Abstract

Objective: To assess the effect ground electrode position on intraoperative neural response telemetry (tNRT) and threshold for facial nerve stimulation during cochlear implantation.

Study Design: Prospective case series

Setting: Tertiary referral center

Patients: Adults (N=15) over 18 years of age with normal cochlear anatomy who received CI512 device with full insertion of electrode array

Intervention: Following electrode insertion, tNRT and presence of facial nerve stimulation were recorded with the ground electrode in the standard location (under the temporalis muscle) and in three alternate locations within the surgical field.

Main outcome measure: intraoperative tNRT measurements and occurrence of facial nerve stimulation

Results: No correlation existed between tNRT responses or threshold for facial nerve stimulation and position of the ground electrode (p>0.05). Telemetry data from 3 alternative locations did not differ significantly from data obtained in the standard position.

Conclusions: Intraoperative telemetry is a well-established and valued aspect of contemporary cochlear implantation, conveying information about device function, response of the auditory system to electrical stimulation and preliminary programming data. This study suggests ground electrode position had no effect on intraoperative recording of tNRT or the threshold for facial nerve stimulation. This data may inform future cochlear implant device design, including alternate placement or elimination of the ground electrode.

Methods

Post-lingually deafened individuals over 18 years of age with normal cochlear anatomy (as assessed by pre-operative imaging) were prospectively enrolled prior to surgery. Electromyographic recording of the facial nerve was standard in all cases. Cochlear implantation was performed by a single surgeon in the standard fashion utilizing a transmastoid facial recess approach to the cochlea. In each case, there was full insertion of the electrode array via an anterior inferior cochleostomy. Following electrode insertion, Auto-NRT was performed with the ground electrode in the control location and in 3 additional positions. (Figure 1) The control location was located under the temporalis muscle. Auto-NRT was performed remotely by a cochlear implant audiologist experienced in intraoperative telemetry.1 The order of positions was randomized and the audiologist was blinded to electrode position. Auto-NRT was performed on electrodes 1, 5, 10, 15 and 20. The ground electrode was repositioned a maximum of 3 times when there was difficulty obtaining NRT values. The ground was placed in the control position prior to surgery completion.

Results

Electrode impedances were obtained on all patients. One patient had one open electrode (E10) which normalized upon subsequent repeat measurement (5 minutes later).

Overall, there was no correlation between measured tNRT and position of the ground electrode (p > 0.05). Data obtained in the control position under the temporalis muscle did not significantly differ from any of the other 3 positions.

In 11 patients, tNRT was obtained on all electrodes tested in all 4 positions. In 2 patients, 1 of the 5 electrodes tested was out of compliance and no measurements could be obtained in any location. In 1 patient, 2 of the 5 electrodes tested yielded no data in any location. Lastly, in 1 patient, tNRT could not be obtained on any electrode in position 3 despite multiple attempts at repositioning.

Intra-operative facial nerve stimulation was noted in one patient during stimulation of E20 (in all positions, including reference). This patient had a history of cochlear otosclerosis. The facial nerve was fully functional (House-Brackmann I) post-operatively.

<table>
<thead>
<tr>
<th>Patients (N=15)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age (yrs. range)</td>
<td>60.5 (30-62)</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
</tr>
<tr>
<td>Left side implanted</td>
<td>7</td>
</tr>
<tr>
<td>Facial nerve stimulation</td>
<td>1 (E20)</td>
</tr>
<tr>
<td>tNRT complete</td>
<td>11</td>
</tr>
</tbody>
</table>

Discussion

Current Nucleus® cochlear implant design (Cochlear Corporation, Sydney, Australia) contains an intra-cochlear electrode array and two extra-cochlear electrodes: an additional, separate ground electrode (ECE1) and one on the device case (ECE2). The separate ground electrode (ECE1) is normally placed beneath the temporalis muscle, adjacent to the stimulator, approximately 20 mm from the device. This electrode provides a return path for stimulation current when coupled with an intra-cochlear electrode measuring NRT. ECE1 serves as a ground during intraoperative testing (NRT) and remains in place post-operatively. In an attempt to simplify the design of the receiver-stimulator, alternate placement or elimination of this ground electrode has been proposed. The current study addressed this question by comparing NRT measurements with the ground electrode in the standard (control) location and then in 3 alternate positions.

The results of this study show no significant difference in threshold neural response telemetry for any of the three alternate locations compared to the standard placement. Furthermore, no participant experienced unexpected or long-term facial nerve stimulation. Intraoperative facial nerve stimulation occurred in 1 patient with cochlear otosclerosis. Prior research suggests that the pathophysiology of cochlear otosclerosis may pre-dispose these patients to facial nerve stimulation when the intra-cochlear electrode is stimulated.2 As expected, the facial nerve was fully functional post-operatively. Inability to measure NRT in some electrodes is consistent with prior literature and did not suggest a pattern related to ground electrode position.3

As CI technology and device design evolve, investigators have questioned the need for a separate ground electrode. This study suggests that ground electrode position had no effect on intraoperative recording of tNRT or the threshold for facial nerve stimulation. Future implant design may incorporate this data to modify or eliminate the ground electrode.

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*This study was approved by the NYU IRB Study #10-02533