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Change in Loneliness after Intervention with Cochlear Implants or Hearing Aids

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Abstract

Objective—To investigate the impact of hearing aid and cochlear implant use on loneliness in adults

Study Design—Prospective observational cohort study

Methods—113 adults aged 50 years with post-lingual hearing loss receiving routine clinical care at a tertiary academic medical center were evaluated with the UCLA Loneliness Scale before and 6 and 12 months after intervention with hearing aids or cochlear implants. Change in score was assessed using linear mixed effect models adjusted for age, gender, education, and history of hypertension, diabetes, and smoking.

Results—Significant improvements in loneliness scores were observed in cochlear implant users from baseline to 6 months (−3.79 [95% confidence interval (CI): −5.73, −1.85], $P<.001$) and baseline to 12 months (−3.26 [95% CI: −5.66, −0.87], $P=.007$). We did not observe a significant improvement in loneliness scores in hearing aid users from baseline to 6 months (−0.83 [95% CI: −2.68, 1.02], $P=.381$) or baseline to 12 months (−0.34 [95% CI: −2.77, −2.10], $P=.007$). The most substantial increases were observed in individuals with the lowest baseline scores.

Conclusions—Treatment of hearing loss with cochlear implants results in a significant reduction in loneliness symptoms. This improvement was not observed with hearing aids. We observed differential effects of treatment depending on the baseline loneliness score with the greatest improvements observed in individuals with the most loneliness symptoms at baseline.

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Level of Evidence: 2b, individual cohort study

Keywords

Loneliness; mental health; hearing impairment; hearing aid; cochlear implant

INTRODUCTION

Hearing deficits are common in older adults. The prevalence of hearing loss doubles with every age decade, such that by the age of 70, two-thirds of adults are hearing impaired.^{1,2} Individuals with hearing loss have been shown to have poorer health outcomes, including decreased cognitive function,³⁻⁵ quality of life,^{6,7} and mobility.⁸ The association between hearing impairment (HI) and loneliness has been reported in both younger⁹ and older adults.¹⁰ Hearing aids (HA) and cochlear implants (CI) are the most common devices used for the treatment of hearing loss. However, there is limited research examining how hearing loss treatment impacts loneliness.

Loneliness is defined as a discrepancy between a person's preferred and actual level of social contact.¹¹ The prevalence of loneliness is estimated to be 20-40% in the adult U.S. population,¹²⁻¹⁵ with similar estimates reported in other countries.¹⁶ Loneliness has been linked with depression,¹⁷ cognitive decline,¹⁸ reduced physical activity,¹⁹ and mortality.²⁰ Hearing loss has long been subjectively reported as a cause of loneliness.¹³ Understandably, individuals with hearing loss have been shown to participate in fewer social activities than those without HI.²¹ CI and HA use could plausibly reduce loneliness through improvements to speech and noise understanding,²² social interaction,²³ or cognitive function.³ To our knowledge, no study to date has longitudinally examined loneliness before and after hearing loss treatment.

The Studying Multiple Outcomes after Aural Rehabilitative Treatment (SMART) Study evaluated hearing impaired adults before and after receiving a CI or HA during routine care at a tertiary academic medical center. In this prospective, observational cohort study, we investigated whether loneliness, measured by the UCLA Loneliness Scale, changed within one year of receiving a CI or HA. Our hypothesis was that there would be an improvement in loneliness from baseline to 6 and 12 months after intervention with CIs and HAs.

MATERIALS AND METHODS

Study Participants

The design and methods of the SMART Study have been described previously.²⁴ We recruited patients from the Johns Hopkins Department of Otolaryngology-Head and Neck Surgery who presented for evaluation for HAs or CIs from 2011 to 2014. Patients who fulfilled the following criteria were eligible for the study: (1) 50 years of age, (2) English-speaking, (3) receiving a hearing aid for the first time (or <1 hour/day of prior use) or receiving a first cochlear implant, (4) diagnosed with post-lingual hearing loss (i.e., onset of impairment after the acquisition of speech and language), and (5) aural-oral verbal communication as primary communication modality.

Participants completed 3 study visits: (1) Baseline evaluation before receiving the intervention, (2) 6-month post-intervention follow-up evaluation, and (3) 12-month post-intervention follow-up evaluation. 145 patients, out of 564 eligible patients, agreed to participate in the study. The most common reasons for not participating in the study included lack of interest, time constraints, transportation limitations, and feasibility of returning for follow-up visits. All study participants were provided with a parking voucher (\$8 value) and a meal voucher (up to \$10 value) at each study visit. Study participants also received an additional 1 year extended warranty on their hearing device, provided by the respective hearing aid (Phonak, Oticon, Starkey, Unitron, Widex) or cochlear implant (Cochlear America, Med-El Corp., Advanced Bionics) companies. Of the 145 individuals consented, 32 individuals (22%) dropped out of the study for various reasons: 10 individuals could not be reached, 8 individuals provided personal reasons, 6 individuals reported device issues, 4 individuals reported illness, and 4 individuals returned their hearing aids. The remaining 113 individuals comprise our analytic cohort. Written informed consents were obtained from participants by a clinical research coordinator and other trained research personnel. All study procedures were reviewed and approved by the Johns Hopkins Institutional Review Board (Baltimore, Maryland).

Treatment of Hearing Loss

Study participants received hearing aids or cochlear implants according to routine clinical care at Johns Hopkins. Although the range of aural rehabilitation varied for individuals, all patients received teaching on effective communication techniques by an audiologist. For individuals fitted with hearing aids, decisions as to type of technology, unilateral vs. bilateral fitting, hearing aid features, and fitting procedures were determined by the individual audiologist and patient. Cochlear implantation surgeries and pre- and post-operative fitting and programming were performed by the staff of the Johns Hopkins Listening Center. Decisions as to which cochlear implant technology to use and fitting procedures were made individually between the implant audiologist and the patient.

Covariates

Data on demographic variables, medical history, and history of noise exposure were obtained by a trained research coordinator during interviews. Race/ethnicity was grouped as Non-Hispanic White or Caucasian, Non-Hispanic Black or African-American, Hispanic or Latino, Asian or Pacific Islander, American Indian or Alaskan Native, or Native Hawaiian or Other Pacific Islander. Household information was determined by the number of individuals living in the participants' current households. Education was collapsed into a 3-level variable. Variables related to medical history included diabetes (based on self-reported diagnosis), smoking (current/former/never), and hypertension (told by healthcare professional on at least two visits about hypertension diagnosis and/or current use of prescribed hypertension medication). Our analysis found that age and gender did have an effect on loneliness, while the effect of education, hypertension, diabetes, and smoking status was not statistically significant (results not shown). Audiometric assessments were performed during participants' clinical visits and abstracted from the audiometric database at Johns Hopkins.

Loneliness

Loneliness was assessed using the UCLA Loneliness Scale.²⁵ This tool is the most widely used assessment of loneliness in human subjects research¹⁶ and has been validated in an older adult population.²⁶⁻²⁸ The UCLA Loneliness Scale consists of 20 questions that assess how frequently a participant has felt certain emotions: “never,” “rarely,” “sometimes,” or “often,” with scores ranging from 1 to 4 for each question. Higher scores indicated greater degrees of loneliness. We assessed changes in Loneliness Score from baseline to 6 months and baseline to 12 months.

Statistical Analysis

Demographic and clinical characteristics were compared across the treatment groups using the Wilcoxon rank sum and Fisher's exact test where appropriate. Linear mixed effects models were used to model the longitudinal trajectories of loneliness before and after CI or HA fitting, accounting for the repeated measurements within individuals using random intercepts. Contrasts between the time $\times$ treatment interaction were used to assess the difference between groups at each visit, the differences within groups across time, and the changes between consecutive visits by group. All models were adjusted for age, gender, education, and history of hypertension, diabetes, and smoking as time-fixed covariates. Residual diagnostic plots were used to assess residual autocorrelation, the linearity of associations, variance homogeneity, and normality of the residuals and predicted random effects. Participants were excluded if they were missing any covariates or were missing the outcome at baseline. All covariates associated with the likelihood of a missed study visit were included in outcome models, with the assumption that outcomes were missing at random. Significance testing was performed using two-sided tests with a type I error rate of 0.05. All analyses were conducted in R (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Table I describes the demographic characteristics of the SMART study analytic cohort. A total of 63 individuals received CIs and 50 individuals received HAs. CI and HA recipients were not different in terms of age, gender, race, smoking status, history of hypertension or diabetes. Individuals receiving a CI were more likely to have greater hearing impairment (70.0 vs. 37.5, $P<.001$) and lower educational attainment. Missingness at 1 year follow-up was not associated with any demographic characteristics, but was associated with the type of treatment. Because it was not standard of care for HA users to have a routine 1 year follow-up visit, they were more likely than CI users to miss this visit (results not shown).

The change in UCLA Loneliness Score pre- and post- hearing loss treatment was investigated through linear mixed effects models adjusted for age, gender, race, education, and history of hypertension, diabetes, and smoking (Table II). At baseline, HA participants on average scored 5.95 points lower (less loneliness) than CI patients (95% Confidence Interval [CI]: $-9.43, -2.46$; $P<0.001$). A reduction in loneliness was observed for CI users from baseline to 6 months (-3.79 [95% CI: $-5.73, -1.85$], $P<0.001$) and baseline to 12 months (-3.26 [95% CI: $-5.6, -0.87$], $P=0.008$). A significant reduction in loneliness was

not observed in HA users from baseline to 6 months (-0.83 [95% CI: $-2.68, 1.02$], $P=0.381$) nor baseline to 12 months (-0.34 [95% CI: $-2.77, 2.10$], $P=0.786$). Figure 1 (HA) and Figure 2 (CI) depict the distribution of Loneliness Scores at 12 months compared to baseline scores. The most substantial reductions in loneliness were observed in individuals with the greatest baseline loneliness. This is shown in Figure 3 for HA users and Figure 4 for CI users.

DISCUSSION

A significant reduction in loneliness was demonstrated in individuals who underwent routine treatment of hearing loss with CIs. Symptomatic improvements were noted at 6 months and continued to at least 12 months. A statistically significant reduction in loneliness was not found with HA users. The majority of reductions in loneliness were observed in individuals with greater loneliness at baseline. These results were robust to adjustment for multiple potential confounders and are based on the first prospective study to analyze loneliness after hearing loss treatment.

The association of hearing loss and loneliness has been previously documented in this population¹⁰ as well as a population aged 18-30 years.⁹ This is consistent with other research, which has demonstrated an association between hearing loss and depression,²⁹ social isolation,²³ and anxiety.³⁰ Pronk et al. longitudinally followed loneliness in individuals with hearing loss. They identified a proportional increase in loneliness with worsening speech-in-noise testing.³¹ We can therefore speculate that reductions in loneliness are a product of improvement in hearing function.

To our knowledge, one study to date has attempted to characterize the change in loneliness after hearing loss treatment. Poissant et al. had 17 CI users (9 unilateral CI, 8 bilateral CI) complete the UCLA Loneliness Questionnaire 1-2 years post-implantation twice: first, according to their current status, and second, according to how they believe they would have answered prior to implantation. The two means were compared using a student t-test. Individuals reported scoring, on average, 14 points less after implantation ($P=0.005$).³² This is consistent with our findings, although the larger difference in pre- and post-implantation scores highlights the importance of longitudinal follow up as this method was limited by recall bias.

Cochlear implants could improve loneliness through several mechanisms. The observed reduction in loneliness symptoms could be the product of improvements in quality of life,^{33,34} depression,³⁵ and speech understanding³⁶ after cochlear implantation. Demographics³³ and cardiovascular health³⁴ have been shown to impact the association of hearing loss with numerous outcomes. For this reason, our statistical models were adjusted for age, gender, race, and education, as well as history of hypertension, diabetes, and smoking. The reason why HA users did not experience a significant reduction loneliness symptoms is not clear but may be related to the greater variance in baseline loneliness in individuals with lesser degrees of hearing loss obtaining HA versus those with greater hearing loss obtaining CI. Specifically, HA users on average had less loneliness at baseline, and large reductions in loneliness were observed in those individuals with the greatest

degree of loneliness at baseline. Hence, the lack of a statistically-significant improvement in loneliness scores with HA may simply be the result of the greater degree of variance in levels of baseline loneliness in this cohort.

Limitations of this study include the lack of randomization and not having an untreated control arm. Because of this, we cannot conclude whether reductions in loneliness were directly caused by CI or HA use. Although it is fair to speculate that CI recipients received more extensive rehabilitation, this study could not account for the degree of improved aural rehabilitation that each individual achieved with HA or CI use; nor could we account for other factors that impact device effectiveness, including use of assistive listening devices and bilateral amplification or even total hours of use.³⁷ We found that HA users missed follow-up visits more often than CI users. We assumed in our analysis that data was missing at random (MAR), which requires that individuals did not miss visits follow-up based on loneliness or any potential confounder. Continued research will require a more resources, such as the ability to account for study participants' transportation costs, in order to encourage long-term retention.

CONCLUSIONS

This study found that hearing-impaired individuals undergoing routine treatment with CIs had a significant reduction in loneliness symptoms. This improvement was not observed with hearing aids. To our knowledge, this is the first study to longitudinally assess loneliness before and after hearing loss treatment. As more attention is focused on mental health, community engagement, and quality of life, future randomized trials are necessary to examine the impact of rehabilitative therapies on loneliness and the factors affecting potential benefit.

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Fig. 1.
UCLA Loneliness scores at 12 months vs. baseline with LOESS fit and 95% confidence bands for HA users.

Fig. 2.
UCLA Loneliness scores at 12 months vs. baseline with LOESS fit and 95% confidence bands for CI users.

Fig. 3.
Change in UCLA Loneliness scores from baseline to 12 months by baseline UCLA Loneliness scores with LOESS fit and 95% confidence bands for HA users.

Fig. 4.
Change in UCLA Loneliness scores from baseline to 12 months by baseline UCLA Loneliness scores with LOESS fit and 95% confidence bands for CI users.

TABLE I

Baseline Characteristics of Participants

Characteristics	All (n=113)	Hearing Aid (n=63)	Cochlear Implant (n=50)	P Value
Age, mean [IQR]	69.6 [63.5, 78.5]	71.0 [63.4, 75.5]	69.2 [63.9, 78.5]	0.846
Gender, n (%)				0.849
Female	46 (40.7)	25 (39.7)	21 (42.0)	
Race, n (%)				1.000
White	102 (90.3)	57 (90.5)	45 (90.0)	
Education, n (%)				0.012
High school or less	16 (14.2)	4 (6.3)	12 (24.0)	
College or associates	48 (42.5)	26 (41.3)	22 (44.0)	
Postgraduate	49 (43.4)	33 (52.4)	16 (32.0)	
Smoking status, n (%)				0.087
Former or Current	56 (49.6)	26 (41.3)	30 (60.0)	
Hypertension, n (%)	62 (55.0)	35 (56.0)	27 (54.0)	1.000
Diabetes mellitus, n (%)	24 (21.0)	17 (27.0)	7 (14.0)	0.163
PTA [IQR]	46.2 [36.0, 65.6]	36.2 [27.5, 42.5]	69.4 [64.4, 81.6]	<0.001

IQR = Interquartile range

TABLE II

Change in Loneliness after Hearing Loss Treatment

UCLA Loneliness Score	Hearing Aid (n=63)		Cochlear Implant (n=50)	
	Estimate (95% CI)	P Value	Estimate (95% CI)	P Value
Baseline to 6 Months	-0.83 (-2.68, 1.02)	.381	-3.79 (-1.85, -5.73)	<.001
Baseline to 12 Months	-0.34 (-2.77, 2.10)	.786	-3.26 (-5.66, -0.87)	0.008