year follow-up] on 56 children and showed that the results either remained stable or improved. Mahtani et al. (2014), on the other hand, compared CI_1_[Best] with CI_2_[Best] in a population consisting of 30 adults and concluded that although there was a significant improvement in SRS's in silence, SRS's in noise did not change.

It must also be said that the results with CI_2 are not immediately better than the last results with CI_1. On average, it takes between 3 and 9 mo to improve on the last results before CI_2. It is important that patients receive this information before they are reimplanted.

Although group performance improved significantly with the second implant, there were three exceptions (14% in our series) on an individual basis. One participant (P16) had 15–20% lower SRSs in the months after CI_2 than at comparable time points after CI_1. This CI recipient with congenital hearing loss received the first CI at 34 years of age with moderate SRSs (best SRS: 68%). Type C failure was identified after 10 years. The reimplantation was complicated by scar tissue formation, impeding the full insertion of the new electrode carrier. Consequently, only 14 of the 22 electrodes were used. Owing to the high-electrode impedances, four more basal electrodes were inactivated, leaving only eight active electrodes. We believe that this explains the poor SRSs after surgery. The results slowly improved over the years; however, even the best results with CI_2, which are the most recent ones, are still lower (SRS: 59%) than that with CI_1 (Fig. 4).

The second participant (P17) had 13% lower SRS when comparing the best score with CI_2 than that with CI_1. This CI recipient with perilingual hearing loss attributed to ototoxicity received the first CI at the age of 29 years with poor results (best SRS: 56%, 17 years after surgery). After the first CI, this participant showed a quite slow but steady learning curve with an SRS of less than 30%, 5 years after surgery. The implant was explanted 18 mo ago owing to a type C failure. The best results obtained with the second CI were 43%. This is better than the SRS with CI_1 at the same interval after surgery, and we anticipate that this will further improve over time, in analogy with the learning curve after the first CI. A third participant (P21) had a 9% lower SRS when comparing the best score with CI_2 than that with CI_1. This CI recipient with congenital hearing loss received the first implant at the age of 47 years with poor results (best SRS: 54%, 5 years after surgery). In addition to this

TABLE 3. Within-subject speech recognition score gains based on etiology

CI_2–CI_1	[3 mo]	[9 mo]	[3 yrs]	[Best]
Chronic middle ear disease	25%$_{(1)}$	9%$_{(1)}$	–	1%$_{(1)}$
Congenital unknown	12.5%$_{(6)}$	17.5%$_{(6)}$	12%$_{(6)}$	8%$_{(8)}$
DFNA9	10%$_{(1)}$	–7%$_{(1)}$	–	–1%$_{(1)}$
Genetic (TMPRSS3)	40%$_{(1)}$	26%$_{(1)}$	–	15%$_{(1)}$
LVA	–	0%$_{(1)}$	7%$_{(1)}$	31%$_{(1)}$
Meniere	24%$_{(2)}$	10%$_{(2)}$	22%$_{(1)}$	18.5%$_{(2)}$
Meningitis	–	–	–	–13%$_{(1)}$
MYO15A	10%$_{(1)}$	16%$_{(1)}$	19%$_{(1)}$	11%$_{(1)}$
Perilingual ototoxicity	–	18%$_{(1)}$	–	16%$_{(1)}$
Perilingual unknown	31%$_{(3)}$	20%$_{(3)}$	10.5%$_{(2)}$	6%$_{(3)}$
Postlingual unknown	20%$_{(1)}$	19%$_{(1)}$	–1%$_{(1)}$	4%$_{(1)}$
Toxoplasma	–	4%$_{(1)}$	13%$_{(1)}$	18%$_{(1)}$

Median values of the differences between the different CI_2 results and the CI_1 results at comparable moments after implantation.
(x) stands for the number of available comparisons.

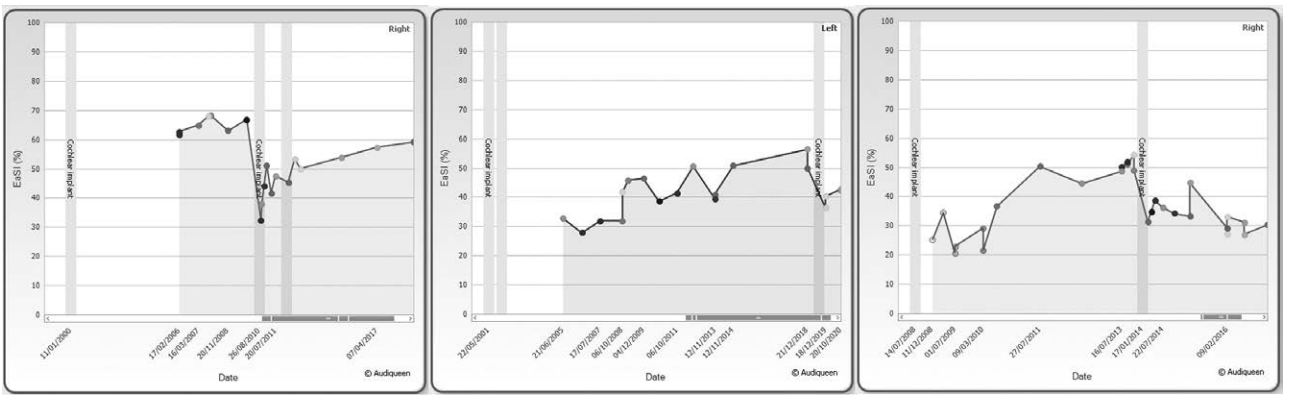

Fig. 4. Time evolution of the SRSs (EaSI) of three subjects (from left to right: P16, P17 and P21) with type C failure of CI_1 who failed to have better results with CI_2. Data before 2005 are missing because in these days, we used to only measure SRS at 70 dB, so no EaSI could be calculated). See text for more details.

congenital hearing loss, which was in line with the very poor quality of his articulation, preoperative computed tomography scans at the age of 47 years revealed fenestral and retrofenestral otosclerosis. The implant was explanted after 5 years owing to a type C failure with nonauditory sensations. The surgery was uneventful; however, in the years after CI_2, this participant developed balancing challenges, which were attributed to possible advanced otosclerosis. He also developed general comorbidities such as leukopenia, orthopedic surgery, and cardiac disorders, necessitating a pacemaker. During the first months after CI_2, the performance was equivalent to similar time points after CI_1; however, the results deteriorated in the years after CI_2 with the most recent SRSs of approximately 30%. We believe that this deterioration is due to the combination of all the aforementioned medical factors.

Migirov et al. (2007) argued that the increase in performance after reimplantation is attributable to the improved hardware and software of the second implant. However, in our study, an increase in EaSI scores was observed in six (67%) of nine participants who were reimplanted with the same brand-model device, and in nine (69%) of 13 participants who were reimplanted with either a device from another implant brand or a different implant model from the same brand. There was also no significant difference in SRS change between the groups reimplanted with the same brand-model implant and those reimplanted with a different model or brand implant. This indicates that replacing a current device with another model and/or brand implant does not necessarily yield better results, which is in line with the studies by Alexiades et al. (2001), Rivas et al. (2008), Van der Marel et al. (2011), and Mahtani et al. (2014). But it is true that speech processors also change over time, and even fitting experience, methods, and expertise may change; therefore, interpreting the contribution of all these factors to the ultimate performance remains challenging. It is remarkable that the best scores in our study group were obtained 51 and 69 mo after CI_1 and CI_2, respectively. This seems to indicate that there is a sustained learning effect, either on the part of the CI recipient, or on the part of the fitting team, or both.

One can argue that the better results with CI_2 as compared to CI_1 are due to the fact that CI_1 may have had issues from the very beginning. This would not change the overall conclusions or the information given to the patient before reimplantation. In addition, we compared CI_1_[Best] and CI_1_[Last]. If the device had malfunctioned from the very beginning, we should not have seen significant difference between these two comparisons. However, the CI_1_[Best] was significantly better than the CI_1_[Last]. It shows us that the device malfunction most likely occurred later than the CI_1_[Best].

The fact that the results obtained after CI_2 come faster than after CI_1 seems to indicate a primer effect on the central auditory system by the first implant, having allowed the patient to adapt and learn from the first CI. This is important because one could also assume the opposite, namely that CI_2 would need more time to achieve optimal results because of possible scar formation, different location of the electrodes, hence difference frequency mapping, or other factors.

We conducted correlation analyses to understand better the factors contributing to postoperative outcomes. Unfortunately, it was not possible to make a statistical comparison based on the etiology of deafness due to the limited number of patients. However, no correlation was found between age at the first or the second implantation and postoperative outcomes. Rivas et al. (2008) reported that functional gain after reimplantation decreased in individuals over 70 years. However, only one of our four patients over 70 years of age had worsened performance (P21), one had no change in performance (P12), and two had significantly improved performances (P7 and P8). As discussed previously, the performance deterioration in patient P21 was attributed to underlying disease progression.

Special attention goes to the soft failures. In our series, there were two B2 failures according to the European consensus statement (2005). It was cumbersome for clinicians to decide explanting an implant that could not be proven to fail technically. Both cases were classified as C-type failures after explantation. This was not based on the technical reports of the explants showing technical failures, but rather on the improved performance after reimplantation. But as discussed previously, in one case (P5) this improvement was temporary while in the other (P19), it came late and this might also have been the case if CI_1 had been worn longer. In retrospect, the authors are not convinced that explantation was an acceptable choice. These decisions were made in 2007 and 2009, and since then, no B2 failures have caused the authors to decide on reimplantation.

It is noteworthy that the time charts show that SRSs fluctuate over time, even if all our results are averages of four presentation levels with 24 CVC words each. It is unclear whether this reflects test-retest variability or real underlying neural or electrophysiological fluctuations. However, it indicates that one should be careful when comparing SRSs too lightly.

CONCLUSIONS

In conclusion, the current analysis shows that, on average, the audiological outcome after reimplantation is better than that with the first implant, and the optimal results appear faster than after the first implant. However, it takes a few months to get better results with CI_2 than the last results with CI_1. We observed only one case (5%) with SRS deterioration attributed to surgical difficulties during the reimplantation and one case (5%) with SRS deterioration attributed to underlying disease progression. In our experience, soft failures, defined as disappointing or deteriorating performance in the absence of technical abnormalities, may be insufficient reasons to justify reimplantation.

ACKNOWLEDGMENTS

O.Ö. and P.J.G. collected and analyzed the data and wrote the article. G.D.C. helped with data collection. P.J.G. provided critical revision. The authors acknowledge the surgeons: Dr. Inge Dhooge, Dr. Sebastien Janssens de Varebeke, Dr. Paul Van De Heyning, Dr. Gerd Claes en, and Dr. Vincent Van Rompaey, who performed the implantations and reimplantations.

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Received April 22, 2021; accepted August 15, 2021

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