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Audiometric Outcomes After Cochlear Implantation for Single-Sided Deafness and Asymmetric Hearing Loss

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ABSTRACT

Objective: To evaluate audiometric results in patients undergoing cochlear implantation (CI) for Single Sided Deafness (SSD) or Asymmetric Hearing Loss (AHL). In addition, we sought to determine if there is a correlation between cause of hearing loss, duration of hearing loss, sex, and age with improvement in the hearing parameters.

Method: A retrospective cohort study of patients undergoing CI at a large medical center. Patients over 18 years old with SSD or AHL were offered CI. Data from CI performed for SSD/AHL from 9/2020 to 9/2023 were used for analysis. Consonant Nucleus Consonant (CNC) and Arizona Bio (AZ Bio) tests preoperatively and then at various intervals after CI activation. Preoperative tests were performed in the aided [hearing aid (HA) or bone conduction (soft band)]and unaided condition and then compared to postoperative results using the CI with noise presented from various direction. Effect of age, sex, side of implant, type and duration of hearing loss was evaluated on CI outcomes. Chi square and paired T tests were used for analysis.

Results: 27 patients completed preoperative and postoperative testing during a 12-month follow-up. A significant difference was noted in Aided CNC (HA, n=14) at 1st postop test (p<.0001) and average postop test vs preop (p<.0001). No significant change was noted between preop and 1st postop visit and average postop results for the sound field testing [Unaided Az bio SoNo, Aided Az bio SoNo, Aided Az bio SoNo Bone conduction, Unaided Az bio SoNci, Aided with HA Az bio SoNci, Aided (soft band) Az bio SoNci, Unaided Az bio SoNnh, Aided (HA) Az bio SoNnh, Aided (BC) Az bio SoNnh]. No significant difference noted in CNC testing between older (>65y/o)(n=15) and younger (<65 y/o) (n=12) age groups. No difference was noted between age groups (n=5 older vs n=6 younger age group) on Az bio SoNo (sound and noise presented from front of the patient) testing before and after implantation. No difference noted between age groups in AZ bio testing SoNci (sound presented from front and noise presented to the side of the bad ear or implanted ear) after implantation. No differences were noted between male and female recipients in CNC testing before and after CI. There was a significant difference noted in SoNo testing between gender with males less likely to improve with CI compared to bone conduction preop testing. All 5 females (who had data available) significantly improved post CI compared to 33% of males that improved with CI (p=.0157) Males tended to do significantly worse than females (p=.0098) in SoNnh (sound from front and noise to the normal hearing ear) condition.

Conclusions: A significant difference was noted in CNC after CI compared to aided condition preop. No difference was noted in sound-field testing with CI. No difference in audiometric testing noted between age groups or by gender.

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INTRODUCTION

A cochlear implant is a cost- effective treatment for bilateral profound hearing loss.
It's a well-established treatment for bilateral severe to profound hearing loss since the early 1980s.[1] Singled-sided deafness (SSD) and Asymmetric hearing loss (AHL) can be debilitating conditions. They can have significant impact on patients' quality of life, lead to tinnitus distress, trouble with hearing in noise, and problems with spatial hearing. Traditional use of CROS hearing aids and bone anchored hearing devices have had limited success in these conditions.[2] Previous studies have shown that CI in SSD and AHL patients can improve speech recognition, tinnitus distress, and quality of life. Unfortunately, many of these studies have been limited by small sample size and utilization of inconsistent auditory testing measures.[2-5] Many existing studies are limited by the varied and inconsistent audiometric tests, quality of life measures, and tinnitus distress measures used to evaluate patient outcomes. Furthermore, there is a concern that the brain will have difficulty in distinguishing between acoustic and electrical signals and that the cochlear implant electric signals may interfere with acoustic hearing in the better hearing ear or the only hearing ear or that the acoustic hearing may interfere with hearing in the implanted ear.[6-8]

This is a pilot study of a single institution experience with CI for SSD/AHL. The aim is to evaluate quality of life, effect on tinnitus distress,& spatial hearing in patients with SSD or AHL treated with a cochlear implant. We hypothesize that CI in the specified patient population (SSD/AHL) improves speech understanding and hearing in noise. The second objective was to determine patient related factors and its effect on hearing after cochlear implantation. Specifically, we sought to determine if there is a correlation between cause of hearing loss, duration of hearing loss, sex, and age with improvement in QOL measures.

METHODS

A retrospective cohort study of patients undergoing CI at a large medical center. Patients over 18 years old with SSD or AHL were offered CI. Data from CI performed for SSD/AHL from 9/2020 to 9/2023 were used for analysis. Testing consisted of Consonant Nucleus Consonant (CNC) and Arizona Bio (AZ Bio) tests preoperatively and then at various intervals after CI activation. Preoperative tests were performed in the aided [hearing aid (HA) or bone conduction (soft band)] and unaided condition and then compared to postoperative results using the CI with noise presented from various direction. Noise was presented from 3 directions: from the front with sound and speech presentation, presented to the side of normal hearing ear, or to the side of cochlear implant or worse hearing ear in the pre-implant testing. Effect of Age (<65 y/o vs >65 y/o), sex, side of implant, duration of hearing loss was evaluated for CI outcomes. Chi square and paired T tests were used for analysis

TABLE1. Characteristics of Hearing loss Patients undergoing Cochlear Implantation (N=27)

Patients with SSD, n (%)	19 (70.4)
Patients with ASNHL, n (%)	8 (29.6)
Males, n (%)	16 (59.3)
Females, n (%)	11 (40.7)
Age at CI (yr), Mean, (range)	65 (29-80)
Duration of Hearing loss (n=26) (months), Mean, (range)	40.8 (5-144)
Cause of Hearing loss	Meniere's -1 Iatrogenic – 1 Labyrinthitis – 1 Autoimmune – 1 Sudden /Idiopathic – 15 ASNHL/Mixed - 8
Side of Implantation	Right – 15 (55.6%) Left – 12 (44.4)
Number of patients tested at first Postop visit; 2nd visit;3rd visit	27; 15; 6
Time after CI until 1st testing (weeks), median (range)	10.5 (4-56)
Time after CI until 2nd testing (weeks), median (range)	26 (8-52)
Time after CI until 3rd testing (weeks), median (range)	46 (42-51)

CI – Cochlear implantation; n- number of patients ; SSD – Singled Sided Deafness; ASNHL – Asymmetric Sensorineural Hearing Loss

Table 2 . Comparison of Audiometric and Quality measures before and after cochlear implantation

	Preop- median (range)	1st Postop	P-value	Ave. Postop	P-value
Aided (HA)CNC (%)(n=24)	6.1 (0-36)	38.0 (0-82)	<0.0001	42.6 (0-82)	<.0001
Unaided Az SoNo (n-13)	29.8 (0-83)	39.5 (0-93)	0.32	42.3 (0-96.5)	0.23
Aided Az SoNo BC (n-14)	32.1 (0-75)	41.6 (0-96.5)	0.45	Not reported due to incomplete testing.	N/A
Unaided Az Bio SoNci (n=9)	91.4 (68-100)	96.2 (85-100)	0.11	46.3 (0-96.5)	0.11
Aided Az Bio SoNci (BC) (n=9)	91.8 (79-100)	96.2 (85-100)	0.09	46.3 (0-96.5)	0.09
Unaided Az Bio SoNnh (n=10)	65.7 (0-99)	67.8 (25-97)	0.8	69.2(25-98)	0.66
Aided Az Bio SoNnh (BC) (n=8)	68.6 (7-99)	74.5 (25-97)	0.48	45.7 (14-88)	0.35
Aided Az Bio SoNnh (HA)(n=8)	40.6 (0-91)	65.8 (32-97)	0.08	67.5(32-98)	0.07

RESULTS

- 27 patients had both preoperative and postoperative testing completed during a 12-month follow-up.
- The majority of patients were implanted with the Cochlear Americas implant CI632.
- 27 patients had at least one postop testing at average time of 10.5 weeks post activation.
- Only 15 and 6 patients had a second and third postoperative testing at average time of 26 and 46 weeks after activation, respectively (Table 1).
- A significant difference in Aided CNC (HA, n=14) testing comparing results at 1st postop testing (p<.0001) and average postop test vs preop was noted (p<.0001).
- Mean preop CNC aided test was 6.1 % vs 38.0% at 1st postop testing with 42.6% average postop test results over 3 visits, max 12 months post activation.
- No significant change was noted between preop and 1st postop visit and average postop results for the following preop conditions: Unaided Az bio SoNo, Aided Az bio SoNo, Aided Az bio SoNo Bone conduction, Unaided Az bio SoNci, Aided with Hearing aid Az bio SoNci, Aided with bone conduction device Az bio SoNci, Unaided Az bio SoNnh, Aided (HA) Az bio SoNnh, Aided (BC) Az bio SoNnh.
- No difference in CNC was noted between age groups or based on gender.
- No difference n CNC or Azbio in SoNo was noted between patients with SSD or AHL.
- No difference in AZ bio testing in SoNo and SoNci condition was noted between young and older age groups. In the SoNnh – there were not enough patients tested postop to reliably evaluate the effect of age on results
- Interestingly more women showed improvement in Az bio testing in SoNo condition after CI. There was not enough data for SoNci and SoNnh conditions.
- A significant improvement in Azbio test was noted in SoNci condition with SSD patients doing better than the AHL group (n=9, p=.0233) in the non-aided preop condition. No difference was noted when compared to aided preop condition. However, the number of patients tested was low (n=9).
- Shorter duration of hearing loss was associated with better AZ bio results after CI in the SoNnh condition. (n=10, p=.0098)

SoNo – Sound presented from front/ Noise from front
SoNci – Sound presented from front/ Noise to ear to be implanted
SoNnh – Sound presented from front/ Noise to good ear

Discussion/Conclusions

This study confirms that cochlear implantation provides a significant and rapid improvement in speech understanding in quiet for patients with hearing loss. The procedure is effective across age groups and for both SSD and AHL populations. However, listening in noise continues to pose a significant challenge, with no aggregate group improvement observed in the tested spatial configurations.

The key clinical implications are threefold:
Managing Expectations: Patients should be counseled that performance in noisy environments may not show the same dramatic improvement as noted in speech understanding in quiet and will likely require the use of complementary strategies (e.g., remote microphones).
Timing of Intervention: The finding of greater benefit in noise in patients with shorter hearing loss reinforces the importance of early implantation to maximize results.
Future Research: The potential differences in outcomes based on etiology (SSD vs. AHL) and gender should be further investigated in larger, prospective studies to better understand the factors that predict success in complex listening situations and to personalize rehabilitation strategies.

Overall, cochlear implantation remains a highly effective treatment and this study contributes to a better understanding of which patients may benefit most and in which specific auditory scenarios.

REFERENCES

1. Dreyfuss M, Giat Y, Veraguth, et al. Cost effectiveness of cochlear implantation in single-sided deafness. Otol Neurotol 42: 1129-1135, 2021.

2. Levy D, Lee J, Nguyen S, et al. Cochlear implantation for treatment of tinnitus in single-sided deafness: a systematic review and meta-analysis. Otol Neurotol 41: e1004-e1012, 2020.

3. Van de Heyning P, Vermeire K, Diebl M, et al. Incapacitating unilateral tinnitus in single-sided deafness treated by cochlear implantation. Ann Otol Rhinol Laryngol 27: 676-82, 2004.

4. Galvin J, Fu Q, Wilkinson E, et al. Benefits of cochlear implantation for single sided deafness: aea from the House Clinic-University of Southern California – University of California clinical trial. Ear Hear 40: 766-81, 2019.

5. Buss E, Dillon M, Rooth M, et al. Effects of cochlear implantation on binaural hearing in adults with unilateral hearing loss. Trends Hearing 22:1-15, 2018.

6. Junior F, Pinna M, Alves R, et al. Cochlear implantation and single-sided deafness: a systematic review of the literature. Int Arch Otorhinolaryngol 20: 69-75, 2016.

7. Bernstein J, Stakhovskaya O, Jensen K, Goupell M. Acoustic hearing can interfere with single-sided deafness cochlear implant speech perception. Ear Hear 41: 747-761, 2020.

8. Dillon M, Buss E, Rooth, et al. Cochlear implantation in cases of asymmetric hearing loss: subjective benefit, word recognition and spatial hearing. Trends Hearing 24: 1-20, 2020.