Localization Abilities of Cochlear Implant Recipients in Cases of Single-Sided Deafness

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Background

Single-Sided Deafness (SSD) can be defined as moderate-to-profound sensorineural hearing loss with limited speech perception benefit in one ear and normal hearing in the contralateral ear. Despite the presence of one normal hearing ear, SSD patients typically experience difficulty with localization[1] and understanding speech in noise[2,3], in addition to a reduced quality of life[4]. Current hearing technology options for patients with SSD include contralateral routing of the signal (CROS) hearing aids and bone conduction devices.

The main advantage of CROS hearing aids and bone conduction devices is the ability for the patient to hear sounds coming from the affected side. However, both of these technologies send the signal to the normal hearing ear, which keeps the patient in a unilateral listening condition. This results in the inability to take advantage of binaural listening cues to help improve speech understanding in noise and localization of sounds in the environment[5]. Stimulation of the auditory pathway on the affected ear could provide binaural cues to SSD patients.

Cochlear implantation may provide a benefit over the current hearing technology options for SSD, as it stimulates the auditory pathway on the affected side. This may permit bilateral stimulation of the auditory pathway, potentially allowing the patient to take advantage of binaural cues to improve speech understanding in noise, localization, and quality of life.

Aim

To assess whether cochlear implant subjects with SSD experience subjective and objective improvements in localization

Methods

All subject received their cochlear implant as part of a FDA clinical trial investigating cochlear implantation in cases of Single-Sided Deafness.

Inclusion Criteria:

- Affected ear: moderate-to-profound sensorineural hearing loss
- Aided CNC word score ≤ 60% in the ear to be implanted
- Contralateral ear: normal-to-mild hearing
- ≥ 18 years of age at implantation
- Duration of moderate-to-profound hearing loss ≤ 10 years
- Completion of at least a 1-month trial with hearing technology
- Realistic expectations
- No reported cognitive issues

Exclusion Criteria:

- Conductive hearing loss
- Compromised auditory nerve
- Cochlear ossification
- Sudden HL that has not been evaluated by a physician
- Tinnitus as primary reason for seeking CI

Listening Conditions:

- Unaided (contra ear only)
- Bone-conduction hearing aid (BCHA) plus contra ear
- Cochlear implant (CI) + contra ear (CI+Contra)

Assessment Intervals:

- Preoperative evaluation
- 1-month post-initial activation
- 3-months post-initial activation
- 6-months post-initial activation
- 9-months post-initial activation

Localization Task:

- 11-speaker array (**Figure 1**)
- Subject seated 1 meter away facing speaker #6
- 200 ms speech noise bursts
- Varying intensity level (60, 70 & 80 dB SPL)
- Subject verbalized speaker number
- No feedback provided

Results

Thirteen (13) subjects were enrolled and received a cochlear implant (CI) as part of the clinical trial investigating cochlear implantation in cases of single-sided deafness. All subjects were implanted with the MED-EL Concert standard electrode array and were fit with the Opus 2 external speech processor. All subjects were mapped with the FS4 signal coding strategy. Demographic information for this cohort are listed in **Table 1**.

Figure 1: Image of the 11-speaker array

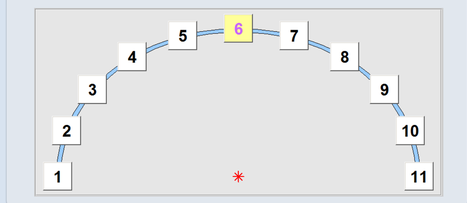


Table 1: Demographic information for the 13 subjects who completed the 9-month follow-up interval.

Demographic	Max	Min	Average
Duration of Hearing Loss	6.6	0.3	**2.6**
Age at Implantation	66.0	22.6	**48.8**

At the preoperative interval subjects were tested in two conditions: 1) unaided, and 2) with a bone-conduction hearing aid (BCHA; BAHA Intenso on a test band). During follow-up intervals, subjects were tested with their CI plus the normal hearing ear (CI+contra) to assess whether the addition of the CI improved localization abilities. Ten (10) normal hearing subjects completed the test battery for a performance comparison.

The difference between the sound source and the response on each trial was reported in root-mean-square (rms) error, where a lower value is indicative of better performance. Initial results between conditions were compared using a Welch's *t*-test, with $\alpha<0.05$. There was no difference in the rms error between the unaided and BCHA conditions ($p=0.24$) at the preoperative interval. There was a significant difference between the preoperative unaided condition and the CI+contra condition after 1-month ($p<0.001$) of listening experience with the CI. Subjects also reported a significant improvement in localization abilities between the preoperative and 1-month follow-up interval on the speech ($p<0.001$) and spatial ($p<0.001$) subscales on the Speech, Spatial and Qualities (SSQ) questionnaire.

Figure 2: Localization results for each subject at the preoperative, 1-month, 3-month, 6-month, and 9-month follow-up intervals.

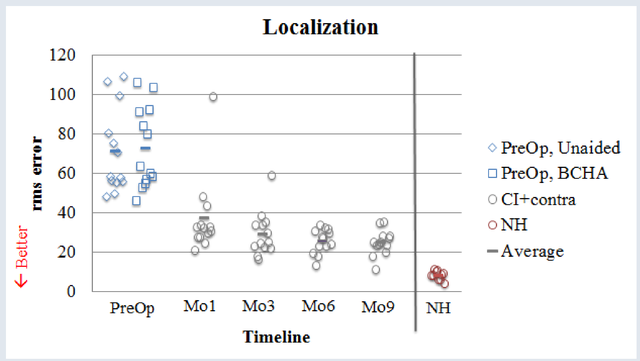
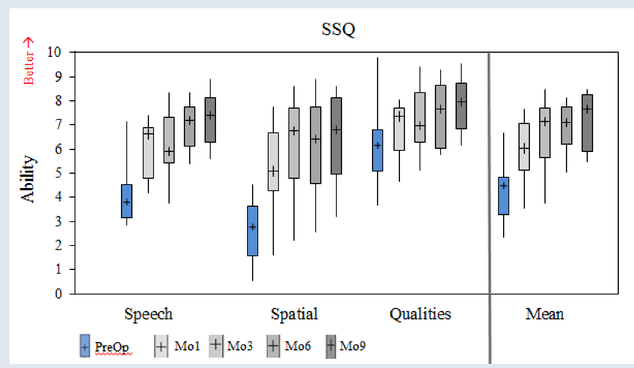


Figure 3: Subjective results on SSQ for all subjects at the preoperative, 1-month, 3-month, 6-month, and 9-month follow-up intervals.



Conclusions

There was no difference in localization abilities between the unaided and BCHA conditions at the preoperative interval. Subjects experienced a significant improvement in rms error when listening with a cochlear implant plus the normal hearing ear as compared to preoperative listening conditions. The subjective benefit measured with the SSQ questionnaire reflected these findings.

Patients with unilateral hearing loss who meet cochlear implantation candidacy criteria on the affected side may experience improvements in localization abilities with the use of a cochlear implant.

References

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CAUTION: Not FDA approved. Investigational Device Exemption