Long-term Speech Perception in Elderly Cochlear Implant Users

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Importance: A review of a test battery presented in both quiet and noise may clarify what the progression of speech perception abilities is in older adult cochlear implant users and whether the performance declines with advancing age.

Objective: To examine whether older adults (≥65 years) with cochlear implants maintain stable speech perception performance after at least 10 years of listening experience with an external speech processor.

Design and Setting: Retrospective analysis performed in an academic tertiary care center.

Participants: Fourteen older adult cochlear implant recipients with at least 10 years of listening experience.

Main Outcome Measures: Speech perception outcomes as measured with Consonant-Nucleus-Consonant words in quiet and Hearing in Noise Test sentences in quiet and steady-state noise were analyzed retrospectively at the 6-month and 1-, 5-, and 10-year post-operative follow-up intervals.

Results: Consonant-Nucleus-Consonant word scores remained stable between 6 months and 1 year of listening experience, improved significantly (P < .001) between 1 year and 5 years, and remained stable between 5 years and 10 years. Hearing in Noise Test sentence scores in quiet and noise showed a similar pattern, with stability in performance between the 6-month to 1-year and 5-year to 10-year follow-up intervals, and significantly improved performance (P = .04) between the 1-year and 5-year follow-up intervals.

Conclusions and Relevance: On average, patients who undergo cochlear implantation at age 65 years or older do not experience a decline in speech perception performance with extended listening experience and may potentially continue to see improvements beyond the 1-year follow-up interval.

The prevalence of hearing loss is known to increase with age. In the US population, hearing loss affects 45% of people in their 60s, 68% of people in their 70s, and 89% of people 80 years or older.\(^1\) Cochlear implantation is indicated for adults with moderate to profound sensorineural hearing loss who gain little benefit from conventional amplification. Generally, postlingually deafened adults experience a growth in speech perception within the first 6 months of listening experience with a cochlear implant, followed by a plateau in performance that can be maintained with long-term use.\(^2\) Typically, advanced age at implantation is not considered a contraindication to surgery; however, little is known of the long-term progression and stability of speech perception in the older adult population.

Comparisons with a younger cohort are often conducted when reviewing the speech perception performance of older adult patients with cochlear implants. However, variability in the literature exists regarding the influence of age at implantation, with some studies\(^3\) reporting no difference in speech perception performance and other studies\(^4,5\) showing a significant difference. Most of these evaluations include speech perception performance after approximately 12 months of listening experience. There is limited research on the stability of speech perception in the older adult population after multiple years of listening experience.

One factor that may influence the long-term speech perception of older adult cochlear implant patients is age-related degeneration of the peripheral and central auditory system.\(^6\) Older adults with normal hearing experience challenges with temporal pre-
The initial query of the adult cochlear implant database yielded 305 surgical procedures that were completed in patients who were 65 years or older at implantation. Data (on 291 surgical procedures) were excluded if the test battery was incomplete (n=3), if the patient had not experienced 10 or more years of cochlear implant use (n=191), if the patient was not fluent in English (n=5) or had a history of prelingual hearing loss (n=8), or if there had been a revision surgical procedure (n=48) or bilateral implantation (n=18) (36 surgical procedures in total). The resulting older adult cohort consisted of 14 patients.

Among the study cohort identified in the database, 191 patients did not have at least 10 years of listening experience. The following reasons were given for the limited data: death of the patient (n=17), the patient moved and was unavailable for follow-up testing (n=7), the surgical procedure occurred on or after 2002 (n=161), or the patient could not complete the test battery because of reported dementia (n=6).

Of 14 older adult patients reviewed, the age at implantation ranged from 65 to 80 years (mean [SD] age, 70.0 [4.5] years). Recipients of each implant manufacturer were included: Advanced Bionics Corporation (n=3), Cochlear Corporation (n=2), and MED-EL Corporation (n=9). Dates of implantation spanned from November 1999 to December 2002; therefore, patients received similar generations of internal arrays. Demographic information for this population is summarized in the Table.

Candidacy criteria at the time this cohort underwent evaluation for cochlear implantation were a severe to profound hearing loss and poor speech perception with appropriately fit conventional amplification. The mean preoperative speech perception scores were 2% for CNC words, 7% for HINT sentences in quiet, and 0% for HINT sentences in noise.

Figure 1 shows the speech perception performance scores on CNC words in quiet at 6 months to 1, 5, and 10 years after surgery. Circles represent each patient’s score, which are ranked within each test interval from youngest to oldest for a visual representation of individual performance over time. There was a significant effect of follow-up interval (F₁,30 = 13.68, P < .001), consistent with an improvement in speech perception over time. Preplanned paired t tests were used to evaluate the...
pattern of improvement. Speech perception was stable between 6 months and 1 year \((P = .22)\), improved significantly between 1 year and 5 years \((P < .001)\), and remained stable between 5 years and 10 years \((P = .99)\). Figure 2 shows the speech perception performance scores on HINT sentences in quiet and noise over time. The analysis of variance included the 4 levels of follow-up intervals and 2 levels of background (quiet and noise). There were significant main effects of follow-up interval \((F_{3,39} = 4.58, P = .008)\) and background \((F_{1,13} = 164.71, P < .001)\) but no interaction between these factors \((F_{3,39} = 0.46, P = .71)\). This result is consistent with an improvement over time that is comparable for sentences presented in quiet and noise.

As with CNC words, preplanned paired \(t\) tests indicate that performance was stable between 6 months and 1 year \((P = .22)\), improved significantly between 1 year and 5 years \((P = .04)\), and remained stable between 5 years and 10 years \((P = .98)\).

In an effort to further understand the significant improvement noted between the 1-year and 5-year follow-up intervals, a larger cohort of older adult cochlear implant patients with at least 5 years of listening experience was examined. Demographic information for this cohort is given in the Table. In this population \((n = 58)\), the analysis of variance included 3 levels of follow-up intervals (6 months, 1 year, and 5 years). Figure 3 shows the outcomes for CNC words in quiet, and Figure 4 shows the outcomes for HINT sentences in quiet and noise. Similar to the results observed for the smaller group with at least 10 years of follow-up data, there was a significant effect of follow-up interval for CNC words in quiet \((F_{2,114} = 11.96, P < .001)\), consistent with improved speech perception after at least 5 years of listening experience. Preplanned paired \(t\) tests showed no difference between the speech perception at 6 months and 1 year \((P = .13)\) and a significant improvement between 1 year and 5 years \((P = .005)\). For HINT sentences in quiet and noise, there was a significant effect of follow-up interval \((F_{2,114} = 6.44, P = .002)\) and background \((F_{1,57} = 489.64, P < .001)\) but no interaction between these factors \((F_{2,114} = 0.004, P > .99)\). Preplanned paired \(t\) tests demonstrated a significant improvement between 6 months and 1 year \((P = .049)\) and stable speech perception between 1 year and 5 years \((P = .29)\).

**COMMENT**

Older adults who qualify for cochlear implantation attain significant improvement in speech perception per-
Although average speech perception performance was maintained during at least 10 years of listening experience, some variability within individuals was noted. However, decreased performance experienced at a specific interval seemed to rebound at the subsequent interval. This validates the importance of clinicians’ following up cochlear implant recipients annually to monitor for fluctuations and to screen for emerging issues.

There was no decline in the mean speech perception abilities of older adults with extended listening experience and advanced age. One cause of potential regression in the speech perception abilities of older adults is cognitive decline. Advancing age and hearing loss have been linked to cognitive decline, which may influence the stability of speech perception over time. Lin et al. reported an association between patients with hearing loss and incident dementia, noting that incident dementia was almost 5 times more prevalent among patients with severe hearing loss than among those with normal hearing. However, there was a positive association reported between hearing aid use and cognitive functioning in older adults. Further research is needed to understand whether cochlear implantation has a similar influence on cognitive function in older adults. Cognitive assessment may need to be included in the preoperative evaluation of older adult cochlear implant candidates.

Advanced age has been shown to negatively influence the speech perception abilities of individuals with normal hearing and patients with hearing loss when tested in the presence of noise. Not surprisingly, there was a reduction in the speech perception abilities of this population when tested in noise compared with results in quiet. Notably, the elderly cohort studied herein maintained similar speech perception performance in noise after at least 10 years of listening experience with cochlear implantation. Although this ability may be reduced compared with that in younger listeners, it continues to be superior to that obtained with conventional amplification in these listeners. This validates the efficacy of cochlear implantation in the older adult population because it offers superior speech perception over preoperative abilities, even in noise.

Bilateral cochlear implant patients were excluded from this analysis to limit the influence of any possible interaction of the contralateral cochlear implant. Buss et al. reported benefits of bilateral cochlear implantation in adults, including head shadow effect, binaural summation, and squelch effect. When comparing the performance of older and younger adult bilateral cochlear implant patients, Noble et al. reported mixed outcomes within the older population. This variation in outcome may reflect the age-related effects previously mentioned, limiting the ability of patients to use binaural cues. There may also be an effect of duration of listening experience, as seen herein in speech perception performance scores. Further research is needed to evaluate the success of bilateral cochlear implantation in older adults, including the ability to integrate binaural cues, the rate of performance growth between the initial side and the second side, and differences between sequential and simultaneous implantation.

In addition, patients with a history of revision surgery were excluded from the analysis to limit the un-

**Figure 4.** Percentage correct on Hearing in Noise Test (HINT) sentences in quiet (A) and noise (signal-to-noise ratio [SNR], –10 dB) (B), with up to 5 years of listening experience. Data are presented the same as in Figure 2.
known influence of revision surgery on long-term speech perception performance. Rivas et al reported on outcomes of revision surgery in adult cochlear implant patients, including a small subset of elderly patients. There is limited additional information as to whether older adult patients can maintain the speech perception performance achieved before device failure. Further analysis is needed to review the influence of revision surgery on older adult speech perception.

Although the results presented herein support the objective benefit of cochlear implantation in older adults, additional analysis is needed of the long-term effect on quality of life. The positive influence on quality of life challenges the argument that advanced age is a reason to deny cochlear implantation owing to a limited number of years of use. Cochlear implantation has been shown to increase the quality of life in elderly patients, with no difference compared with the subjective improvement noted by younger patients. Long-term increases in quality of life from improvement in speech perception, ability to detect environmental sounds, and increased independence validate cochlear implantation as a viable and valuable treatment option for older adults.

Cochlear implantation is a viable treatment option with seemingly no upper age limit for patients deemed healthy to undergo surgery. Clinicians should continue to follow up older adult cochlear implant patients annually to monitor the progression of speech perception abilities with advanced age. Further research within this population is needed to evaluate the relationship of cognition and cochlear implant use, postoperative changes to quality of life, the use of binaural cues in bilateral cochlear implants and other implantable auditory technologies; May 4, 2012; Baltimore, Maryland.

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REFERENCES