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Original Research Article

Comparison of the quality-of-life benefit received from cochlear implants and hearing aids among hearing-impaired adults

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ABSTRACT

Background: To compare the quality-of-life (QOL) benefit received from cochlear implants (CIs) and hearing aids (HAs) among hearing-impaired adults. Using Case Control Study design, health-related questionnaire based on indices for audiological data and quality of life (QOL) was prepared. The questionnaire was used to compare the satisfaction level of users of Cochlear Implants with that of Hearing aids.
Methods: Retrospective and prospective data pandemic from December 2019 to May 2021 was collected. Twenty-five cases of adult Cochlear Implant users were compared against equal number of age-matched control cases of users Hearing aids. Questionnaire to assess the influence of either on quality of life was mailed to the receipients.
Results: Scores for the Hearing aids group matched very well with the scores for the Cochlear Implant group. Overall QoL scores were extensively higher for all 6 subdomains. \Multiple evaluation of variance showed greater QOL benefit in CI than HA users across the physical, psychological, and social subdomains ($p<0.001$).
Conclusions: Cochlear implants provide extensive benefit for those with profound hearing loss as hearing aids bring for those with less severe hearing loss.

Keywords: Cochlear implant, Hearing loss, Hearing aids, Quality of life

INTRODUCTION

Both hearing aids and cochlear implants help people with hearing loss to communicate better. Hearing aids do not require surgery and are best suited for people with less severe hearing loss and fair speech understanding. Cochlear implants require surgery and are best suited for people with more severe hearing loss and poor speech understanding.[1]

Hearing loss brings serious health implication as it is the third most common chronic condition among other health conditions.[2] About two-thirds of adults ≥70 years of age have hearing loss. Individuals with hearing impairment have poorer cognitive, physical, and mental function as well as lower health-related quality of life. A study of 2304 hearing-impaired adults older than 50 years found that adults with untreated hearing loss were more likely to suffer from sadness, depression, anxiety, social isolation, and insecurity. It has also been found that the

hearing impaired had fewer relationships, decreased social activity, and increased depression. As the population ages, increased numbers of older adults will suffer hearing loss. Approximately 12.4% of the population is over the age of 65 years, and the segment greater than 85 years has had the greatest increase. Furthermore, between 35% and 42% of those aged 65 years and older are hearing impaired.[3]

Auditory rehabilitation can reverse the adverse affects of and dysfunction from hearing loss. Hearing aids can improve the overall quality of life (QOL) in hearing-impaired adults.[4,5] For patients who receive no benefit from hearing aids (HAs), cochlear implants (CIs) provide improved audiologic performance and improvements in QOL.[6,7,8] This study compares the functioning, with respect to QOL, of CI patients with an average group of HA patients. By evaluating the QOL benefit from CIs with that of HAs in hearing-impaired adults, the impact of auditory intervention on the functional gap between CI and HA candidates is assessed. Specifically, the degree that CIs raise deaf patients' QOL toward levels enjoyed by HA patients can be determined. Such an analysis may bring further insight about how each intervention impacts patients' lives.

METHODS

Ethical approval was obtained for this study from Human Research Ethics Committee before any data collection took place.

Study design

It was both retrospective as well as prospective study designed to study the QoL change in patients with HA versus those with CI.

This study strictly adhered to the ICH-E6 GCP guidelines 1996 and the principles enunciated in the declaration of Helsinki (2008) were followed. Multiple center, case-control, observational Study.

Study area

This study was conducted retrospectively as well as prospectively on the available data of patients retrieved from the Max Hospital, Saket (Delhi) and Sankalp ENT and Cochlear Implant Centre, Dwarka (Delhi) from period December 2019 to May 2021.

The sample size for case-control study was calculated via:

$$n = N \times X \div (X + N - 1)$$

where,

$$X = Z\alpha \div 22 \times p \times (1 - p) \div MOE2$$

and Zα/2 is the critical value of the Normal distribution at α/2 (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), MOE is the margin of error, p is the sample proportion, and N is the population size.

Expected proportion in controls: 0.04

Assumed odd ratio: 10

Confidence level: 0.95

Power: 0.8

Study type

The study was case control study. Sample size per group was 25. Total sample size (both groups) was 50

Twenty five cochlear implant (CI) (Case group) patients who were in the age range of 18 years or older with an implant age of six to twenty four months were identified. The rationale was due to the commonly reported poorer performance and emotional distress within the early months post switch on which could affect the outcome of the results. It was decided that only those who had never been implanted with a CI before would be included. That is, participants could not be undergoing, reimplantation or bilateral implantations. Because the study focused on the experience of transitioning to a CI, it needed to be the individual's first CI to help answer the research questions. From the same audiology clinic, a random sample of Hearing aid (HA) (Control Group) patients in the same age range as CI patients were selected. Demographic, medical, and audiological data were collected from patient records. The number of chronic medical problems, current age, age at intervention (first hearing aid use or cochlear implantation), length of hearing loss, time since intervention, race, and marital status were collected for each person. Education was obtained on survey responders and defined as less than or equal to high school or greater than high school. To assess QOL, the Nijmegen Cochlear Implant Questionnaire, a health-related QOL questionnaire recently designed and validated, was used.9,10 This questionnaire is composed of 6 subdomains: basic sound perception, advanced sound perception, and speech production comprise the physical domain; self-esteem is the psychological domain; activity limitations and social interactions encompass the social domain. Both CI and HA patients were separately mailed 2 copies of thquestionnaire. The first version was for the pre-rehab state (ie, without the CI or HA) and the second version for the post-rehab state (i.e., with the CI or HA). They were mailed at least 2 weeks apart and were returned anonymously. Follow-up phone calls were made to ensure receipt of the questionnaire.

In the present study, the conventional approach used was by measuring HRQoL under three domains: physical, psychological, and social functioning. Further sub-

domains such as, basic sound perception, advanced sound perception, and speech production, activity and social functioning and self-esteem, were also used. In the first part of the questionnaire, each item was formulated as a statement with a 5-point scale to indicate the extent to which the stated question was true. The 5 response categories were as follows: never (1), sometimes (2), regularly (3), usually (4), and always (5) for 45 items(control group) with last questions asking about the participant's expectations of the CI such as the perceived benefits, concerns, and impact that the CI has brought, and for 47 items (case group) in which last questions were based on CSIQ(Cochlear Implant Satisfaction Questionnaire).The second part of the questionnaire was prepared with the objective to assess the satisfaction of the client with his daily life (CSQ). The first 40 of these were derived from the Nijmegen Cochlear Implant Questionnaire (NCIQ). The second part of the questionnaire (Q41-47) was based on the Cochlear Implant Satisfaction Questionnaire (CISQ). The control group's questionnaire consisted of 45 items. The first 40 items were the same as the CI group's questionnaire, with the wording modified to suit the control group. Items 41-45 were open-ended questions asking about the participant's expectations of the CI such as the perceived benefits, concerns, and impact that the CI may have in their life. All questions to both the cohorts were same, with modified wording to suit the respective group. The questions were open-ended and the participant's expectations were emphasised. The subdomain scores were obtained by adding the score for every question and then dividing the sum by the number of subdomain questions that were completed.

Statistical analysis was performed with SigmaStat and SPSS software (SPSS Inc., Chicago, IL, USA). Repeated-measure analysis of variance was used to determine if group (CI versus HA), time of evaluation (pre- versus post-intervention), or interaction between group and time were associated with QOL benefit. Subsequent analysis of QOL benefit and potential confounding variables was performed. If the assumptions of normality were not met, tests were conducted using nonparametric tests. Multiple linear regression assessed the association between QOL benefit and group while adjusting for identified confounding variables. To control for multiple tests, analysis of the 6 QOL subdomain benefit scores was conducted using multivariate analysis of variance and covariance of group differences (CI vs HA). Given a statistically significant multivariate finding, subsequent analysis of covariance procedures were conducted on each QOL subdomain benefit score while adjusting for confounding variables.

One factor inherent to many questionnaire-based studies, including the present one, is that the population sampling may be biased in that respondents chose to answer this optional questionnaire. Those that responded may have had a particular motivation or reason to respond. In addition, the closed-set format of many of the questions meant that participants were not free to explore other issues that they may have felt to be important, nor the freedom to comment on issues that are important to them. Similarly, the 5-point rating scale used may have not provided sufficient precision for CI recipients to accurately convey their opinions. However, both the closed-set format and the 5-point scale provide advantages with regard to time efficiency, ease of response interpretation, and therefore possibly increased participant response rates.

Another limitation of the questionnaires that were used in the current study was that even though these questionnaires were based on existing questionnaires, the modified versions used in this study have not been evaluated, and there were no existing norms. Further, in regards to the NCIQ which had been translated from Dutch, it was necessary to re-word some of the questions in to make them clearer, and grammatically correct.

RESULTS

A total of 23 responses were received from the CI recipients (aged 18 to 80 years), of these 23 implantees, 68.57% were males and 31.42% were females. 30 responses were received from HA participants (aged 25 to 93 years), Those respondees consisted of 62.85% males and 37.15% females. All CI patients were post lingually deafened.

Table 1: Speech perception details for CI and HA participants.

	Pre-CI speech production**
Cochlear implant	17.62% (92)
Hearing aids	32.1% (121)

**% - correct score in their best aided condition,

Table 2: Group mean subdomain scores*.

Subdomain	Pre Mean (SD)	Post Mean (SD)
Basic sound preception	16.6 (10.49)	78.6 (17.13)
Advanced sound preception	18.8 (15.63)	67.8 (12.47)
Social Interaction	28.6 (19.64)	80.1 (13.41)
Activity Limitation	27.8 (19.27)	71.9 (14.89)
Self - esteem	35.3 (22.76)	75.4 (12.88)
Speech Production	75.5 (13.8)	88.9 (11.52)

*This was calculated as the difference between the mean pre and post scores for the two groups

Speech discrimination was determined in two different situations. Scores were calculated by summing up the mean score of the individual patients (with Hearing aids or Cochlear Implant). By calculating with Chi-Square test, Cochlear Implantation (Post-CI), the speech production score was found to be 59.2% which compares favourably with the Pre CI Speech Production.

There was satisfactory increase in the individual score when the recepient shifted from Hearing aids to Cochlear Implant (Table 1).

Table 3: Mean comparison of QoL scores.

Subdomain	Mean (SD) CI	HA	Range CI	HA
Basic sound preception	21.94 (1.84)	9.42 (1.25)	20-25	07-17
Advanced sound preception	21.80 (1.49)	13.77 (2.22)	21-25	13-18
Speech production	24.29 (0.71)	21.83 (1.09)	23-25	20-24
Self esteem	23.74 (1.03)	18.29 (1.25)	22-25	17-21
Activity limitation	23.09 (1.22)	17.03 (1.38)	22-25	15-20
Social interaction	22.51 (1.50)	16.17 (1.20)	21-25	14-18

** This was calculated as the difference between the mean scores for the two groups.

In the CI, the highest rated QOL subdomain score was speech production (24.29+0.71), followed by social interaction (23.74+1.03), activity limitations (23.09+1.22), basic sound perception (22.51+1.50), self-esteem (21.80+1.49), and advanced sound perception (21.94+1.83).

Highest satisfaction rate area is of interconnectedness (mean=25.94), followed by communication with others (mean=24.99), family life (mean=22.62), radio (mean=16.00), music (mean=11.64), new relationship (mean=11.08), contribute to society (mean=10.87).

A one-way Analysis of Variance (ANOVA) shows that there are significant differences between the highest-rated subdomain of speech production, ($p<0.01$). There are also significant differences between activity limitations and advanced sound perception ($p=0.019$); social interaction and advanced sound perception ($p=0.001$); and social interaction and self-esteem ($p=0.050$).

About 70% of the CI cohort reported that the CI had met "most" or "all" of their expectations. Overall 92% rated the quality of results obtained from their CI as "good" or "excellent" and 97% were "mostly" or "very" satisfied with their CI.

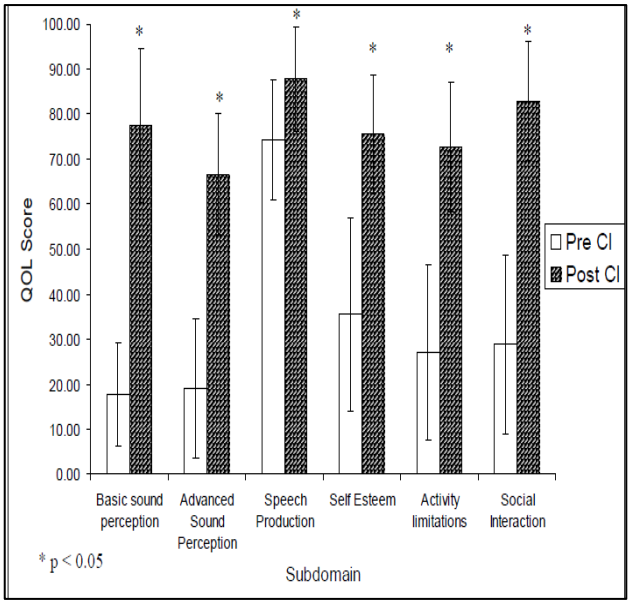

Figure 1: Pre-to-post subdomain scores for the CI group.

Figure 1 shows that the highest subdomain pre-and post-implant was speech production and the lowest subdomain post-CI was advanced sound perception.

Result of hearing aids group

The highest rated subdomain score for the HA group was for speech production, followed by self-esteem, activity limitations, social interaction, advanced sound perception, and basic sound perception .

Main findings from the responses from the qualitative questions (i.e. Q41-45) were that the HA participants excepted their lives to become easier following implantation, and also hoped that the CI would enable them to be more sociable, as well as to decrease the stress.

There are significant differences between the highest rated subdomain of speech production and all other categories ($p<0.001$ for all comparisons), as well as between basic sound perception and self-esteem ($p=0.003$), and advanced sound perception and self-esteem ($p=0.014$).

QOL comparison of CI and HA groups

Comparisons of the different QOL subdomains were made between the CI and HA groups to compare CI recipients to HA users. To briefly re-cap, three general QOL categories (physical, psychological and social functioning) were measured by using six subdomains (i.e. basic sound perception, advanced sound perception, speech production, self-esteem, activity limitations, and social activity). Table 14 shows the mean comparison of both the groups. The QOL subdomain scores from the CI

and HA groups are compared to investigate for differences between CI recipients and HA users, CI recipients scored significantly higher (better) than those on the HA for all subdomains ($p<0.001$ for all comparisons).

Results from a 2-way repeated measures analysis of variance (ANOVA) showed that there was a significant difference for the between-subjects factor of group (i.e. CI vs. HA; $p<0.001$), and a significant difference for the within-subjects factor of subdomains ($p<0.001$), as well as a highly significant interaction between these two factors ($p<0.001$)

In order to assess for changes in QOL as a result of cochlear implantation, QOL ratings obtained from current CI recipients were compared to those on the HA for a CI. Overall mean scores were higher for the CI group for all six QOL subdomains. The highest rated subdomain for the CI group was speech production, followed by social interaction, activity limitation, basic sound perception, self-esteem, and advanced sound perception respectively. The majority of CI recipients reported that the CI had met their needs and expectations, and that they were satisfied with their CI. In addition, all but one would recommend a CI to others if they were in a similar circumstance.

For the HA group, QOL ratings were highest for the speech production category, followed by self-esteem, activity limitations, social interaction, advanced sound perception, and lastly basic sound perception. HA participants excepted their lives to become easier following implantation and hoped that the CI would enable them to be more sociable, as well as to decrease the stress in their own life.

DISCUSSION

The number of elderly adults continues to increase. Consequently, more people will be afflicted with hearing loss. Identifying and treating the hearing impaired may ameliorate the adverse consequences of hearing loss. This study demonstrates that HAs and CIs can improve the overall QOL of hearing-impaired adults with a trend of greater benefit among the CI patients. Furthermore, the increase in at least 1 subdomain (basic sound perception) was significantly larger in CI users as compared to HA patients. This study used a new health-related QOL questionnaire designed for use in CI users.

The questionnaire was previously tested and was found to be reliable, valid, and able to detect clinical changes and to have good internal consistency among CI users.9,10 Our study also administered this questionnaire to HA patients. The questionnaire was able to detect changes in pre-rehab vs post-rehab QOL performance and correlated with objective audiologic measures in both the CI and HA users, supporting its use as a measurement tool in each group. Thus, the QOL benefit, in the physical, psychological, and social domains, from CIs and Has could be measured. Future studies could compare this questionnaire with QOL tools specifically designed for HA patients. Overall, the present study further supports the previously identified association between QOL and hearing loss. Hearing impairment negatively impacts physical and social function, emotional state, and communication.[11,12] Additionally, patients with more significant hearing loss experience greater impairment in their QOL. In the present study, HA patients with lower pre-rehab speech discrimination levels demonstrated reduced pre-rehab QOL scores (r ⁄⁄0.41, p⁄⁄0.05, Spearman correlation). Similarly, Bess et al found that the degree of hearing loss correlated with patients'level of physical and psychosocial disability.[12] Furthermore, the finding that improved audiologic performance brings about positive changes in QOL is also supported by our study. Among the HA patients, improvements were seen in overall QOL and not only the physical subdomains but also in self-esteem and social functioning. Mulrow et al also found significant changes in social, emotional, and communication function.[13] Similar to HAs, CIs also improve QOL among the hearing impaired. Like Hinderink et al, we found that CI users demonstrated increased overall QOL and benefits in all physical, psychological, and social subdomains (9). Additionally, our QOL benefit was associated with improvements in objective sound-only sentence recognition scores (r ⁄⁄0.56, p⁄⁄0.03, Spear-man correlation). The more audiologic improvement patients had, the greater overall QOL benefit they realized. Wyatt et al also found better speech, hearing, and cognitive function and improved emotional state among adult CI users.[14] Other reports have found improved audiologic performance and enhanced QOL in elderly CI patients.[15,16,17] Furthermore, elderly patients implanted at younger ages have been shown to receive greater QOL benefit from their implant. Thus, early identification of deaf adults may further enhance the benefit received from cochlear implants.

Cochlear implants provide exciting options for patients with profound hearing loss. Although the details of how the comparison was performed were not mentioned, Summerfield et al found that adult multichannel CI patients had larger increases in QOL compared to HA users.18 In our study, after controlling for variables that affect QOL, a trend towards significance of twice as much overall QOL benefit in CI users vs HA patients occurred. Additionally, the benefit seen in the basic sound perception subdomain for CI patients was almost 3 times that of the HA users (F(1,46) ⁄⁄14.227, p↕0.001, effect size ⁄⁄0.236) with trends of greater improvement for CI than HA patients in the other subdomains. Despite the severity of their hearing loss, CI patients obtained at least comparable benefit as patients with milder forms of hearing loss received from HAs. In particular, CIs narrowed the gap between elderly patients with profound hearing loss and HA patients with less severe hearing impairment with respect to overall QOL and across all subdomains.

Although CI users more commonly had monaural auditory input, CI patients still approached the QOL levels of HA patients. Perhaps bilateral implantation would bring further improvements in QOL. Thus, CIs raised the physical, psychological, and social function of deaf patients closer to levels enjoyed by HA patients. A few points regarding the study design are relevant. First, limited numbers did not allow subgroup analysis between different levels of hearing loss across the 2 groups. To avoid responder burden from multiple surveys, generic QOL measures were not mailed. This limited our ability to compare auditory rehabilitation's impact on QOL with other interventions for various disease states. Health-related QOL data from the pre-rehab state was collected retrospectively, possibly leading to recall bias. Elderly patients or those further in time from their intervention may not accurately remember their preintervention state. By including current age in the regression model, we attempted to control for the relationship between age and QOL benefit. However, no association between time since intervention and QOL benefit scores was found, indicating that the passage of time alone did not result in greater improvement in postintervention QOL. Attempts to minimize respondents' remembering their pre-rehab answers and, subsequently, influencing their post rehab answers, were made by sending the pre-rehab and post-rehab questionnaires a minimum of 2 weeks apart. Additionally, Hinderink et al showed that retrospectively collected preimplant QOL data from CI users was comparable to prospective QOL scores from patients with profound hearing loss on a CI waiting list.[9] While this supports the collection method of the preintervention data, future prospec tive studies are needed to corroborate our findings. Because HA users consistently had higher pre-rehab QOL scores than CI patients, we remined open to the possibility of a "ceiling effect."The HA users'milder degrees of hearing loss may have resulted in these higher pre-rehab QOL scores. By starting at higher levels, concern could arise that HA patients' scores may not have been able to improve as much as the CI users'. However, such a "ceiling effect" does not seem to have occurred. Compared to the CI group, the HA pre-rehab scores did not become prohibitively close to the maximum score of 100.

Lastly, although no statistically significant differences were seen between responders and non-responders (Table 1), a selection bias likely existed. While all CI users did respond, only 61.2% of the HA users responded to the questionnaire ($p \leq 0.001$, chi-square). The CI group includes patients who had improvements in their QOL as well as those with little or no improvement. In contrast, as determined by phone follow-up of nonresponders, the HA group excluded many poor performers. In fact, 21.1% ofHA nonresponders verbally admitted that they quit using their aids due to frustration. Since the HA QOL measurements may be artificially inflated, the difference in QOL benefit received from CIs compared to HAs may be underestimated. Despite the findings of this and other studies showing clear benefit in both auditory performance and QOL, many elderly patients are not receiving the benefits of cochlear implantation. Cost and difficulty obtaining coverage and reimbursement from health insurance companies have been barriers to implantation. However, the favorable cost-effectiveness of adult cochlear implantation has been demonstrated.[19,20,21] Also, lack of awareness about cochlear implantation among other medical specialties has limited referrals. In a survey of primary care physicians, three-fourths did not refer adults for implantation most commonly because of uncertainty about patient candidacy and uncertainty about where to refer patients.[22] Because CIs reduced the functional gap between CI and HA users, exciting opportunities for auditory rehabilitation may be missed. Educating patients and physicians about the benefits of cochlear implantation can secure its essential role in treating hearing-impaired elderly adults.

Limitations

Firstly, due to the complexity of QOL it is not possible to fully measure or interpret QOL by single questionnaires. For example, factors that are important to one person's QOL may not be important to another person, and/or may not have been included in the questionnaire. Furthermore, individuals would weight different factors differently as to how much each contributed to their QOL; the questionnaires in this study did not ask respondents to weight how important different factors were in determining their QOL. Additionally, comparisons between participants' QOL in this study to those of the general population were not been conducted, as the purpose of this research was to look at the effect of implantation on QOL, rather than investigating the QOL of CI recipients compared to the general population. Another limitation of this study was the limited time frame for the study, which prevented norms and re-test validity measurements for this questionnaire being obtained. The limited time frame also prevented longer term or follow-up evaluations being collected.

CONCLUSION

This study aimed to obtain information regarding changes in QOL in CI recipients, and to assess where the changes were most noticed in daily life. Results showed that CIs had a positive impact on the QOL of CI recipients, where changes occurred in the subdomains of basic and advanced sound perception, speech production, self-esteem, activity limitations, and social interaction. It was also found that the CI recipients' ratings were significantly better ($p < 0.001$), than those on the HA for a CI, thus supporting the first hypothesis. In particular, positive effects on QOL provided by the CI were evident where recipients reported improved family life, interconnectedness, communication, and independence. The CI-New subgroup of CI recipients also reported improved confidence, self-esteem and independence, compared to their pre-implant state. They felt more able

to participate in conversations, and reported better vocational prospects, with decreased feelings of loneliness, depression, and social isolation. Comments from CI recipients also showed the high value placed on a CI, and the ability to be able to hear again; a number of CI recipients expressed that the CI was the best thing that had ever happened to them

Nevertheless, satisfaction with the CI was diminished for some areas over others. It was apparent that satisfaction in listening to music, as well as when in noisy environments was lower than that in other areas. This corroborates with a host of other studies that have identified music and background noise as problematic issues for recipients, despite the advances in implant technology.

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