Evolution of Type D Personality Traits after Cochlear Implantation In Severely Hearing Impaired Adults Aged 55 Years and Older: An Exploratory Prospective, Longitudinal, Controlled, Multicenter Study

Abstract

Purpose: To study the evolution of type D personality traits in older adults after cochlear implantation compared to a control group of severely hearing impaired older adults who did not receive a Cochlear Implant (CI). The influence of Covid19 on this evolution was also explored. Type D personality combines a high degree of negative affectivity (NA) and social inhibition (SI).

Methods: In this prospective, longitudinal, controlled multicenter exploratory study, 76 older CI users and 21 severely hearing impaired controls without CI were included. The CI group and the control group did not differ significantly regarding age, formal education, residual hearing, DS14 total score, NA and SI at baseline. Type D personality traits were assessed with the Type D Scale-14 (DS14) at baseline (T0) and 14 months later (T14).

Results: Type D personality traits differed significantly over time between the CI group and the control group ($p < 0.001$). In the CI group, the DS14 total score (mean delta T = -6.63; $p <0.001$), NA (mean delta T = -3.26; $p <0.001$) and SI (mean delta T = -3.37; $p <0.001$) improved significantly over time (delta T = T14 - T0), while no significant difference was found in the control group. Significantly fewer subjects were categorized as Type D personalities in the CI group (delta T = -12; $p = 0.023$) at T14, whereas no significant change was found in the control group (delta T = 3; $p = 0.250$). Covid19 did not influence the evolution of type D personality traits significantly in the CI group.

Conclusion: Cochlear implantation has a positive effect on type D personality traits in older adults with a severe-to-profound hearing impairment.

1. Introduction

Hearing loss (HL) is highly prevalent in the older adult population and its prevalence increases with age. Adults over 65 years old comprise 25% of the world's adult population, approximately one third of these individuals are affected by HL [1]. A hearing impairment poses challenges to communication, which forms the basis of social and relationship functioning. Impaired communication due to HL often leads to a reduction in daily life activities in older adults and significantly impinges upon their psychosocial and psychological well-being [2-4]. The way older adults with HL cope with this burden might be influenced by their personality, which determines individuals' characteristic behavior and thought [5]. Franklin et al. (2013) found for example that individuals who are more open to new experiences, e.g. scoring higher on the openness personality dimension, show better background noise acceptation and might therefore be better hearing aid candidates than persons with a more conscientious personality [6]. In addition, Hutchinson et al. (2005) indicated that the thinking personality domain of the Myers-Briggs Type Indicator negatively correlates with hearing aid benefit in older adults with HL [7]. However, research on personality and personality trait changes in (older) adults with HL remains scarce.

Denollet identified the type D personality in 1996 after studying the influence of personality on cardiovascular outcomes [8]. Type D personality was determined to be a significant predictor of poor treatment adherence, unhealthy behavior and long-term cardiovascular mortality independent of biomedical risk factors [8-11]. Two joint global personality traits characterize type D personalities: negative affectivity (NA) and social inhibition (SI). NA denotes the tendency to perceive negative emotions across time and situations, while SI refers to the inhibition of emotions and behaviors in social interactions to avoid disapproval by others [8,12]. The combination of high NA and SI results in a distressed type D personality, given their high susceptibility to chronic distress and greater risk for symptoms of anxiety and depression, as well as irritability and lower levels of self-esteem, well-being, and positive affect. Type D personality traits can be assessed using the Type D scale-14 (DS14), which was developed by Denollet in 2005 [12]. According to Denollet (2005), the prevalence of type D in the general population is 21% versus 53% in hypertension and 28% in coronary heart disease patients.

Type D personality and its prevalence in hearing impaired subjects has not been explored comprehensively yet. HL predicts poorer outcomes for several mental health factors in older adults, including anxiety and depression, for which type D personalities are more vulnerable than the general population [2,3,8]. In addition, SI might also occur in hearing impaired subjects, regarding the communication issues related to HL [4]. Overall, these challenges are more common in subjects with a severe-to-profound hearing impairment, for which cochlear implants (CI's) are the recommended treatment [3]. Several studies demonstrated that CI's not only improve hearing in severely hearing impaired older adults, but also enhance quality of life, mental health issues and Type D personality traits significantly [13-17]. Mertens et al. (2020) established a 20% decrease in older hearing impaired adults categorized as Type D personalities 1 year after cochlear implantation, while this number increased by 13% in their severely hearing impaired matched control group without CI. This prospective longitudinal controlled multicenter exploratory study focuses on part of the mental health outcome data collected in a larger study evaluating the evolution of cognitive abilities in adults aged 55 years and older with postlingual severe-to-profound sensorineural HL after cochlear implantation (Clinical Trials registration number: NCT02794350) [13,16,18]. Our study aims to explore the evolution of type D personality traits in adults aged 55 years and older after cochlear implantation, compared to a control group of severely hearing impaired adults aged 55 years and older who did not receive a CI. Some of the participants in the CI group had their 1-year follow-up assessment (T14) during the

Covid19 pandemic, which could have had a negative influence on their mental health. Therefore, the effect of Covid19 on type D personality traits in CI users aged 55 years and older was also explored.

2 Methods

2.1 Ethics

The study was carried out in conformity with the recommendations of the local ethics committees and competing authorities (Antwerp 15/17/181; Madrid PI-2504; Warsaw KB/16/2016; Bradford 16/EM/0437; Perth RGS0000000335). All participants gave their written informed consent in accordance with the Declaration of Helsinki prior to participation.

2.2 Design

This prospective longitudinal controlled multicenter exploratory study focuses on part of the mental health data collected in a larger study investigating the evolution of cognitive abilities, audiometric performances, quality of life and mental health after cochlear implantation in adults aged 55 years and older. The age cut-off of 55 years was chosen because this was the youngest mean age in which hearing loss presence was shown to increase dementia [19]. The study protocol was retrospectively registered at Clinical Trials (ClinicalTrials.gov) on June 9th, 2016 (NCT02794350). The study was conducted during a 6-year period (April 2015 - April 2021) in five participating centers: Antwerp University Hospital (Antwerp, Belgium), La Paz University Hospital (Madrid, Spain), World Hearing Center (Warsaw, Poland), Yorkshire Auditory Implant Service (Bradford, United Kingdom), and Fiona Stanley Hospital (Perth, Australia). A consecutive sample of severely hearing impaired adults who met the inclusion criteria for the intervention or the control group were included in the study during this period. Data were collected at baseline (T0), 1 month before cochlear implantation in the intervention group, and 14 months later (T14), at the 1-year follow-up test interval in the intervention group. The study assessments were not suspended during the Covid19 pandemic between February 2020 and April 2021. The control group was assessed at T0 and T14 before Covid19. All T0 assessments of the intervention group were scheduled before the pandemic, but n = 17 assessments at T14 went on during the pandemic. Therefore, DS14 scores of the 17 CI users that had their T14 assessment during the Covid19 pandemic were compared with the other CI users' DS14 scores to see if there would be any difference in DS14 scores at T14 and if the evolution of the DS14 scores differed between both groups. The primary outcome measure of this study was the DS14 total score, with NA, SI, the frequency of type D personality categorization and the comparison between CI users assessed before versus during Covid19 as secondary exploratory outcome measures.

2.3 Participants

The intervention group consisted of a consecutive sample of CI candidates (1) aged 55 years or older, (2) with a postlingual, bilateral, and severe-to-profound hearing impairment, (3) complying with the respective local national CI reimbursement criteria and (4) receiving a unilateral CI (MED-EL, Innsbruck, Austria). Participants were excluded if they could not complete the test protocol due to additional impairments such as uncorrected vision. The speech processor was activated approximately four weeks postoperatively and its settings were optimized during regular local programming sessions. The control group comprised a consecutive sample of adults aged 55 years and older with postlingual, bilateral severe-to-profound hearing loss who were referred for consideration for a CI. The subjects in the control group were not scheduled for cochlear implantation due to one of the following three reasons: (1) the subject did not meet the local criteria for CI reimbursement, (2) the subject was still on a CI waiting list during the study, (3) the subject did not want to undergo surgery.

2.4 Type D Scale-14 (DS14)

Type D Scale-14 (DS14) is a validated 14-item questionnaire developed to identify individuals with type D personality traits. DS14 consists of two subdomains: negative affectivity (NA) and social inhibition (SI), each including 7 items. All items are formulated as statements with the following 4 response alternatives indicating the degree to which the statement is true: false (0), rather false (1), neutral (2), rather true (3) and true (4). A person is classified as a type D personality if both the NA and the SI total scores are equal or greater than ten. Scores per subdomain range from 0 to 28, the total score ranges from 0 to 56. Subjects completed the questionnaire at a routine visit to the clinic, via email or via post at baseline (T0), before cochlear implantation for the intervention group, and 14 months later (T14), one year after cochlear implantation for the intervention group.

2.5 Statistics

The statistical analysis was performed using IBM SPSS Statistics version 27 (IBM Corp., New York, NY). First, the normality of the data was checked using Q-Q plots and the Kolmogorov-Smirnov test. The percentage of residual hearing was calculated based on the Hearing Preservation Classification System introduced by Skarzynski et al. in 2013 [20]. The DS14 scores at baseline (T0), residual hearing and formal education were not normally distributed in the intervention group, so the non-parametric Mann-Whitney U test was used to compare the control group and the intervention group for these variables. Age was normally distributed in both groups so the parametric independent samples t-test was performed to compare age between the intervention group and the control group. Linear mixed model (LMM) was used for the comparison between CI users and controls with DS14 total scores, NA or SI as outcome variable; subject ID as random intercept; Group (CI group / control group), Time Point (T0 / T14) and the interaction Group*Time Point as fixed factors. Post hoc pairwise comparisons were performed with the non-parametric Wilcoxon Signed Ranks test. Bonferroni correction was applied by adjusting the p-values of the primary outcome measure (DS14 total score) to correct for multiple comparisons. For the comparison between CI users tested before and during Covid19 LMM was also performed with DS14 total scores NA or SI as outcome variables; subject ID as random intercept; Group (before Covid19 / during Covid19), Time Point (T0 / T14) and the interaction Group*Time Point as fixed factors. Post hoc pairwise comparisons were also performed with the non-parametric Wilcoxon Signed Ranks test. McNemar's test was used to determine if the frequency of Type D personality traits differed between T0 and T14 for the CI group and the control group.

3 Results

The intervention group consisted of 76 CI candidates (29 females, 47 males), the control group comprised 21 adults (15 females, 6 males). The intervention group and the control group did not differ significantly regarding age (mean difference = 2 years; $p = 0.346$), formal education (mean difference = 1 year; $p = 0.213$), residual hearing (mean difference = 3.75%; $p = 0.245$), DS14 total score (median difference = 0; $p = 0.362$), NA (median difference = 2; $p = 0.881$) and SI (median difference = 1; $p = 0.173$) at baseline (T0). Table 1 gives an overview of the characteristics of the intervention group and the control group at baseline (T0).

Figure 1 depicts the DS14 outcome measures for the differences between T14 and T0 for the CI group and the control group (delta T = T14 - T0). The interaction between time point (T0 and T14) and group (CI group and control group) was significant for our primary outcome measure, the DS14 total score (LMM: $F(1,95) = 19.33$; $p < 0.001$), and for NA (LMM: $F(1,95) = 15.39$; $p < 0.001$) and SI (LMM: $F(1,95) = 12.31$; $p < 0.001$) (secondary exploratory outcome measures). This indicates that the evolution of DS14 total scores, NA and SI over time was different between the CI group and the control group.

Although the interaction between time point and group was significant, neither group LMM: F(1,95) = 0.40, p = 0.53) nor time point (LMM: F(1,95) = 2.12, p = 0.15) contributed significantly to the model as independent factors for the DS14 total score. For NA and SI, the contribution of group [NA (LMM: F(1,95) = 1.43, p = 0.236), SI (LMM: F(1,95) = 0.01, p = 0.935)] and time point [NA (LMM: F(1,95) = 1.75, p = 0.19) and SI (LMM: F(1,95) = 1.3, p = 0.256)] was also not significant. These findings indicate that (1) no overall differences in DS14 total scores, NA and SI were found between groups; (2) no overall differences in DS14 total scores, NA and SI between time points were found. Of all pairwise comparisons, only the comparison between the preoperative and postoperative measurement within the CI group was significant ($p < 0.001$) for DS14 total score (mean delta T = -6.63), NA (mean delta T = -3.26) as well as SI (mean delta T = -3.37). At T14, significantly fewer subjects were categorized as Type D personalities (NA and SI ≥10) in the CI group (delta T = -12; p = 0.023), whereas the number of subjects categorized as type D personalities did not change significantly in the control group (delta T = 3; p = 0.250). More details can be found in Table 2.

Figure 2 shows the difference between T14 and T0 DS14 scores for the CI users assessed during Covid19 (n = 17) and the CI users assessed before Covid19 (n = 59). The interaction between Time Point (T0 / T14) and Group (before Covid19 / during Covid19) was not significant for the DS14 total score (LMM: F(1,74) = 0.01; p = 0.935), NA (LMM: F(1,74) = 0.02, p = 0.896) and SI (LMM: F(1,74) = 0.07, p = 0.799), implying that the evolution of DS14 total score, NA and SI over time did not differ between the CI group assessed during Covid19 and the CI group assessed before. Group (before Covid19 / during Covid19) did not contribute significantly to the model as an independent factor for the DS14 total score (LMM: F(1,74) = 0.2, p = 0.657), NA (LMM: F(1,74) = 0.12, p = 0.730) and SI (LMM: F(1,74) = 0.17, p = 0.680), meaning that no overall differences in DS14 total scores, NA and SI were found between the CI group assessed during Covid19 and the CI group assessed before. Time point (T0 / T14) significantly contributed to the model as an independent factor for the DS14 Total score (LMM: F(1,74) = 26.83, $p < 0.001$), NA LMM: F(1,74) = 20.67, $p < 0.001$) and SI (LMM: F(1,74) = 17.43, $p < 0.001$), indicating that a significant overall difference was found between T0 and T14 DS14 total score, NA and SI for the CI group, as mentioned. All post hoc pairwise comparisons between preoperative and postoperative measurements within both groups were significant.

4 Discussion

This prospective longitudinal controlled multicenter study aimed to assess the evolution of negative and type D personality traits in older adults after cochlear implantation compared to a control group of severely hearing impaired older adults who did not receive a CI. A significantly positive influence of cochlear implantation on type D personality traits was found. Our older adult CI users reported that they experienced fewer negative emotions such as irritability or dysphoria and felt more comfortable in social situations one year after cochlear implantation, while the control group's type D traits remained stable over time. Significantly fewer subjects were categorized as type D personalities after implantation (T14) in the CI group, whereas this number did not change significantly in the control group at T14. These results support and complement the findings of Mertens et al. (2020) concerning the positive effect of a CI on type D personality traits. Our study primarily focused on type D personality evolution in a larger sample of CI users (n = 76), while Mertens et al. (2020) highlighted cognitive ability improvement after cochlear implantation and had a smaller study sample (n = 21) but used matched controls. Several longitudinal studies showed that cochlear implantation has a positive effect on daily life activities, mental health and communication, which could partly explain why type D personality traits decrease after receiving a CI [17,21-23]. Our results are also in line with the findings of Condén et al. (2014) that DS14 scores and, by extension, type D personality traits can change over time, especially during critical life events that require psychological adaptation such as myocardial

infarction in their study and cochlear implantation in ours [5]. More longitudinal research is needed to determine if the effect of cochlear implantation on type D traits in older adults is persistent.

Possible overlap between depression and type D personality trait measures are under debate in the literature. It is suggested that type D personality is related to the prevalence and persistence of depression and that DS14 is more likely to measure depression rather than personality features [5,24]. Similar to type D personality, depression is linked to cardiovascular disease and premature mortality [25,26]. Cochlear implantation has been proven to reduce depressive symptoms significantly, which is consistent with our findings regarding type D personality traits [13,15,27,28]. However, although type D does increase the risk of depression, these factors are not interchangeable [5,29]. A large-scale longitudinal study of Denollet et al. (2009) demonstrated that Type D personality and depression are partly overlapping, but refer to two different forms of distress in coronary patients. Subjects that are sensitive to negative emotions, such as type D personalities, are more likely to develop depressive symptoms. Nevertheless, type D personality combines being prone to negative emotions with inhibiting self-expression in social interactions (high NA and SI). Hence, type D personality is linked to but distinct from depressive disorders [29]. A potential distinction between true type D personality and acquired type D traits because of severe-to-profound hearing loss or any other reasons should also be considered. Cochlear implantation does change the presence of type D traits in a severely-to-profoundly hearing impaired population, but whether this involves a true type D personality change or a change of acquired type D traits leading to non-categorization as a type D personality could be debated.

In our study sample, type D personality traits were more common than in the general population. This might be explained by the fact that older adult subjects are generally affected by age-related health problems, such as cardiovascular disease and hypertension which are linked to type D personality traits [30]. However, hypertension or cardiovascular disease were not examined in our participants, so we could not link the prevalence of these disorders to the prevalence of type D traits in our sample. Nevertheless, cochlear implantation significantly reduced type D personality trait prevalence in our sample, revealing that HL also affects these personality traits. At baseline (T0), proportionally, more subjects were categorized as type D personalities in the CI group than in the control group, while there was no difference in DS14 scores at baseline between the two groups. These numbers switched at T14 with, proportionally, more type D controls than CI users. Possibly, CI candidates more often have the combination of high SI and NA preoperatively and therefore perceive more psychosocial issues, which could give them extra motivation to undergo cochlear implantation. In addition, persons with a severe hearing impairment might suffer more from quality of life diminishing HL comorbidities, such as vestibular loss, which could also negatively affect both SI and NA [31]. The number of CI users categorized as type D personalities remains high after implantation (33%). Given that type D personality is a significant predictor of poor treatment adherence and adverse clinical outcomes, personality traits of severely hearing impaired older adults should be assessed and taken into account in rehabilitation [9-11]. Additionally, further studies focusing on the impact of type D personality traits on rehabilitation and CI outcome measures are recommended.

Several studies found no difference between men and women in Type-D prevalence at a single time-point [5,32-34]. Therefore, gender was not included in the analysis although there was a difference between the CI group and the control group regarding the proportions of men and women in our study sample. The recruitment of a severely hearing impaired older adult control group without CI was challenging, resulting in a small sample size (n = 21). A randomized controlled trial where subjects are randomly assigned to the intervention group receiving a CI and to the control group not undergoing cochlear implantation was not possible, as not providing a CI to individuals meeting the

reimbursement criteria would be unethical. Therefore, part of our control group consisted of subjects on the waiting list for CI subsidy, who would eventually be implanted after T14. We also made use of the different local reimbursement criteria across the participating centers. Before December 2019, for example, the reimbursement criteria were quite strict in Belgium (best ear mean preoperative unaided hearing threshold at least 85 dB HL at 0.5, 1 and 2 kHz) and participants not meeting those criteria were included in the control group. These subjects had similar residual hearing compared to the intervention group of, for example, Warsaw with less strict CI reimbursement criteria.

Surprisingly, the Covid19 pandemic did not significantly interfere with the evolution of type D personality traits in the CI group one year postoperatively. The positive effect of cochlear implantation seems stronger than the expected negative effect of Covid19 on type D traits in our sample of CI users. A possible explanation for this might be that CI users' social interaction could already have been reduced to a minimum level due to their severe-to-profound HL. Covid19 might therefore not have had a significant additional negative effect on their social life. Moreover, rehabilitation was not suspended during Covid19 and rather improved social interaction of CI users, for example during the appointments with healthcare professionals. However, none of the subjects had both T0 and T14 assessments or only their T0 assessment during the pandemic and our sample size of CI users assessed during Covid19 was limited. Hence, further research should be undertaken to study the impact of Covid19 on the evolution of type D personality traits and mental health outcomes in severely hearing impaired subjects.

5 Conclusion

Cochlear implantation positively impacts the evolution of type D personality traits in severely hearing impaired older adults. Nevertheless, the prevalence of type D personality traits in severely hearing impaired older adults remains higher than the type D traits prevalence in the general population. Therefore, personality traits of older adults with a severe hearing impairment should be assessed and considered in rehabilitation. Further research is recommended to study the influence of type D personality traits on CI and rehabilitation outcomes.

6 References

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Figure legends

Figure 1. DS14 outcome measures for the differences between T14 and T0 for the CI group and the control group.

Figure 2. DS14 outcome measures for the differences between T14 and T0 for the CI group assessed during Covid19 and the CI group assessed before Covid19.

Table legends

Table 1. Overview of the characteristics of the intervention group and the control group at baseline (T0)

Table 2. Frequencies and p-values per group for type D personality traits