Delayed Hearing Loss in Hybrid Cochlear Implant Users
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BACKGROUND

CI candidacy has relaxed over the years.
1. Patient outcomes in terms of perceptual abilities have been better than originally expected.
2. Devices and surgical techniques have been modified to preserve cochlear structure and function. Loss of residual hearing is no longer a certain sacrifice/risk of CI.

Hearing Preservation
1. Surgery
   - Minimal drilling (small cochleostomy/round window insertion)
   - Copious irrigation
   - No suctioning once the scala is opened
   - Slow, steady insertion of the electrode array
   - Suturing the array at the tegmen mastoideum for stabilization
   - Peri- and postoperative steroids
2. Implant Design
   - Short
   - Thin
   - Flexible
   - Tapered tip
   - Designs to minimize insertion force and contact with the outer or inner wall.

Advanced Bionics: Mid scala array
https://www.advancedbionics.com/content/advancedbionics/us/en/home.html

Cochlear: L24 and 532 arrays; Nucleus Hybrid Implant System

Med El: Synchrony implant; Synchrony EAS system
http://www.medel.com/eas-candidacy
Benefits of electric + acoustic in the same ear

a. Speech discrimination in quiet
b. Speech discrimination in noise
c. Music perception


Risks of cochlear implantation in an ear with residual acoustic hearing

a. Immediate loss of acoustic hearing
b. Delayed loss of acoustic hearing


Underlying mechanisms of hearing loss following implantation

a. Conductive hearing loss
b. Surgical trauma (basilar membrane, inner-, outer walls)
c. Delayed degeneration of hair cells/support cells/synaptic/spiral ganglion damage.
d. Excitotoxicity from excess acoustic-electric stimulation (synaptic damage)
e. Fibrosis and ossification
f. Hydrops

(e.g. Choi and Oghalai, 2005; Tanaka et al., 2014; Chole et al., 2014; Reiss et al., 2015; Kopelovich et al., 2015; Quesnel et al., 2015; Ishiyama et al., 2016)
RETROSPECTIVE REVIEW

Purpose: To explore possible mechanisms of progressive/delayed loss of residual hearing.

Outcome Measures
1. Unaided audiometric thresholds (PTA of 125, 250, 500, & 1000 Hz)
2. Electrode impedance (Z)
3. Electrically evoked compound action potentials (ECAPs): thresholds, slopes and suprathreshold amplitudes

Sample

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<tr>
<th>Array</th>
<th>Electrodes</th>
<th>Length</th>
<th>Total</th>
<th>Included</th>
<th>Data Range</th>
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<td>22</td>
<td>20</td>
<td>63</td>
<td>15</td>
<td>2012 to 2016</td>
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<tr>
<td>L24</td>
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<td>14.5</td>
<td>41</td>
<td>31</td>
<td>2014 to 2016</td>
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<tr>
<td>S12</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>15</td>
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<tr>
<td>S8 (24RE)</td>
<td>6</td>
<td>10</td>
<td>12</td>
<td>12</td>
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<tr>
<td>S8 (24M)</td>
<td>6</td>
<td>10</td>
<td>12</td>
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<td>2000 to 2016</td>
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<tr>
<td>Total</td>
<td>143</td>
<td>85</td>
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Hearing Loss Categories

1. Stable

2. Symmetrical

3. Implanted Ear: Gradual

4. Implanted Ear: Precipitous
Results

38% of the sample had hearing loss in the implanted ear.

- Loss of hearing ≠ loss of functional hearing.
- ~50% of patients with delayed hearing loss in the implanted ear still used an acoustic component at the end of the study and had audiometric thresholds better than 90 dB HL (4F PTA).

Z changes were at or below zero for stable / symmetrical group and greater than zero for precipitous hearing loss group. The timing of the transient increase in impedance was related to the timing of the drop in acoustic hearing. Statistical analysis support the differences observed in this figure. “Gradual” group was not considered in the statistical analysis due to the small sample size.
ECAP changes (in thresholds, slopes or amplitudes) were not correlated with PTA changes.

SUMMARY/TAKE-HOME

- 38% of this sample exhibited delayed hearing loss.
  - Degree of loss was varied.
  - Timing of loss was varied.
  - Rate of loss was varied.
- Transient increases in electrode impedance are observed in many patients showing precipitous drop in hearing.
  - Consistent with fibrous tissue growth in the cochlea as a contributing mechanism?
- Changes in ECAP amplitudes/slopes/thresholds are not correlated with changes in PTA.
  - Measurement limitation: ECAPs are measured from electrodes located in more basal regions and PTA reflects acoustic hearing in apical regions
- When counseling patients:
  - Loss of residual hearing in the implanted ear is still a risk factor, even with the new devices and techniques.
  - Loss of hearing might show up immediately following surgery or over time.
  - We don’t have a complete understanding about what is responsible for this loss.
  - Risk factors: age (older), gender (male), etiology (NIHL)? (Kopelovich et al. (2014). Risk factors for loss of ipsilateral residual hearing after Hybrid cochlear implantation.)

It is unlikely that the underlying mechanism of hearing loss is the same for all patients. It will be important to continue to evaluate various measures of auditory function to determine what is happening for an individual.
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Retrospective review has been accepted for publication: