Cochlear implant outcomes in prelingually deafened adults with and without sound deprivation: Are there differences in quality of life?

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Cochlear Implant Outcomes in Prelingually Deafened Adults with and without Sound Deprivation: Are There Differences in Quality of Life?

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Background: Indications for cochlear implantation (CI) are constantly being updated, and with them, the audiometric results achieved by patients. Patient satisfaction should always be considered, even in patients with lower audiological results. The aim of the present study was to compare quality of life (QoL), self-perceived hearing benefit, and audiometric results between prelingually and postlingually deafened patients, with and without sound deprivation, after CI.

Material/Methods: The sample included 46 patients with bilateral sensorineural hearing loss: 22 postlingually deafened and 24 prelingually deafened, further subdivided into sound-deprived (n=10) and non-sound-deprived (n=14). Auditory performance was evaluated with pure tone audiometry, speech recognition scores (SRS), and self-perceived hearing benefit, whereas QoL was evaluated with 2 self-reported questionnaires (Comprehensive Cochlear Implant Questionnaire and World Health Organization Quality of Life-BREF).

Results: Audiometric results were worse in the prelingually deafened than in the postlingually deafened group, and worse in the prelingually deafened patients with sound deprivation. There was no marked difference in perceived CI benefit or QoL between the 2 groups or within the 2 prelingually deafened subgroups. No correlation was found between SRS and duration of CI use or between QoL and SRS in the prelingually and postlingually deafened groups.

Conclusions: Our findings demonstrate better auditory performance for the postlingually deafened group and no differences in perceived QoL or benefit of CI between the groups. The sound-deprived patients had equal scores on the perceived QoL questionnaire. These analyses suggest that sound-deprived, prelingually deafened patients may benefit from CI.

Keywords: **Cochlear Implants • Deafness • Quality of Life**

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Background

Until the mid-1990s, patients with prelingual deafness were not considered suitable candidates for cochlear implantation (CI). Studies conducted at the time showed that such patients could achieve improvements in the perception of environmental sounds but not in speech recognition [1,2]. Much has changed in the last 15 years with advances in surgery, anesthesiology, and CI technology. Modern devices provide sound processing and stimulation strategies that allow better speech understanding by facilitating central deciphering of CI stimulation of the auditory nerve [3]. Furthermore, audiological CI indication criteria have been expanded to include the prelingually deafened, as demonstrated in recent studies [4].

Especially in prelingually deafened candidates, there is wide variability in audiological outcomes, owing to the multiple factors at play: earlier implantation [5,6], severity [7,8] and age at onset of the hearing loss (prelingual or perilingual) [9], and etiology of the deafness. While all these factors except etiology play a minor role in postlingual deafness [10-12], they are of extreme importance for predicting audiometric outcome and speech recognition results in prelingually deafened patients.

Recent evidence supports the hypothesis that there is no correlation between audiological CI results and reported benefit in quality of life (QoL) [13,14]. This is true in prelingually deafened patients and has been documented in a recent review [4]. In such patients, CI is not unreasonable, but it must be accompanied by good counseling to explain what can be expected and explore what motivates the patient to undergo surgery. The review concluded that more data need to be collected and that future studies involving late-implanted, prelingually deafened adults should categorize patients by criteria of residual hearing, age at onset of hearing loss, and etiology. It is equally important to differentiate patients based on their response to QoL questionnaires.

The aim of the present study was to compare social and audiometric data between a group of late prelingually deaf CI patients, with and without sound deprivation, and a group of postlingual deaf CI patients to evaluate possible differences in subjective hearing benefit and perceived QoL.

Material and Methods

This was a retrospective, observational study of 46 patients undergoing CI. All patients had bilateral, severe-to-profound, sensorineural hearing loss and speech recognition scores (SRS) ≤50% for Italian open-set disyllabic words presented at 60 dB sound pressure level (SPL) in quiet and best-aided conditions after evaluation of optimal hearing aid fitting. Preoperative petromastoid computed tomography and brain magnetic resonance imaging scans were obtained to evaluate the internal ear anatomy. The sample included consecutive patients who underwent CI in the ENT Division, Department of Surgical Sciences, University of Torino, between 2013 and 2018. Exclusion criteria were: inner ear malformation or incomplete insertion of the electrode in the cochlea, age <18 years or >80 years, bimodal hearing solution with SRS >50% with a hearing aid in the better ear, and singled-sided deafness.

CIs from 3 different manufacturers were used: Advanced Bionics, Stäfa, Switzerland (n=9); Cochlear, Sydney, Australia (n=16); and Med-El, Innsbruck, Austria (n=21). The CIs were always activated within the first month after surgery and the subsequent fitting was performed by the same audiologist for all patients. Similarly, the rehabilitation program was always carried out by a single speech therapist. No complications were reported.

Data from the medical records were retrieved for civil status, educational level, and etiology of hearing loss. Pure tone audiometry (PTA) and speech recognition tests were regularly performed using the same instrumentation. All audiometric tests were performed with the CI, with the contralateral hearing aid in bimodal stimulation and with the contralateral CI in sequential stimulation after at least 12 months of use; only the data relating to the most recent examinations were extracted and used. Speech recognition tests followed the same protocol in all patients. The proportion of correctly recognized words from disyllabic word lists was noted; the patients were presented with 20 recorded disyllabic words at 60 dB SPL in a quiet room via a loudspeaker placed 1 meter in front of them. They were asked to repeat the words they heard, and at the end of the test, the SRS was expressed as a percentage. The mean PTA threshold was obtained as the mean at 500, 1000, 2000, and 4000 Hz.

A total of 46 patients were selected. The sample was divided into 2 groups according to whether the onset of hearing loss was prelingual or postlingual. The prelingually deafened group (PRE-LG) was composed of 24 patients and the postlingually deafened group (POST-LG) was composed of 22 patients. All POST-LG patients had received a CI in an ear without significant auditory deprivation. In accordance with recent literature, we considered auditory deprivation significant if it was for a period longer than 15 years [12,15].

The PRE-LG group was further divided into 2 subgroups: 10 "D" patients with significant auditory deprivation and 14 "S" patients with auditory stimulation before CI.

The patients filled out 2 questionnaires that investigated their perceived hearing benefit and QoL. The Comprehensive Cochlear

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Implant Questionnaire (CCIQ) evaluates the impact of CI on social life, activities, and confidence of use. It is composed of 28 items that measure physical, psychological, and social benefits on a Likert-like scale from 1 to 5. The CCIQ is not validated when given in Italian, so we used 2 different translators with medical backgrounds. Working separately, they developed 2 Italian versions of the questionnaire and noted any doubts or difficulties they encountered. Then, they compared the 2 translations and agreed on a final version with the help of an ear, nose, and throat specialist. The World Health Organization Quality of Life-BREF (WHOQOL-BREF) questionnaire, which is validated for use in Italian [16] and was adapted from the extended version "w100," is composed of 26 items that investigate 4 domains: physical, psychological, social, and environmental health. At least 12 months elapsed between the surgery and questionnaire administration: the mean time period was 43 months (range, 12-96).

Statistical Analysis

Categorical variables were reported as frequencies and percentages, whereas continuous variables were reported as means and standard deviations when distribution was normal (normality distribution was tested with the Shapiro-Wilk normality test), or as medians and interquartile ranges (IQRs) when distribution was not normal. Differences between the 2 groups were analyzed with a chi-square test for categorical data (with Fisher correction when needed), while continuous variables were analyzed using an independent *t* test when 2 groups were compared and with an analysis of variance test for more than 2 groups. A Mann-Whitney test was applied for non-normal distribution and Spearman rank correlations were run to assess the relationship between SRS and duration of use or QoL. Statistical significance was set at the conventional $P<0.05$. The results were analyzed using StataSE statistical software, version 15 (Stata Corp., College Station, Texas, United States).

Compliance with Ethical Standards

The present study was an observational case series and all procedures performed were in accordance with the ethical standards of the institution and conducted according to the principles expressed in the Declaration of Helsinki.

All data were analyzed anonymously and in accordance with the ethical standards of the institution.

Results

The sample was divided into 2 groups: the PRE-LG group, composed of 24 patients (5 men and 19 women; mean age 41.5 years; range 20-55) and the POST-LG group, composed of 22 patients (12 men and 10 women; mean age 57.5 years; range, 26-75).

As regards socio-demographic data, we observed that in the PRE-LG group, 66.7% of patients were employed, 16.7% were unemployed, 16.7% were students, and 58.3% were unmarried, while in the POST-LG group, 59.1% were employed, 36.4% were retired, 4.6% unemployed, 18.2% single, and 63.6% were married. These differences were statistically significant ($P<0.001$ for employment status and $P=0.006$ for civil status).

The most common cause of hearing loss in the POST-LG group was Ménière's disease (35.7%), followed by unknown etiology (21.4%), ototoxicity (14.3%), and post-infectious, post-traumatic, neuromuscular, and work-related causes (7.1% each). In the PRE-LG group, the deafness was secondary to infection (41.2%), genetic disease (35.3%), of unknown etiology (17.7%), and head trauma (5.9%). The difference in distribution of etiology was statistically significant ($P=0.001$). As for CI data, we showed that the mean age at CI positioning was 42.6 years for the whole sample (37.9 in the PRE-LG and 48.4 in the POST-LG group, $P=0.034$).

Among the PRE-LG patients, 23 (95.8%) had received oralist rehabilitation with differences in duration of hearing aid fitting; 1 patient (4.2%) had complete auditory deprivation since birth. In this group, 10 patients (41.7%) received the implant in the sound-deprived ear, ie, without acoustic stimulation for over 15 years (D), and 14 patients (58.3%) continued to use their hearing aids until CI (S). In addition, 12 patients (50%) had unilateral CI, 5 patients (20.8%) had undergone bilateral CI, and 7 patients (29.2%) had bimodal stimulation.

In the POST-LG group, 3 patients (13.6%) had unilateral CI, 5 (22.7%) had undergone bilateral CI, and 14 patients (63.6%) had bimodal stimulation.

Table 1 lists SRS and audiometric results in the 2 groups. One patient (4.1%) in the PRE-LG group was unable to perform the speech recognition test. In the other patients, SRS ranged between 10% and 100%. **Table 2** lists the distribution of patients in relation to SRS. In contrast, **Table 3** lists SRS distribution in the PRE-LG D and S subgroups. The median SRS was 40% (range, 20%-80%) for subgroup D and 80% (range, 40-90%) for subgroup S ($P=0.119$).

At least 12 months elapsed between the surgery and questionnaire administration: the mean period was 43 months (range, 12-96). The percentage of respondents was 71% (17 patients) in the PRE-LG group and 64% (14 patients) in the POST-LG group.

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Table 1. Median pure tone audiometry and speech recognition scores in the prelingually deafened and postlingually deafened groups.

	TOTAL (n=46)	PRE-LG (n=24)	POST-LG (n=22)	*p* Value
PTA, median (IQR)	28.8 (22.5; 35)	29.4 (23.8; 41.9)	27.4 (22.5; 32.5)	0.159
SRS (%), median (IQR)	90 (60; 100)	80 (30; 90)	100 (90; 100)	**<0.001***

PTA – pure tone average; IQR – interquartile range; SRS – Speech Recognition Score; PRE-LG – pre-lingually deafened patients; POST-LG – post-lingually deafened patients; * Mann-Whitney test.

Table 2. Distribution of patients in relation to speech recognition scores.

SRS	TOTAL (n=46)	PRE-LG (n=23)	POST-LG (n=22)	*p* Value
10	1/45 (2.2%)	1/23 (4.4%)	0	**0.008**
20	3/45 (6.7%)	3/23 (13.0%)	0	
30	4/45 (8.9%)	3/23 (13.0%)	1/22 (4.6%)	
40	1/45 (2.2%)	1/23 (4.4%)	0	
50	1/45 (2.2%)	1/23 (4.4%)	0	
60	2/45 (4.4%)	0	2/22 (9.1%)	
70	0	0	0	
80	8/45 (17.8%)	6/23 (26.1%)	2/22 (9.1%)	
90	9/45 (20.0%)	5/23 (21.7%)	4/22 (18.2%)	
100	16/45 (35.6%)	3/23 (13.0%)	13/22 (59.1%)	

SRS – Speech Recognition Score; PRE-LG – pre-lingually deafened patients; POST-LG – post-lingually deafened patients.

Table 3. Distribution of speech recognition scores for the D and S subgroups.

SRS	D (%)	S (%)	*p* Value
0	1/10 (10.0)	0	0.741
10	1/10 (10.0)	0	
20	1/10 (10.0)	2/14 (14.3)	
30	2/10 (20.0)	1/14 (7.1)	
40	0	1 (7.1)	
50	1/10 (10.0)	0	
80	2/10 (20.0)	4/14 (28.6)	
90	1/10 (10.0)	4/14 (28.6)	
100	1/10 (10.0)	2/14 (14.3)	

SRS – speech recognition score; D – sound-deprived patient; S – sound-stimulated patient.

There was a statistically significant difference between the 2 groups for only 3 of 28 items on the CCIQ questionnaire, in which responses are given on a 5-point Likert-like scale (never, rarely, sometimes, often, always). Concerning the item "I still have trouble conversing in rooms where there is an echo, like large auditoriums or gyms," the median response was 2 (interquartile range [IQR], 1-3) for the PRE-LG group and 3 (range, 2-4) for the POST-LG group (*P*=0.010). As regards the item "Is the music more enjoyable?," the median response was 3 (IQR 3-4) for the PRE-LG group and 2.5 (IQR 0-3) for the POST-LG group (*P*=0.027). Finally, for the item "I can better understand a conversation in a noisy room," the median response was 2 (IQR 2-3) for the PRE-LG group and 3 (3-4) for the POST-LG group (*P*=0.020). No differences in responses on the QoL questionnaire (WHOQOL-BREF) were observed between the 2 groups. The median for the responses was 2.8 (2.2;3.1) for the PRE-LG and 2.9 (2.5;3.1) for the POST-LG group (*P*=0.360) and the median for the 2 groups together was 2.8 (2.5;3.1). The median

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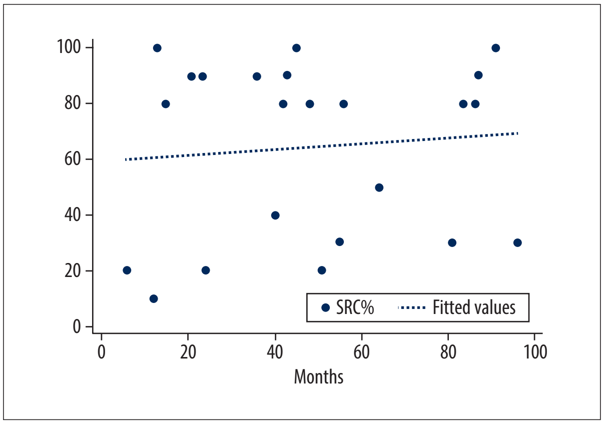

Figure 1. Correlation between months of cochlear implant use and speech recognition score in the prelingually deafened group (rs=0.07; *P*=0.736). SRS – speech recognition score, PRE-LG – prelingually deafened patients.

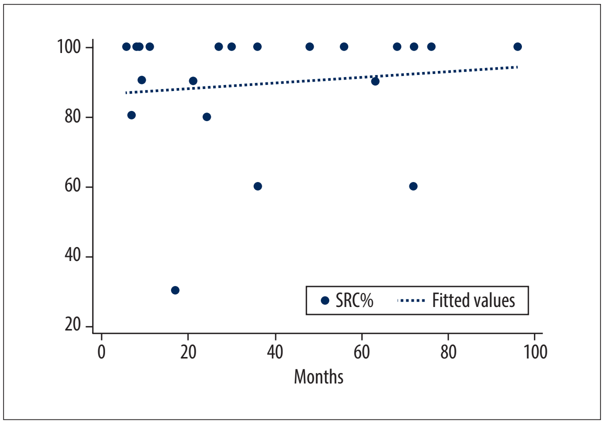

Figure 3. Correlation between speech recognition score and mean quality of life score for each patient in the prelingually deafened group (rs=0.32; *P*=0.216). SRS – speech recognition score, PRE-LG – prelingually deafened patients.

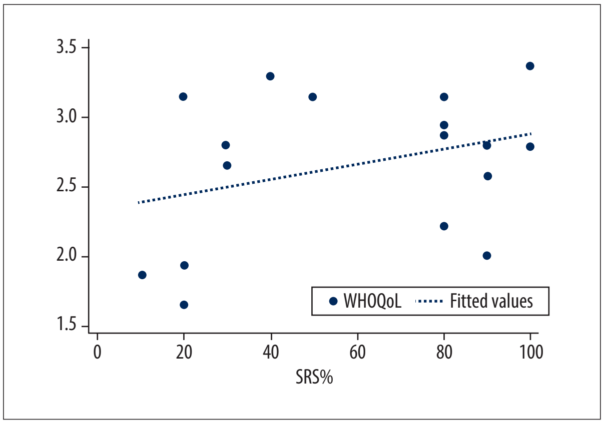

Figure 2. Correlation between months of cochlear implant use and speech recognition score in the postlingually deafened group (rs=0.11; *P*=0.618). SRS – speech recognition score, POST-LG – postlingually deafened patients.

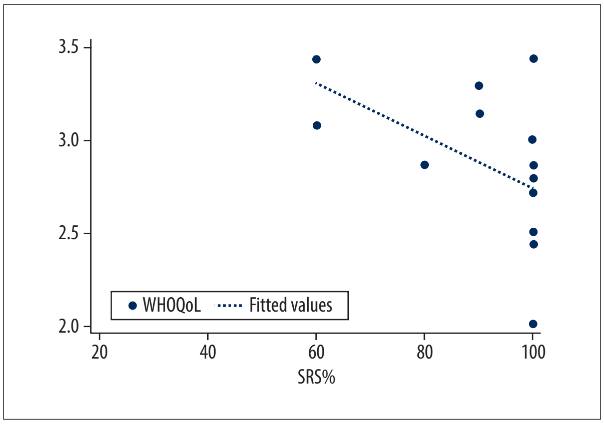

Figure 4. Correlation between speech recognition score and mean quality of life score for each patient in the postlingually deafened group (rs=-0.60; *P*=0.024). SRS – speech recognition score, POST-LG – postlingually deafened patient.

response was 2.5 (1.9;2.9) for subgroup D and 2.8 (2.6;3.1) for subgroup S (*P*=0.303).

The relationships between the SRS and duration of CI use, as well as between the SRS and the perceived QoL in the PRE-LG and the POST-LG groups, were evaluated with a Spearman rank correlation (**Figures 1-4**). A strong negative correlation was found between SRS and mean QoL score for each patient in the POST-LG group (Spearman rho -0.60, *P*=0.024, **Figure 4**).

Discussion

Audiological improvement in late-implanted PRE-LG deafened patients is commonly considered worse than that achieved in POST-LG adults. Moreover, the wide range of audiometric performance that persists among PRE-LG deafened patients [4] is due to multiple prognostic factors, the foremost being oralist rehabilitation and sound deprivation in the ear that has undergone CI [17]. In the present study, the sample consisted of 24 PRE-LG deafened patients with and without a long duration of sound deprivation and 22 POST-LG deafened patients.

Our results showed that audiometric outcomes were poorer in the PRE-LG patients, with a wide difference in SRS within the group. Furthermore, subgroup analysis showed a difference in SRS (albeit not statistically significant) between the 2 groups (40% vs 80% for the D and S groups, respectively), compared to a median of 80% for the whole PRE-LG group.

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This finding indicates that, in contrast to acquired hearing loss, outcomes are poorer in patients with congenital deafness in cases in which the ear that has undergone CI had sound deprivation [10,18]. An anomalous finding emerging from our study regards hearing performance: SRS did not correlate with the duration of use of the CI in the POST-LG and PRE-LG groups. The absence of a correlation in the POST-LG group is in line with previous data. Modern devices enable patients to achieve satisfying hearing results within very short rehabilitation times [18]. Studies have shown, however, that the prelingually deafened need more time and rehabilitation to reach similar outcomes [12,18]. No reliable correlation could be found because of the heterogeneous prognostic factors in the PRE-LG group. Auditory performance is correlated with rehabilitation benefit [13].

The questionnaire response rate was 71% in the PRE-LG group and 64% in the POST-LG group because for some patients, the questionnaires were too difficult and long to fill out. In our study, the responses to the CCIQ questionnaire were statistically significantly different between the 2 groups for only 3 of 28 items. Moreover, for 2 of those 3 items, the PRE-LG group responses indicated much more satisfaction than in the POST-LG group, even among those with better auditory performance. The median of the PRE-LG group response reveals that, despite the significantly lower SRS than that in the POST-LG group, these patients reported greater benefit in understanding speech, in environments with echo and when enjoying music. A plausible explanation is that postlingually deafened adults learned how to listen with normal binaural hearing in a room with echo and how to appreciate the melody in music.

We found no difference in the median QoL scores between the PRE-LG group and the POST-LG group. This lack of a significant difference clearly reveals how CI is important for prelingually deafened patients because it can enable them to reach a relatively higher QoL score despite the low SRS and increased social isolation that seemed to be indicated by our data: 58% of the PRE-LG group patients were unmarried and 16.7% were unemployed at the time of the questionnaire compilation. These findings are in line with previous studies and are a major reason why CI is increasingly proposed to prelingually deafened patients [9,19].

Analysis of the correlation between SRS and QoL in each group showed a weak positive correlation for the PRE-LG group. However, such a correlation was not statistically significant, indicating that QoL does not differ in this group with an SRS of 20% compared to patients with an SRS of 100%. In contrast, we found a strongly and statistically significant negative correlation between SRS and mean QoL in the POST-LG group. The explanation could be that hearing loss in the better-performing patients in the POST-LG group occurred later in life, when they transitioned from normal hearing to CI more rapidly and without the use of a hearing aid (data not shown). Therefore, they did not experience long-term difficulties in hearing, but rather, had a preserved, recent memory of normal hearing that lessened appreciation of hearing with a CI. The absence of a correlation between SRS and QoL was noted for the PRE-LG group and was particularly evident on subgroup analysis.

A comparison between the 6 prelingually deafened patients with sound deprivation (and lower SRS) and the 11 PRE-LG patients without sound deprivation showed no statistically relevant difference in mean QoL scores (2.46 in group D vs 2.75 in group S; P=0.3). The information we have added with our study is that we found no difference in the PRE-LG group between deprived (D) and not deprived (S) patients. We note that there is very little literature on QoL in deprived prelingual deaf patients.

A limitation of the present study was the small number of patients recruited into the PRE-LG D subgroup; in fact, these patients are often excluded from presurgical counseling because they are often poor candidates for CI. In fact, however, there is no evidence in the literature supporting the benefits of CI in prelingually deprived patients. Another limit was the absence of a QoL questionnaire pre-CI, meaning that we could not compare changes in perceived QoL.

Conclusions

Our findings showed better auditory performance in the patients in the POST-LG group and no differences between the groups in perceived QoL or benefit of CI. The sound-deprived patients had lower SRS than the sound-stimulated patients but equal scores on the perceived QoL questionnaire. A subjective evaluation of QoL revealed that sound-deprived, prelingually deafened patients may be eligible for CI.

Conflict of Interest

None.

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