Cochlear Implant
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Abstract: The cochlear implant is an effective solution to sensorineural hearing loss in both pre- and post-lingual hearing loss patients. It is able to convert sound received by an external microphone into electrical signals, which stimulate the auditory nerve directly via an electrode array.

I. Introduction

The cochlear implant’s genesis dates back 1957, when the first electrical stimulation of fibers of the inner ear was performed by A. Djorno and C. Eyries, which successfully restored hearing to a bilaterally deaf patient. This device is not a cure for deafness in general, but rather a way of partially restoring hearing to patients with sensorineural hearing loss. Such hearing loss is caused typically by abnormalities in hair cells of the cochlea. In a normally functioning ear, vibrations from the tympanic membrane (eardrum) cause fluid in the cochlea to flow through the spiraled organ. The cilia from the hair cells sense this motion and resultant action potentials are fired which stimulate the cochlear/auditory nerve. Cochlear implants bypass this process completely, converting sound received via microphone into electrical signals, which stimulate the auditory nerve directly (Wikipedia, 2014).

II. Methods

The cochlear implant functions by using a system of external and internal devices. The external devices include a microphone, a speech processor, and a transmitter. The internal devices include a receiver/stimulator and an electrode array. The receiver is placed adjacent to the transmitter subdermally, while the array wraps around the natural cochlea and is connected via wire to the receiver. The microphone receives sound, and the speech processor filters the sound and converts it to electrical signals using fast Fourier Transforms. The transmitter then sends the signals wirelessly to the receiver/stimulator, which then sends them to the electrodes. The individual electrodes then stimulate the auditory nerve, whose signals are processed in the auditory cortex (Nidcd.nih.gov, 2014).

III. Results

One study of profoundly deaf children found that for each 6-month period over the first 30 months post-implantation, the increase in “language age” was about double that of deaf children without cochlear implants (Svirsly, et al., 2000). Another study displayed the ability of both pre- and post-lingual hearing loss patients to accurately identify sentences with high success rates over a landline telephone (LT on graph), a landline with an adapter (LTA), and a cell phone (CT). Results are seen below (Rigotti et al., 2013).

<table>
<thead>
<tr>
<th></th>
<th>Prelingual (n=9)</th>
<th>Postlingual (n=18)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>LT (n=9)</td>
<td>LTA (n=5)</td>
</tr>
<tr>
<td>Average (%)</td>
<td>82.22</td>
<td>92.80</td>
</tr>
<tr>
<td>Standard deviation (%)</td>
<td>12.62</td>
<td>6.72</td>
</tr>
<tr>
<td>Maximum (%)</td>
<td>66.00</td>
<td>82.00</td>
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<tr>
<td>Maximum (%)</td>
<td>100.00</td>
<td>100.00</td>
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</tbody>
</table>

IV. Discussion

Hearing loss patients have exhibited significant improvements in their hearing, speech comprehension, and speech development following a cochlear implant. However, intense post-implantation therapy is necessary in order to improve these abilities. Another limitation is the distortion that results from reverberations. Late echoing effects that go unnoticed by the non-hearing-impaired can be problematic for the speech processor (Hu and Kokkinakis, 2014). Additionally, the device costs between $45,000 and $125,000, and surgical complications can lead to a damaged vestibular system, infections, and facial muscle weakness or paralysis.

The future of this technology includes improving surgical techniques to ensure that residual hearing is still intact, in case a cure ever comes about (Wikipedia, 2014). One study also suggests that longer electrode arrays that span more of the natural cochlea and spiral ganglion may significantly improve the range and specificity of pitches that the implant can transmit (Landsberger et al., 2014).

References