Electrode Array Extrusion in Cochlear Implantation: Our Experience

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Cochlear implantation (CI) is the standard treatment for patients with severe to profound sensorineural hearing loss (HL), in which hearing aids are not beneficial [1-3]. The complications after CI are classified into minor and major complications, and revision surgery usually is necessary in the management of major complications [4].

Electrode array extrusion or migration is rare, but it is a major complication that requires re-implantation, which is needed in 1-15% of overall revision surgeries for CI [4,5]. The incidence of electrode extrusion or migration in CI has been reported to range between 1 and 12% [6]. In this study, considering the significance of electrode extrusion in CI, we reviewed and analyzed several patients with electrode array extrusion of CI for further understanding of the risk and mechanism of electrode extrusion in CI.

We retrospectively reviewed medical records of 1,391 patients with CI in our tertiary institution from October 1988 to December 2020. Among these patients, we identified seven patients who experienced electrode extrusion (Table 1). There were six male patients and one female patient, one individual of pediatric age and six adults. One pediatric patient who had CI had congenital HL, and six adult patients with CI had a history of mastoidectomy due to chronic otitis media (COM) before CI. Among the patients with mastoidectomy, five patients underwent open cavity (canal wall down) mastoidectomy, and one had intact call wall (canal wall up) mastoidectomy.

The extruded electrode arrays were straight type in four patients and perimodiolar type in three patients. The mean interval between CI and electrode extrusion was 8.6 ± 5.5 years (range: 11 months to 14 years 11 months). For the events before electrode extrusion, high impedance was measured at four channels in one pediatric patient, and HL was aggravated after ear wax removal, ear pick use, inflammation, or ear dressing in four adult patients, while there were no specific events in the other two adult patients. Electrode extrusion was confirmed with physical examination at outpatient clinics and transocular plain X-ray or temporal bone computed tomography in all patients. Electrode arrays were extruded from the cochlea and exposed in the external auditory canal (EAC) in all of the patients. Posterior EAC was destructed in two patients with previously intact EAC, and no new bone formation was observed in the pediatric patient (Fig. 1). Devices were removed from all of the seven patients, and simultaneous revision CI was performed in four patients.

During surgeries for CI in six patients with previous mastoidectomy and for revision CI in four patients,
remnant air cells in mastoid bone were drilled out so as not to aggravate infection. The inserted electrode was covered sufficiently with temporalis fascia, cartilage, and fibrin glue along the full length. We did not perform subtotal petrosectomy in these patients considering the disadvantages such as EAC blind sac closure breakdown, entrapped cholesteatoma, and infection of obliterated cavity.

Electrode extrusion should be considered in patients with open cavity mastoidectomy. Mastoid cavities in patients with canal wall down mastoidectomy raise concerns with operative and postoperative management, especially when there is a large meatoplasty. Several surgical techniques to decrease operative and postoperative complications in these patients have been reported, including maintenance of the cavity with soft tissue coverage of the electrode, overclosure of the EAC with and without mastoid obliteration or Eustachian tube plugging, posterior EAC wall reconstruction, subtotal petrosectomy with EAC overclosure, and CI via the middle fossa approach bypassing the canal wall down cavity [7]. Subtotal petrosectomy with closure of the EAC was reported to be as an appropriate method for CI in patients with COM [1,3,8,9].

The mechanism of electrode migration remains unclear [4,5]. However, several mechanisms of electrode extrusion have been described. Iatrogenic defects of the posterior EAC during CI were reported to be the cause of electrode extrusion. If the electrode is in contact with the posterior EAC wall, pressure on the wall could have an effect on wall breakdown, particularly the excessively thinned wall [10]. Head trauma and intracochlear fibrosis and ossification can induce electrode extrusion [4,5]. In the present study, four of six adult patients had events of traumatic external force or inflammation in the implanted ear before electrode extrusion. Based on our study and previous reports, previous mastoidectomy can be a risk factor for electrode extrusion due to posterior EAC wall defect or thinning.

For CI in children, new bone formation and mastoid growth are mechanisms of electrode extrusion. The electrode array might be fixed by new bone formation at the mastoid tip. New bone formation within the mastoid cavity during skull growth can displace the electrode over time, pulling it out of the cochlea [4,5].

A straight electrode has a higher incidence of extrusion compared to a perimodiolar electrode due to its design. Precurved perimodiolar electrode arrays can be self-retained inside the cochlea, whereas straight electrode arrays can exert forces to the cochlear outer wall due to the inherent tendency to spring back into their original straight position [5,6]. However, in the present study, three of seven patients with electrode extrusion had undergone perimodiolar electrode arrays.
In a study by Dietz et al. with 162 patients with CI, 12 patients with CI electrode extrusion were identified and all extruded electrodes were straight [5]. In another systematic review, the interval between CI and electrode migration ranged from weeks to several years [4]. In the present study, the mean interval between CI and electrode extrusion was longer in patients with perimodiolar electrode array (55.3 ± 5.51 months) than in those with straight electrode array (36.4 ± 22.9 months). Therefore, although straight electrodes have a higher risk of extrusion compared to perimodiolar electrodes, perimodiolar electrodes can be extruded long after CI.

We verified the high possibility of electrode extrusion in adult patients with open cavity mastoidectomy and in pediatric patients based on long-term experience. Canal wall down mastoid cavity and pediatric early age are risk factors for electrode array extrusion in CI. Patients with these factors should be followed long-term to assess electrode extrusion.

REFERENCES


FIGURE LEGENDS
Fig. 1. Electrode array extrusion in cochlear implantation. (A) Endoscopic view of the left ear in Patient 4. (B) Transocular X-ray image of the left ear in Patient 4. (C) Temporal bone computed tomography image in Patient 5 revealing extruded electrode array through the destructed external auditory canal.
Table 1. Characteristics of patients with electrode extrusion in cochlear implantation

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Sex</th>
<th>Type of COM surgery before CI</th>
<th>Site</th>
<th>Age at CI (y)</th>
<th>Age at electrode extrusion (y)</th>
<th>Interval between CI and electrode extrusion (y)</th>
<th>Implanted device</th>
<th>Electrode type</th>
<th>Event before electrode extrusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>OCM</td>
<td>L</td>
<td>45</td>
<td>54</td>
<td>9 y 6 m</td>
<td>Cochlear Nucleus CI22M</td>
<td>S</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>OCM</td>
<td>L</td>
<td>45</td>
<td>60</td>
<td>14 y 11 m</td>
<td>Cochlear Nucleus CI22M</td>
<td>S</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>OCM</td>
<td>R</td>
<td>61</td>
<td>62</td>
<td>11 m</td>
<td>Contour Advance CI24RE (CA)</td>
<td>P</td>
<td>HL aggravated after inflammation</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>OCM</td>
<td>L</td>
<td>55</td>
<td>62</td>
<td>7 y</td>
<td>Cochlear Nucleus 24 Contour CI24R (CS)</td>
<td>P</td>
<td>HL aggravated after ear wax removal</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>N/A</td>
<td>L</td>
<td>2 y 5 m</td>
<td>4 y 9 m</td>
<td>2 y 4 m</td>
<td>MED-EL Concerto medium</td>
<td>S</td>
<td>High impedance measured at four channels</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>OCM</td>
<td>L</td>
<td>53</td>
<td>64</td>
<td>10 y 10 m</td>
<td>Advanced Bionics HiRes 90K</td>
<td>S</td>
<td>HL aggravated after ear pick use</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>ICWM</td>
<td>L</td>
<td>50</td>
<td>65</td>
<td>14 y 7 m</td>
<td>Cochlear Nucleus 24 Contour Advance CI24R (CA)</td>
<td>P</td>
<td>HL aggravated after ear dressing</td>
</tr>
</tbody>
</table>

COM, chronic otitis media; CI, cochlear implantation; M, male; F, female; OCM, open cavity mastoidectomy; ICWM, intact canal wall mastoidectomy; L, left; R, right; y, years; m, months; S, straight; P, perimodiolar; HL, hearing loss; N/A, not applicable.

*Electrode arrays were extruded from the cochlea and exposed in the external auditory canal in all of the patients. Devices were removed from all patients, and simultaneous revision CI was performed in Patients 4, 5, 6, and 7. The re-implanted device remained well-activated for 9 years, 5 years 2 months, 5 years 1 month, and 1 year 6 months in Patients 4, 5, 6, and 7, respectively.*