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Original Article

Datalogging Findings in Adult Cochlear Implant Recipients Who Never Developed Intelligible Speech

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BACKGROUND: The aim was to evaluate the usage patterns of adult cochlear implant recipients with a history of pre-lingual or peri-lingual acquired deafness and poor speech intelligibility.

METHODS: A retrospective chart review of all patients meeting inclusion criteria within the patient cohort of the auditory implant centre of the University College London Hospitals was conducted. Outcome measurements included sound processor daily usage and speech perception scores postimplantation.

RESULTS: Fifty-nine adults met the inclusion criteria. Daily usage was found to be 8.7 hours per day on average (range: 7.9-9.7 hours) at 4.6 years postimplantation. Five recipients became nonusers (8.5%). Average usage of 11.0 daily hours at 3 months postimplantation was a significant predictor of implant usage at 4.6 years. On average, Bamford–Kowal–Bench sentence scores did not improve significantly by 1 year postimplantation. Neither the preimplantation speech intelligibility rating nor the Bamford–Kowal–Bench sentence scores were significantly correlated with postoperative usage data.

CONCLUSION: Despite non-significant improvements to speech perception scores in this patient cohort, pre-lingual and peri-lingual cochlear implant recipients are consistent users of their devices, with an average daily use of 11.0 hours at 3 months postimplantation and 8.7 hours at 4.6 years. Consistent users at 3-months postimplant are likely to continue being consistent users at 4.6 years after implantation. Understanding likely usage rates is an important consideration for patients and clinicians in the shared decision-making process about whether to undergo cochlear implantation. Further research is needed to understand why this group of patients, who receive no benefit from speech intelligibility, choose to wear their processors so consistently.

KEYWORDS: Cochlear implant, daily usage, datalogging, device use, non-traditional, scene analysis

INTRODUCTION

It is well established that cochlear implants are an effective means of restoring access to communication for patients with a severe-to-profound sensorineural hearing loss who do not adequately benefit from hearing aids.[1] Candidacy indications vary around the world, and indications have relaxed over time to commonly include more individuals not previously considered, such as those with greater residual hearing, asymmetric hearing losses, and single-sided deafness.[2,3] This is a result of the growing evidence base of the benefits of cochlear implantation in these populations.[3] However, outcomes vary, and certain patient characteristics have been found to influence their likelihood of improvement in speech perception postimplant.[4] As a patient group, prelingually deafened individuals achieve significantly poorer postimplant speech scores than those with later acquired hearing loss and have a higher probability of becoming a nonuser of their device.[5] Despite this, a Delphi consensus recommended that long durations of deafness should not preclude candidacy,[1] and most of these patients are satisfied with their outcome and report benefits to their communication.[6-10] In this population, predictive factors for better speech perception postimplantation have been found to be preimplant speech

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intelligibility and use of an oral communication method,[6] which are important considerations for professionals assessing these candidates. Although speech perception is fundamentally seen as the measurement of benefit for a cochlear implant, for prelingually deafened adults who are deemed appropriate candidates, determining a successful outcome needs to go beyond speech perception in a clinical setting.[8,9] As part of a wider holistic view of outcome, datalogging and device usage can be a valuable clinical tool in counseling this population postoperatively, giving the clinician an indication of whether the device is being utilised and indicating the sound environments the individual is typically emersed in. Recommended daily usage rates tend to be above 10 hours, which has been associated with better speech perception scores, albeit in postlingually deafened adults.[11] Datalogging is also advantageous in that it is an objective measure that captures information in the recipient's real-world listening environments.

This study aims to investigate usage patterns in a cohort of cochlear implant recipients who were pre-lingually or peri-lingually deafened but implanted as adults and who never developed good oral spoken language, to help inform shared decisions made with this population.

MATERIAL AN METHODS

A retrospective chart review was conducted on the cohort of cochlear implant patients at our tertiary referral centre. This study went through the University College London Hospitals local approval process and was approved as a service review audit; therefore, it did not require or National Health Service (NHS) Ethics approval, nor was informed consent warranted. Inclusion criteria were as follows: (1) aged 18 years and over; (2) reported pre-lingual or peri-lingual deafness diagnosis before 4 years of age; (3) at least 1 year's implant experience with available speech perception testing; (4) score of 3 or below on the speech intelligibility rating (SIR),[12] meaning they did not develop intelligible speech to an untrained listener; and (5) datalogging information available from their most recent follow-up. The exclusion criteria were those who experienced device failure. The decision to proceed with cochlear implantation was made following a multidisciplinary assessment in accordance with the national guidelines for cochlear implantation in the UK.[13] Outcome measures were the Bamford–Kowal–Bench (BKB) sentences in quiet beyond 1-year postimplantation, usage data from their most recent follow-up, and usage data at 3-month, 6-month, and 1-year intervals, where available.

MAIN POINTS

- Pre-lingually and peri-lingually deafened adults implanted in adulthood did not significantly improve their speech perception scores post-operatively after 1 year.
- The datalogging findings in this study show that the vast majority of recipients go on to use their device for more than 8 hours a day at 4 years post-implantation.
- Consistent users in the first 3 months post-implantation predict long -term usage as measured after 4 years, which has implications for counselling patients in the early period post-implantation and emphasizes the importance of early acclimatisation to electrical stimulation.

Statistical analysis was performed using Statistical Package for Social Science Statistics software version 27.0 (IBM SPSS Corp.; Armonk, NY, USA), with 95% CIs. Linear regression models were used to determine predictors of usage. Binomial logistic regression models were performed to predict the probability of patients becoming users or nonusers.

RESULTS

Fifty-nine patients met the inclusion criteria, and all were implanted in adulthood (aged 18 years or above), with a mean age of 40 and a range of 18-67 years old. Of the patients included, 88% used British Sign Language (BSL) as a form of communication. Eighteen patients were implanted with cochlear implants manufactured by Advanced Bionics Corporation (AB) and 41 by Cochlear Ltd. Of the 59 patients analysed in this study, 5 were considered nonusers (fewer than 2 hours of daily use of the sound processor, which is a definition accepted in the published literature[14]), with 1 not using the sound processor at all. Table 1 details the demographics of the study's population.

Speech Intelligibility Rating

Table 2 details the study's population distribution by SIR and links this distribution to communication mode.

Bamford–Kowal–Bench Scores

The Wilcoxon signed-rank test between preoperative and postoperative BKB scores did not show a significant improvement ($Z = 1.936$, $P = .053$). The mean preoperative BKB score was 3.88% (95% CI of 1.31-6.43), and the postoperative mean score was 8.22% (range: 2.99-13.45).

Usage Data

The mean daily cochlear implant usage was 8.7 hours (range: 7.6-9.7 hours) at their most recent follow-up, which was, on average, at 4.6 years postimplantation (range: 3.3-5.9 years). Datalogging information over time was available for a portion of the included recipients. Missing values relate to missing data either because datalogging was not available at those time points (for patients implanted before 2013, given that datalogging only became widely available in sound processors since 2013[15]), because the patient did not attend for that specific follow-up, or because that data were not recorded at the time. Mean daily usage (in hours) at 3-months postimplantation was 11.0 (range: 10.0-11.9, n = 32). Daily usage at 6-month follow-up was 10.4 hours (range: 8.5-12.3, n = 13) and at 1-year follow-up was 10.5 hours (range: 9.0-12.0, n = 22), both reduced from that observed at 3 months postimplantation. Figure 1 compares daily usage at 3-month follow-up and at the most recent follow-up.

Linear regression models showed a relationship between usage at the 3-month follow-up and usage at the recipient's most recent follow-up (Pearson's correlation coefficient $r = 0.741$, $P < .001$). A logistic regression was performed to ascertain the effects of daily usage at 3 months postimplantation on the likelihood that participants remain users. The logistic regression model was statistically significant: $X^2(1) = 6.062$, $P = .040$. The model correctly identified 93.8% of cases. Users at 3 months were 1.95 times more likely to remain users than to become nonusers.

Neither SIR nor preoperative BKB scores were significantly correlated with postoperative usage data.

Table 1. Demographics

	Etiology	Hearing Aid User?	Nature of Hearing Loss	Communication Mode	SIR	Age Implanted	User?	Pre-op BKB Scores	Post-op BKB Scores
1	Unknown congenital	No	Prelingual	BSL	1	43	No	0	Not tested
2	Maternal rubella	Yes	Prelingual	BSL	1	46	No	2	2
3	Waardenburg's syndrome	No	Prelingual	BSL	1	18	Yes	0	0
4	Unknown congenital	No	Prelingual	BSL	1	26	Yes	0	Not tested
5	Unknown congenital	Yes	Prelingual	Oral & BSL	1	40	Yes	23	32
6	Usher syndrome type 1	No	Prelingual	BSL	1	56	Yes	0	0
7	Meningitis	Yes	Peri-lingual	BSL	1	51	Yes	0	0
8	Usher syndrome type 1	No	Prelingual	BSL	1	33	Yes	0	0
9	Unknown congenital	Yes	Prelingual	BSL	1	20	No	0	Not tested
10	Measles	Yes	Prelingual	Oral	1	35	No	0	Not tested
11	Connexin 26	Yes	Prelingual	Oral & BSL	1	24	Yes	0	0
12	Unknown congenital	Yes	Prelingual	BSL	1	18	Yes	0	0
13	Unknown congenital	Yes	Prelingual	BSL	1	29	Yes	0	Not tested
14	Wolfram syndrome	No	Prelingual	Oral & BSL	2	50	Yes	0	4
15	Unknown congenital	Yes	Prelingual	BSL	2	51	Yes	0	4
16	Maternal rubella	No	Prelingual	Oral & BSL	2	44	Yes	4	0
17	Unknown congenital	Yes	Prelingual	Oral & BSL	2	32	Yes	1	6
18	Unknown congenital	Yes	Peri-lingual	BSL	2	21	Yes	0	Not tested
19	Pendred syndrome	No	Peri-lingual	BSL	2	43	Yes	0	0
20	Unknown congenital	Yes	Prelingual	Oral	2	63	Yes	0	0
21	Head injury	No	Peri-lingual	BSL	2	47	Yes	0	0
22	Rubella	Yes	Prelingual	Oral & BSL	2	44	Yes	34	9
23	Rubella	Yes	Prelingual	Oral & BSL	2	46	Yes	0	Not tested
24	Meningitis	No	Prelingual	Oral	2	40	Yes	0	Not tested
25	Unknown congenital	Yes	Prelingual	Oral & BSL	2	64	Yes	0	0
26	Hypoxia	Yes	Prelingual	Oral & BSL	2	61	Yes	4	10
27	Unknown congenital	No	Peri-lingual	Oral & BSL	2	30	Yes	2	0
28	CMV	Yes	Prelingual	BSL	3	38	No	48	79
29	Unknown congenital	Yes	Prelingual	Oral & BSL	3	28	Yes	0	0
30	Unknown congenital	Yes	Prelingual	Oral & BSL	3	41	Yes	10	Not tested
31	Unknown congenital	No	Prelingual	Oral & BSL	3	43	Yes	0	Not tested
32	Unknown congenital	Yes	Prelingual	Oral & BSL	3	41	Yes	4	0
33	Unknown congenital	Yes	Prelingual	BSL	3	45	Yes	0	4
34	Unknown congenital	Yes	Prelingual	Oral & BSL	3	31	Yes	25	19
35	Measles	Yes	Peri-lingual	Oral	3	49	Yes	6	Not tested
36	Unknown congenital	Unknown	Prelingual	Oral	3	21	Yes	28	54
37	Maternal rubella	Yes	Prelingual	Oral & BSL	3	45	Yes	6	0
38	Stickler syndrome	Yes	Prelingual	Oral & BSL	3	35	Yes	Not tested	0
39	Maternal rubella	Yes	Prelingual	Oral & BSL	3	56	Yes	0	4
40	Maternal rubella	Yes	Prelingual	Oral & BSL	3	50	Yes	0	68
41	Maternal rubella	Yes	Prelingual	Oral & BSL	3	38	Yes	5	4
42	Unknown congenital	Yes	Prelingual	BSL	3	49	Yes	0	Not tested
43	Unknown congenital	Yes	Prelingual	Oral & BSL	3	53	Yes	0	Not tested
44	Hypoxia	Yes	Prelingual	Oral & BSL	3	67	Yes	0	8

(*Continued*)

Table 1. Demographics (*Continued*)

	Etiology	Hearing Aid User?	Nature of Hearing Loss	Communication Mode	SIR	Age Implanted	User?	Pre-op BKB Scores	Post-op BKB Scores
45	Unknown congenital	Yes	Prelingual	Oral & BSL	3	64	Yes	0	14
46	Unknown congenital	Yes	Prelingual	Oral & BSL	3	40	Yes	0	18
47	Usher syndrome type 1	Unknown	Prelingual	BSL	1	23	Yes	Not tested	0
48	Usher syndrome type 1	Unknown	Prelingual	BSL	1	25	Yes	0	0
49	Unknown congenital	Yes	Prelingual	BSL	3	24	Yes	0	2
50	Pendred syndrome	Yes	Prelingual	Oral	3	55	Yes	0	0
51	Unknown congenital	Yes	Prelingual	Oral & BSL	3	26	Yes	15	8
52	Maternal rubella	Yes	Prelingual	BSL	2	44	Yes	0	0
53	Unknown congenital	Unknown	Prelingual	Oral & BSL	3	32	Yes	0	14
54	Unknown congenital	Yes	Peri-lingual	Oral & BSL	3	43	Yes	Not tested	7
55	Usher syndrome type 1	No	Prelingual	BSL	2	28	Yes	0	0
56	Basal tubercolosis	Unknown	Prelingual	Oral	2	52	Yes	0	0
57	Usher syndrome type 1	No	Prelingual	BSL	1	49	Yes	0	0
58	Unknown congenital	Yes	Peri-lingual	BSL	1	21	Yes	0	Not tested
59	Unknown congenital	No	Prelingual	BSL	2	37	Yes	0	0

BSL, British Sign Language; BKB, Bamford–Kowal–Bench; SIR, speech intelligibility rating.

When analysing long-term usage grouped by SIR (figure 2), mean usage was 6.6 hours per day for recipients with a SIR of 1 (range: 4.3-8.9), 10.6 hours per day for those who were attributed a SIR of 2 (range: 9.2-11.9), and 8.7 hours per day for patients with a SIR of 3 (range: 7.1-10.4).

Figure 3 shows long-term usage grouped by mode of communication and mean daily usage of 7.6 hours for recipients who communicate using BSL alone (range: 5.7-9.4), 8.5 hours for oral communicators (range: 3.9-13.1), and 9.7 hours for patients who communicate both orally and using BSL (range: 8.5-11.0). Multinomial logistic regression between SIR and long-term usage was not statistically significant ($P = .07$). Equally, linear regressions between preoperative BKB scores and long-term usage were also not statistically significant ($P = .409$).

Scene Analysis at the Most Recent Follow-Up

Each manufacturer reports scene classifying usage metrics differently with a proprietary formula. The results in this section will therefore be reported by the manufacturer rather than aggregated.

Table 2. Speech Intelligibility Rating

Speech Intelligibility Rating	Count (%)	Communication Mode by Speech Intelligibility Rating
1	17 (28.8)	BSL 14
		Oral & BSL 2
		Oral 1
2	18 (30.5)	BSL 7
		Oral & BSL 8
		Oral 3
3	24 (40.7)	BSL 4
		Oral & BSL 17
		Oral 3

BSL, British Sign Language.

Scene analysis data were obtained for each follow-up point mentioned in this study (3 months, 6 months, 1 year, and most recent follow-up) and is reported in the manufacturer's software as a percentage of total usage data. Advanced Bionics device users (n = 16) were in quiet or speech in quiet 77% of the time (71.1%-82.2%), and Cochlear Ltd. device users (n = 39) were in quiet, on average, 52% (45.4%-57.7%) of the time.

Both manufacturers have different approaches to sound environment classification, with Cochlear naming 6 scenes to AB's 4 scenes. The fact that their algorithms are proprietary information not published in the public domain means that the results of scene analysis are not necessarily comparable. Even if assuming the music environment is

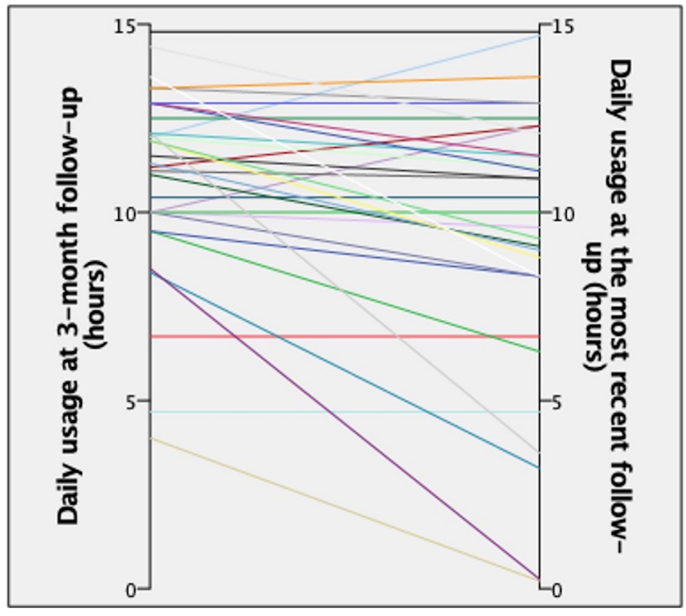

Figure 1. Daily usage over time.

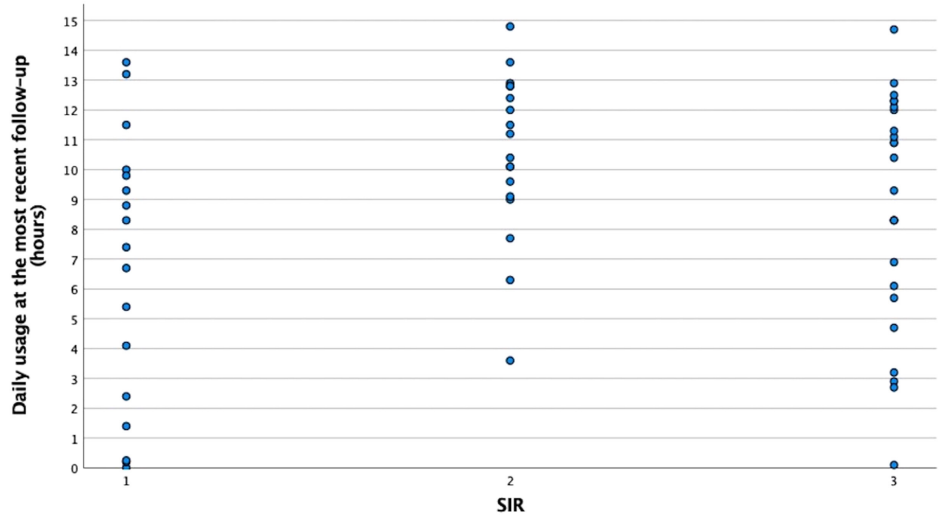

Figure 2. Long-term usage grouped by speech intelligibility rating (SIR).

comparable, other scenes might not be: while AB names a speech in a quiet scene, Cochlear names a quiet scene and a speech scene, for instance, making it important to consider these differences when analysing the results of scene analysis.

On average, recipients were in the following other sound environments: Speech in noise: 16.0% of the time; noise: 17.1%; music: 4.2%; speech: 6.5%; and other: 9.6%.

DISCUSSION

The findings from this study mirror the previous reported literature in that the cohort of prelingually and peri-lingually deafened adults did not significantly improve their speech perception scores postoperatively after 1 year.[5-7,16] However, despite the lack of improvement seen on speech outcome measures, the datalogging findings in this study show that the vast majority of recipients go on to use their device for more than 8 hours a day at 4 years postimplantation. Consistent users in the first 3 months postimplantation predict long-term usage as measured after 4 years, which has implications for counseling patients in the early period postimplantation and emphasizes the importance of early acclimatisation to electrical stimulation.

In terms of listening environments for this patient cohort, our findings support Cristofari et al (2017),[17] where the quiet scenario was the most represented listening environment for adults in their multicenter study. The reasons for this have not been investigated and would be an interesting area of further study. These findings are important to inform early counseling and can be used to work with the patient on their specific listening goals.

This study found that neither preimplant speech intelligibility, communication mode, nor BKB sentence scores correlated with postimplantation usage data. These elements have seldom been investigated in the literature. A recent study by Lahlou and colleagues (2022) found that better speech perception performance postoperatively was predicted by a better preimplant speech intelligibility rating. Data usage was not included as part of this research group's metric of outcome benefit; however, this would be an interesting area for further research.

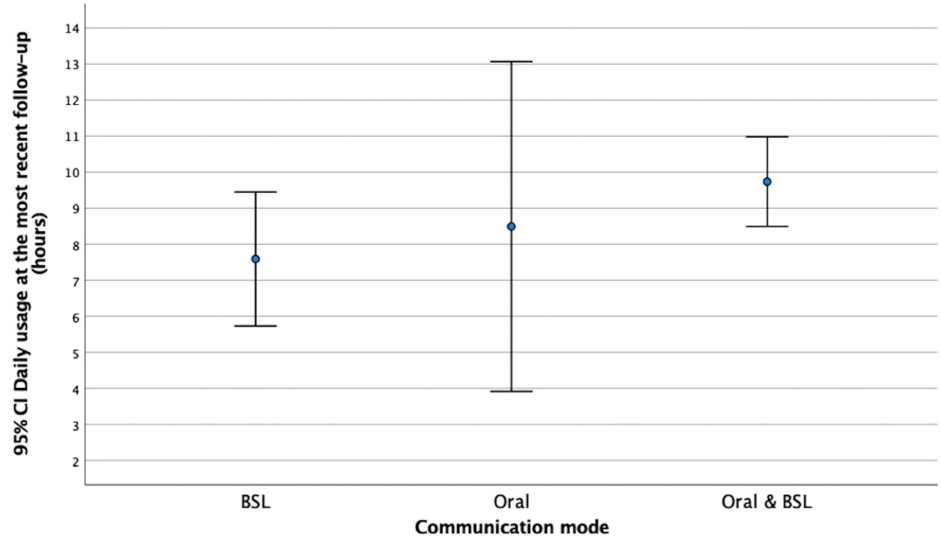

Figure 3. Long-term usage grouped by mode of communication.

Of interest in this patient cohort is the nonuser rate. This study reports 8.5%, which is within the range for similar patient cohorts as reported by Pattisapu et al (2020) in their systematic literature review, including 542 participants, but is much higher than reported in the general implanted population. As part of their scoping review of cochlear implant outcomes, Boisvert et al (2020) looked at studies reporting data usage postimplantation. From the 10 studies that reported nonuser rates (992 participants), 3% became nonusers. Of the 30 nonusers reported in this data set, 53.3% have a history of pre-lingual deafness. This is, therefore, an important consideration for professionals counseling candidates and can be useful in setting expectations for the usage of the sound processor, particularly in the early period postimplantation.

For this patient cohort, describing the likely outcomes of cochlear implants is difficult. Traditional improvements in speech intelligibility do not exist, and describing gains in general listening may be difficult to understand for those who have a very different concept of hearing from those who were postlingually deafened. However, a better understanding of how much and in which environments similar patients used their implants may be useful as a starting point in this discussion.

This study services a group of individuals underrepresented in the literature and adds to the body of work, suggesting that a variety of measures should be considered when determining a successful outcome for this population. It also adds to our knowledge base for counseling potential candidates with this background and what their expectations should be for wearing their devices. The limitation of this study is the narrow focus of outcome measures, relying purely on speech perception outcomes and device data logging. Further research could investigate whether relationships exist between usage and patient-reported measures, such as quality-of-life measures, in this patient group.

Despite non-significant improvements to speech perception scores in this patient cohort, prelingual and peri-lingual cochlear implant recipients are consistent users of their devices, with an average daily use of 11.0 hours at 3 months postimplantation and 8.7 hours at 4.6 years. Consistent users at 3 months postimplant are likely to continue being consistent users at 4.6 years after implantation. Understanding likely usage rates is an important consideration for patients and clinicians in the shared decision-making process about whether to undergo cochlear implantation. Further research is needed to understand why this group of patients, who receive no benefit from speech intelligibility, choose to wear their processors so consistently.

Ethics Committee Approval: This study was approved as a service review audit and, as a retrospective case review, it did not require Ethics approval.

Informed Consent: This study was approved as a service review audit and, as a retrospective case review, it did not require informed consent.

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