Abstract

**Objectives**
1. To examine the histopathology of multi-channel cochlear implant temporal bones
2. To evaluate the relationship of residual spiral ganglion cell counts and clinical hearing performance

**Methods**
Eight temporal bones from four cochlear implant patients were postmortem examined histologically.

**Results**
There were varying amounts of inflammation (fibrosis and ossification) at the basal turn of the cochlea in all 4 implanted temporal bones. Compared to non-implanted sites, two implanted bones had less than a 10-year duration of implantation had no significant changes of spiral ganglion cell population. Two cases with a 10-year duration of implantation had no significant changes of spiral ganglion cell population. One case with a 10-year duration of implantation (15 years) showed a 36% decrease of spiral ganglion cells at the implanted site. The case with the best speech perception (98% with CID sentence test) had the lowest residual spiral ganglion cells (30% of normal spiral ganglion cell population). Two cases with poor clinical performance (<10% with CID sentence test) had residual spiral ganglion cells of 11% and 22%. The case with moderate clinical performance (30% with CID sentence test) had 14% of normal spiral ganglion cell population. Surviving dendritic cells varied from 5% to 30% among 4 cases with no relationship to clinical performance.

**Conclusion**
Our findings suggest prolonged implantation may affect spiral ganglion cell population. Although our temporal bones and speech performance (as previously reported), we were unable to obtain statistical significance due to small sample size.

Introduction

Patients with severe to profound sensorineural hearing loss will benefit from cochlear implantation for speech perception. However, this benefit varies significantly from patient to patient. Many studies have been conducted to try to identify possible predictors for improved clinical performance, but at present, no definitive factors have been found for this variation. Studying the histopathology of temporal bones from living donors who have received cochlear implants will help to elucidate this matter further.

Methods and Materials

A total of eight temporal bones from four patients with unilateral cochlear implants were studied. Clinical information was retrieved from chart review. For each implanted temporal bone, the following data was evaluated: trauma at the cochleostomy site, damage to basal membrane, Organ of Corti, spiral lamina and stria vascularis, inflammatory reaction including new bone formation and fibrosis, as well as viable spiral ganglion cell counts and dendrites. The implanted bones were compared to the non-implanted bones in each case. Spiral ganglion cells and dendrite cell counts were measured. The relationship between SGC counts and auditory outcomes was also studied.

Results

**TABLE 1** Clinical Information of Patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Side</th>
<th>Age (yr)</th>
<th>_duration</th>
<th>Death (yr)</th>
<th>Cause of Deafness</th>
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<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>L</td>
<td>40</td>
<td>5</td>
<td>72</td>
<td>Unknown</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>L</td>
<td>50</td>
<td>5</td>
<td>70</td>
<td>Ototoxicity</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>L</td>
<td>70</td>
<td>5</td>
<td>15</td>
<td>Unknown</td>
</tr>
<tr>
<td>4</td>
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<td>R</td>
<td>51</td>
<td>5</td>
<td>66</td>
<td>Otosclerosis</td>
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</table>

**TABLE 2** Spiral-Ganglion Cell (SGC) Counts of implanted and non-implanted bones

<table>
<thead>
<tr>
<th>Case</th>
<th>Number</th>
<th>implant</th>
<th>non-implant</th>
<th>Total</th>
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</thead>
<tbody>
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<td>1</td>
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<td>3537</td>
<td>5537</td>
<td>8074</td>
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<tr>
<td>2</td>
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<td>3537</td>
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</table>

**Fig. 1a.** Midmodular histologis section of temporal bone (case 1, left ear). Shows distortion of basilar membrane (A) and fracture of osseous spiral lamina. (B) at basal turn of cochlear caused by electrode insertion. Spiral lamina, stria vascularis and organ of Corti appear atrophic (hematoxylin-eosin, magnification x2).

**Fig. 1b.** Higher magnification (x 40) of the area C shows an atrophy appearance of Rosenthal canal at ascending limb of basilar turn of cochlear. This is the case with the lowest spiral ganglion cells in our series.

**Fig. 2.** a. This section (case 2, left ear) shows an electrode tract (A) inside the scala tympani at the basal turn of cochlear and at level of round window. There is extensive fibrous reaction inside scala tympani (B). (Hematoxylin-eosin, magnification x2). b. Cochlear implant (CI).

**Fig. 3.** A. This section of a temporal bone (case 3, left side) shows evidence of endolymphatic hydrops with distention of basilar membrane (A) and a fibrous sheath around the electrode occupying the entire scala tympani. (Hematoxylin-eosin, magnification x2).

**Fig. 4.** This section of a temporal bone (case 3, left side) shows evidence of endolymphatic hydrops with distention of basilar membrane (A).

**Fig. 5.** This is a section of an implanted temporal bone (case 4, right ear) at the cochleostomy site (A) shows surgical trauma at the promontory following cochleostomy. Initial attempt at electrode insertion at the routine cochleostomy site failed. The scala tympani is completely occluded with bony structure (B), severe and extensive cochlear ossification is shown in stria capsula (C). The electrode tract (D) appears within the scala vestibuli with significant new bone formation (E) around the electrode which extends onto the cochleostomy site.

**Case 1.** This is a patient who is status post right acoustic neuroma resection via a trans labyrinthine approach at the age of 50. He had regressive hearing loss of his left ear within 5 years prior to cochlear implantation due to unknown etiology. His pure tone average (PTA) of the left ear was 100 dB with 28% SDS prior to implantation. The patient received a Clarion ABI 5000 cochlear implant at the age of 50. He was doing very well with his cochlear implant. CID Sentence scores improved from 18 to 68 after implantation.

**Case 2.** This is a young woman who lost her hearing at 3 years of age secondary to drug induced ototoxicity. She received her cochlear implant at the age of 46. The patient showed significant benefit from the cochlear implant. Her post implant CID everyday sentence test after 12 months improved from 6% to 89%.

Conclusions

1. Cochlear implants caused varied degrees of inflammation and trauma to cochlea
2. Prolonged implantation may affect spiral ganglion cell population
3. There is no reverse relationship between residual spiral ganglion cells in implanted temporal bones to clinical performance observed from our limited cases. Studies of a larger number of cases are needed.