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Impact of Patient Frailty on Speech Recognition and Quality of Life Outcomes in Adult Cochlear Implant Users

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Objective: The process of cochlear implantation (CI) and subsequent post-cochlear implant care is extensive and can be difficult to navigate for patients considered medically frail. This study investigates potential impact of patient frailty on speech recognition and quality of life outcomes after CI.
Study Design: Retrospective review of a prospectively maintained database.
Setting: Tertiary cochlear implant center.
Patients: Three hundred seventy adults undergoing CI for traditional bilateral hearing loss indication.
Interventions: None.
Main Outcome Measures: Comparison of pre-CI to 12-month post-CI change in consonant–nucleus–consonant phoneme/words, AzBio sentences in quiet/+10SNR, and Cochlear Implant Quality of Life (CIQOL)-35 Profile domain and global scores based on degree of patient frailty as assessed using the five-factor modified frailty index and Charlson Comorbidity Index.
Results: The average age at implantation was 65.4 years (±SD, 15.7; 19–94 years). Overall, there were minimal to absent and non-significant differences in speech recognition outcomes (consonant–nucleus–consonant phoneme/words, and AzBio sentences +10SNR) based on pre-CI patient frailty. The exception was less improvement in AzBio quiet sentence score in patients noted to be severely frail based on Charlson Comorbidity Index (57.1% vs. 35.2%, d = 0.7 [0.3, 1]). Similar findings were observed for CIQOL-35 Profile domain and global scores where no associations were found other than decreased improvement in the social domain in patients noted to be severely frail (21.7 vs. −0.3, d = 1 [0.4, 1.7]).
Conclusions: Although some differences in outcomes were noted based on cochlear implant user frailty, these were small and isolated to only a few outcome measures. Therefore, assuming the patient is medically safe for surgery, preoperative frailty should not dissuade clinicians from recommending CI.
Key Words: Cochlear implant—Frailty—Quality of life—Speech recognition score.

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INTRODUCTION

Hearing loss is a common chronic condition with increasing prevalence with age (1). The consequences of hearing loss have been well documented and include cognitive decline and social isolation resulting in decreased quality of life (2,3). Cochlear implantation (CI) is a safe and effective option to restore hearing for those with moderate to profound hearing loss who do not benefit from a hearing aid (4,5). However, the procedure remains underutilized, as only 6% to 12% of adults who meet candidacy undergo CI (6,7). While this low level of penetration is likely multifactorial, one potential explanation is the hesitancy to perform a surgical procedure in older adults, despite research suggesting no additional risk of surgical complications or device malfunction compared with younger patients (5,8). As such, use of chronologic age alone for risk stratification is too simplistic and has fallen out of favor.

Frailty has gained traction in the surgical literature as a more accurate metric than chronologic age in predicting post-operative morbidity when assessing surgical candidacy. Frailty metrics aim to quantify physiologic age based on the presence or absence of common comorbidities that affect daily functioning. Increased frailty has been associated with worse surgical outcomes across various surgical subspecialities (9). Although widely applied in the surgical literature, including in general surgery (10), orthopedic surgery (11), and neurosurgery (12), frailty metrics have less frequently been employed in otolaryngology studies. Furthermore, there is a dearth of research evaluating the impact of frailty on postoperative outcomes after CI. To date, only one such study exists, in which Aylward et al. (13) examined relations between frailty, utilizing the 11-factor modified frailty index (mFI-11), audiologic measures, and hearing-related quality of life (QOL) in older adults undergoing CI. The objective of the present study was to further ascertain the impact of pre-operative frailty on objective

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TABLE 1. *Patient characteristics*

Sex, n (%)	
Male	196 (53)
Female	174 (47)
Race, n (%)	
White	312 (84.3)
Black	51 (13.5)
Asian	5 (1.4)
Other	2 (0.5)
Ethnicity, n (%)	
Non-Latinx	369 (99.7)
Latinx	1 (0.3)
Mean age of implantation, ± SD, y	65.4 ± 15.7
Mean duration of hearing loss, ± SD, y	24.6 ± 17.7

SD, standard deviation.

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audiologic and QOL outcomes after CI among a cohort of adult recipients.

MATERIALS AND METHODS

The study was approved by our center's Institutional Review Board. Data including patient age, sex, duration of hearing loss, and medical comorbidities, were obtained from a prospectively maintained database of patients who received a cochlear implant at a university-based, tertiary referral center. Patients were included in the study if they were ≥18 years old at time of implantation and received a cochlear implant for bilateral moderate to profound hearing loss, had pre-operative and 12 month post-operative speech recognition scores and/or Cochlear Implant QOL (CIQOL)-35 Profile domain and global scores. The CIQOL-35 Profile is a validated 35 item patient-reported outcome measure (PROM) that reports scores for 6 domains (communication, emotional, entertainment, environment, listening effort, and social) and a global score (14). CIQOL outcomes are scored from 0 (low) -100 (high). Speech recognition measures included consonant–nucleus–consonant word or phonemes, AzBio sentences in quiet (AzBioQ), and AzBio sentences in +10-dB signal-to-noise ratio (AzBio+10), which was only obtained for individuals with AzBioQ scores >50%. For patients who ultimately received bilateral cochlear implants, data associated with the first implant were used. Exclusion criteria were younger than 18 years at time of implantation, unavailable 12-month postoperative speech recognition and/or CIQOL-35 Profile scores, and incomplete documentation of medical comorbidities precluding calculation of frailty scores.

Frailty was measured using two validated indices, the five-item modified frailty index (mFI-5) (15) and the Charlson Comorbidity Index (CCI) (16). Medical comorbidities were reviewed via chart review for calculation of either index separately. For mFI-5, with a score range of 0 to 5, a score of 0 was classified as nonfrail, 1 as prefrail, and ≥2 as frail. For CCI, with a score range of 0–37, a score of 0 was classified as nonfrail, 1–2 as mildly frail, 3–4 as moderately frail, and a score of ≥5 as severely frail.

Statistical Analysis

All analyses were performed with SigmaPlot 14.5 (IBM Corporation, Armonk, NY). Categorical variables were summarized by frequency and percentage. All continuous variables were tested for normal distribution as determined by the Kolmogorov-Smirnov test. Continuous variables were described as mean ± standard deviation (SD) or median with 25th to 75th interquartile range (IQR) based on normality. Comparisons of categorical variables were performed using Pearson's Chi-square test. Comparisons of continuous variables (pre-operative vs. 12-month post-operative measures) were performed with a paired t-test or Wilcoxon Signed Rank test as appropriate. A p value of <0.05 was considered statistically significant for all statistical tests. In addition, Cohen's d effect sizes 95% confidence intervals, denoted as "d [lower CI, upper CI]," were calculated where appropriate. Effect sizes were interpreted as follows per Cohen's conventions: 0.2 to 0.49 = small effect, 0.5 to 0.79 = medium effect, and ≥0.8 = large effect (17).

RESULTS

Patient demographics are summarized in Table 1. A total of 370 patients were included, of which 196 were males and 174 were females. The majority of subjects identified as White (84.3%), followed by Black (13.5%), Asian (1.4%), and Other (0.5%). All but one patient identified as Non-Hispanic or Latinx. The average age at implantation was 65.4 (±15.7, 19–94) years. The average duration of hearing loss before CI was 24.6 (±17.7) years. Using mFI-5, 137 patients (37%) were classified as non-frail, 139 (38%) as prefrail, and 94 (25%) as frail. Using CCI, 49 patients (13%) were classified as non-frail, 90 (24%) were mildly frail, 125 (34%) were moderately frail, and 106 (29%) were severely frail.

To ascertain how the degree of frailty impacts change in speech recognition and CIQOL scores following implantation, the average score difference for each respective audiologic test or instrument was calculated for each subgroup and compared. Tables 2, 3 show the mean difference in word and sentence recognition, and in CIQOL scores respectively

TABLE 2. *Average pre to 12 mo post-CI change in speech recognition scores stratified based on CCI frailty classification*

	CNCw (n = 325), % [SD]	CNCp (n = 323), % [SD]	AzBioQ (n = 285), % [SD]	AzBio + 10 (n = 55), % [SD]
Nonfrail	37.7 [24.6]	48.6 [28.6]	48.9 [35.1]	61.4 [19.0]
Mild	40.9 [26.2]	49.3 [27.6]	57.1 [30.7]	35.6 [29.0]
Moderate	34.4 [20.2]	45.2 [25.1]	45.5 [27.9]	28.9 [28.4]
Severe	31.7 [23.9]	39.1 [29.1]	35.2 [33.2]	41.1 [20.8]

AzBioQ, AzBio sentences in quiet; AzBio+10, AzBio sentences in +10-dB signal-to-noise ratio; CNCp, consonant-nucleus-consonant phonemes; CNCw, consonant-nucleus-consonant word.

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TABLE 3. *Average pre to 12 months post-CI change in CIQOL subdomain scores stratified based on CCI frailty classification*

	Global (n = 74) [SD]	Communication (n = 75) [SD]	Emotion (n = 77) [SD]	Entertainment (n = 74) [SD]	Environment (n = 78) [SD]	Listening (n = 77) [SD]	Social (n = 75) [SD]
Nonfrail	21.8 [27.3]	12.0 [15.0]	21.4 [26.6]	35.6 [16.3]	23.3 [29.9]	15.4 [32.2]	21.4 [33.6]
Mild	15.1 [14.8]	22.3 [18.0]	21.4 [20.8]	15.1 [29.3]	28.3 [27.0]	19.4 [19.7]	21.7 [19.4]
Moderate	5.6 [13.5]	6.9 [17.8]	5.9 [19.4]	10.5 [23.8]	10.8 [22.2]	6.8 [17.5]	9.1 [17.0]
Severe	8.3 [10.9]	11.9 [14.7]	10.5 [16.0]	15.4 [23.0]	11.9 [20.4]	11.2 [15.8]	−0.3 [22.0]

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based on degree of frailty as determined by CCI. Tables 4, 5 display similar content, with degree of frailty determined by mFI-5. Although most mean differences were not statistically significant, there were two exceptions. Mildly frail patients, as determined by CCI, experienced a greater change in AzBioQ scores compared with those who were severely frail (57.1% vs. 35.2%, $d = 0.7$ [0.3, 1]). In addition, mildly frail individuals demonstrated greater improvement in CIQOL social domain score as compared with severely frail individuals based on CCI (21.7 vs. −0.3, $d = 1$ [0.4, 1.7]). (Tables 6A, 6B) display the effect size for each comparison as stratified by degree of frailty. Furthermore, correlation analyses were performed to evaluate the association between frailty and change in speech recognition and CIQOL score post-CI. No significant correlation was found between lower frailty index and audiologic and QOL outcomes.

DISCUSSION

Cochlear implantation is considered a low-risk surgery often performed in the outpatient setting, with procedural risks primarily related to the administration of general anesthesia. Although the safety of this procedure has been shown in older adults (8,18), CI remains underutilized in this patient population, prompting research into the utility of frailty metrics to assess surgical candidacy rather than the use of chronologic age alone. Although frailty indices have been widely utilized in the surgical literature to evaluate outcomes, their use in otolaryngology studies have been limited (19) (20,21). Furthermore, the literature exploring the relationship between comorbidities and cochlear implant outcomes is scant. In a study of 107 patients divided into three subgroups based on age at implantation, Forli et al. found that patients without comorbidities (e.g., hypertension, diabetes mellitus, cardiovascular diseases, neurologic diseases) achieved better speech perception scores post-CI than those with a comorbidity (22). Aylward and colleagues (13) were the first to publish data pertaining to the impact of frailty on hearing measures and QOL after CI. Using mFI-11, they found no significant correlation between frailty and audiologic outcomes (i.e., pure tone average, speech recognition scores) in a cohort of adults 65 years or older. Furthermore, using a modified version of the Nijmegen Cochlear Implant Questionnaire (NCIQ) to measure hearing-specific QOL in cochlear implant users, they found that higher scores in two domains (i.e., activity limitations and social interactions) were correlated with lower frailty index, though the strength of these correlations was low.

The present study demonstrated similar findings, in which the degree of frailty, as assessed by mFI-5 and CCI, was not associated with audiologic outcomes at 12 months postimplantation. In addition, our data demonstrated that cochlear implant recipients with mild frailty experienced significantly greater improvement in social domain scores compared with those with severe frailty at 12-month follow-up. A major advantage of our study is that the CIQOL-35 Profile was used to measure patient outcomes, which has been shown to have greater face and content validity and to be more psychometrically sound than legacy PROMs (e.g., NCIQ) (14). Prior studies have demonstrated the importance of using hearing-specific PROMs over general health related ones to more accurately track post-CIQOL changes (23,24). Further, unlike prior related studies (13,22), preoperative CIQOL-35 Profile scores were available for data analysis in the current study, allowing us to ascertain the relation between patient frailty and pre-CI to post-CI changes in CIQOL domain scores.

A major limitation of this study relates to the inherent weaknesses associated with a retrospective review, namely missing data. Although all audiologic testing was performed at our tertiary, university-based center, several patients were missing some speech recognition and CIQOL scores. In addition, numerous statistical analyses were employed on the same data set, thereby increasing the Type 1 error rate. Furthermore, accurate calculation of the two frailty indices used herein relies on proper chart documentation of each patient's medical history. Although every effort was made to meticulously review all medical documentation, including notes written by the implanting surgeon, the referring providers and anesthesiologists, some medical comorbidities may have been unknowingly missed. Future prospective studies on this topic may be able to address the limitations listed above.

TABLE 4. *Average pre to 12 months post-CI change in speech recognition scores stratified based on mFI-5 frailty classification*

	CNCw (n = 325), % [SD]	CNCp (n = 323), % [SD]	AzBioQ (n = 285), % [SD]	AzBio + 10 (n = 55), % [SD]
Nonfrail	36.3 [24.4]	44.0 [27.9]	48.0 [31.7]	38.1 [31.3]
Prefrail	38.4 [23.4]	48.9 [27.2]	47.4 [30.3]	40.2 [26.2]
Frail	30.6 [30.6]	40.3 [26.9]	39.0 [34.9]	30.0 [24.7]

CONCLUSION

Consistent with findings from the published literature, frailty does not appear to have a substantial impact on speech recognition or CIQOL improvement after CI. Therefore,

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TABLE 5. *Average pre to 12 months post-CI change in CIQOL subdomain scores stratified based on mFI-5 frailty classification*

	Global (n = 74) [SD]	Communication (n = 75) [SD]	Emotion (n = 77) [SD]	Entertainment (n = 74) [SD]	Environment (n = 78) [SD]	Listening (n = 77) [SD]	Social (n = 75) [SD]
Nonfrail	14.2 [17.9]	13.0 [16.5]	12.1 [19.8]	18.8 [28.3]	22.6 [27.2]	13.2 [22.4]	13.0 [22.0]
Prefrail	9.1 [15.8]	10.4 [19.6]	11.9 [22.1]	14.9 [21.1]	14.7 [17.1]	11.0 [21.5]	11.6 [23.2]
Frail	6.6 [11.9]	12.6 [14.7]	12.9 [19.6]	12.1 [26.0]	9.1 [28.3]	11.4 [13.6]	4.7 [22.9]

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TABLE 6A. *Comparison of average pre to 12 months post-CI change in AzBioQ scores stratified based on CCI frailty classification, effect size (d* [95% confidence interval])

	Mild	Moderate	Severe
Nonfrail	−0.3 [−0.6, 0.1]	0.1 [−0.3 to 0.5]	0.4 [0 to 0.8]
Mild	—	0.4 [0.1 to 0.7]	0.7 [0.3 to 1]
Moderate	—	—	−0.3 [−0.6 to 0]

TABLE 6B. *Comparison of average pre to 12 months post-CI change in CIQOL social domain scores stratified based on CCI frailty classification, effect size (d* [95% confidence interval])

	Mild	Moderate	Severe
Nonfrail	−0.01 [−0.9 to 0.8]	0.6 [−0.1 to 1.4]	0.8 [0.02 to 1.7]
Mild	—	−0.7 [−1.3 to −0.1]	1.0 [0.4–1.7]
Moderate	—	—	0.5 [0–1]

assuming the patient is medically safe for surgery, preoperative frailty should not dissuade clinicians from recommending CI. However, future prospective studies are needed to better understand this relation.

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