Hearing Preservation Cochlear Implantation: Benefits of Bilateral Acoustic Hearing

Kelly Jahn, B.S.
Vanderbilt University

TAASLP Convention
October 29, 2015
Background

- 80% of CI candidates now have bilateral residual LF hearing before surgery\(^1,2,3\)

- Preserved acoustic hearing in the implanted ear is possible
  - Both long\(^4,5,6\) (16-30 mm) and short\(^7\) (6-10 mm) electrode arrays

- Allows for use of a hearing aid (HA) and CI in the same ear
  - Ipsilateral electroacoustic stimulation (ipsi EAS)
  - First FDA-approved hybrid CI in the US – Cochlear Nucleus L24 (16 mm)
    - March 2014

---

\(^1\)Balkany et al, 2006; \(^2\)Gifford et al, 2007; \(^3\)Dorman and Gifford, 2010; \(^4\)Gstoettner et al, 2008; \(^5\)Lenarz et al, 2009; \(^6\)Skarzynski et al, 2012; \(^7\)Gantz et al., 2009
FDA Criteria – Hybrid CI

- Unilateral
- Adults

**Implanted Ear:**
- Normal to moderate LF SNHL through 500 Hz ($\leq 60$ dB HL)
- Severe to profound mid to HF SNHL
- Aided CNC word recognition 10-60%

**Non-Implanted Ear:**
- Moderately-severe to severe mid- to HF SNHL
- Aided CNC word recognition $\leq 80$

- Limited benefit from appropriately-fit amplification

U.S. Food and Drug Administration, 2015
Background

• Many patients now have the option to wear a HA in addition to CI in either or both ears

• Speech perception benefit with addition of HA in either ear
  • 70-100% show improved speech perception
  • High variability: 5-65% percentage point improvement across studies\(^1,2,3,4,5\)

• Correlations between degree of HL and benefit of adding a HA\(^6,7,8\)
  • Degree of audibility
  • Usable frequency bandwidth\(^9,10\)

\(^1\)Dunn et al, 2005; \(^2\)Mok et al, 2006; \(^3\)Gifford et al, 2007; \(^4\)Brown and Bacon, 2009; \(^5\)Visram et al, 2012; \(^6\)Mok et al, 2010; \(^7\)Sheffield and Zeng, 2012; \(^8\)Yoon et al, 2012; \(^9\)Gifford et al, 2007; \(^10\)Gifford et al, 2014
Background

• Guidelines exist for HA fitting in non-implanted ear
  • 15-30% benefit in speech perception if aidable hearing at frequencies \( \leq 250 \text{ Hz} \)^{1,2}
  • What about a HA in the implanted ear?

• Effect of frequency bandwidth in the implanted ear on speech perception benefit is unknown
  • Thus, no guidelines exist that outline audiometric criteria for recommending amplification in the implanted ear

• Few studies have examined the benefit of aiding two ears vs. one ear in patients with a unilateral CI

^{1}Zhang et al., 2010a; ^{2}Sheffield & Gifford, 2014
Research Questions

1. Does acoustic hearing in an ear with a CI provide as much speech perception benefit as the same bandwidth of acoustic hearing in the non-implanted ear?

2. Does acoustic hearing in both ears provide more benefit than acoustic hearing in just one ear?

Sheffield, Jahn, & Gifford (2015)
Participants

- 7 adult unilateral CI recipients with bilateral LF acoustic hearing (aidable through 500 Hz)
- At least 15 months experience with the CI and bilateral HAs

Sheffield, Jahn, & Gifford (2015)
Methods

• Speech perception assessed via CNC words in quiet and in multitalker babble (+10 dB SNR)

• 4 Listening Conditions
  • CI alone
  • CI + Implanted ear acoustic hearing (ipsiEAS)
  • CI + Non-implanted ear acoustic hearing (bimodal)
  • CI + bilateral acoustic hearing (EASall)

• Low-pass filters applied to the acoustic signals to simulate varying acoustic hearing bandwidth
  • <125 Hz, <250 Hz, <500 Hz, <750 Hz
  • Acoustic outputs matched to NAL-NL1 targets

Sheffield, Jahn, & Gifford (2015)
Results – Question 1

- **Does acoustic hearing in the CI ear provide as much speech perception benefit as the same bandwidth of acoustic hearing in the non-CI ear?**

- Increasing acoustic benefit as filter bandwidth increases

- No difference in acoustic benefit across ears

- Acoustic hearing in each ear provides similar speech perception benefit

Sheffield, Jahn, & Gifford (2015)
Results – Question 2

• **Does acoustic hearing in both ears provide more benefit than acoustic hearing in just one ear?**

• Limited to no additional benefit from acoustic hearing in the implanted ear when added to the bimodal condition

• Both in quiet and in multitalker babble *originating from a single loudspeaker*

Sheffield, Jahn, & Gifford (2015)
Conclusions

• If CI recipient has aidable hearing ($\leq 80$ dB HL) through 500 Hz in both ears, he or she should obtain equal speech perception benefit via acoustic amplification in either ear
  • If hearing is fairly symmetrical*

• No additional speech perception benefit from acoustic hearing in the implanted ear when added to the bimodal condition

• What *are* the benefits of bilateral acoustic hearing?

Sheffield, Jahn, & Gifford (2015)
Where is bilateral acoustic benefit observed?

- 5 subjects tested in semi-diffuse restaurant noise (+5 dB SNR)
  - Significant benefit (8.8%) of bilateral acoustic hearing observed

- Gifford et al. (2014) – 38 subjects
  - Significant bilateral acoustic benefit in ‘restaurant’ environment (diffuse noise) – 10.2% at +2 dB SNR
  - Significant benefit in reverberant environments – 6.2%
  - Largest improvements in the most challenging listening situations (poorest SNRs)
  - Significant correlation between ITD thresholds and degree of EAS-related benefit for speech recognition in diffuse noise

_Binaural timing cues can be preserved._

_This is associated with higher levels of EAS-related benefit for speech recognition in complex listening environments._
Recommendations

• If a unilateral CI recipient can only wear one hearing aid, amplify the ear with the better acoustic hearing
  • Verify fittings – i.e. NAL-NL1 prescriptive targets

• Attempt to provide acoustic amplification to both ears for frequencies with thresholds up to 80 dB HL
  • Benefits in complex listening environments (i.e. diffuse noise)
  • Preservation of binaural cues (i.e. ITD)

• Test environment should involve spatially-separated signal and noise (allows use of ITD cues)
  • More realistic, everyday listening situation
  • Counseling
References

- Zhang T, Dorman MF, Spahr AJ. (2010a) Information from the voice fundamental frequency (F0) region accounts for the majority of the benefit when acoustic stimulation is added to electric stimulation. Ear Hear 31(1):63–69.
Questions?