Abstract

**Objective:** To assess the safety of 1.5 T magnetic resonance imaging (MRI) in pediatric patients with cochlear implants (CI) and internal magnets. To assess artifacts created by CI magnets.

**Methods:** A retrospective chart review was performed of pediatric CI patients who underwent 1.5T MRI at a university children’s hospital. Binding of the CI magnet was performed before MRI using mold material and/or a compressive gauze dressing. Patients were assessed for ability to complete the MRI, imaging artifact from the CI magnet, magnet position and function following MRI.

**Results:** Seven patients (mean age 9.8 years, range 1-18), and a total of 9 CIs (2 bilateral), underwent 1.5 T MRI scans. There were 5 brain MRI studies, one spine MRI, and one chest MRI. Informed parental consent was obtained. Clinical indications included leukodystrophy (2), hypertonia (1), dystonia (1), hypogonadism (1), and worsening headache (1). Devices from 2 manufacturers were scanned. An axial CT scan was performed before the MRI scan in all 7 patients to assess bone thickness adjacent to the magnet. Three patients had MRI under general anesthesia. The CI produced an artifact with a mean maximal AP dimension of 10.8mm (range 7.5-15) and a transverse of 5.7mm (range 5.5-6). Greatest image distortion occurred with bilateral implants. There was no change in magnet position or CI function after the MRI in all cases.

**Conclusions:** Pediatric patients may safely undergo 1.5 T MRI after CI without removal of the magnet if the device is tightly bound beforehand and strict safety protocols are followed. There are limitations to brain imaging due to artifacts.

Introduction

Cochlear implants (CIs) have now become a standard option for treatment of severe to profound sensorineural hearing loss. Cochlear implant devices consist of an electrode that is placed directly into the cochlea for auditory stimulation, as well as an internal receiver that contains a magnet. Magnetic resonance imaging (MRI) has become a routine imaging modality, providing excellent image quality without ionization radiation. Over the course of their lifetimes, patients with CIs may require MRI as part of a diagnostic workup.

Historically, CIs have been thought to be incompatible with MRI. The magnetic field generated by the MRI can cause magnet displacement and associated discomfort, and the device itself causes imaging artifact. Magnet removal has been required before MRI, which involves a high risk of infection and damage to the device. Recently however, several authors have reported their experiences with binding the CI magnet tightly, finding no adverse events of magnet dislocation or demagnetization. With regards to CI patients, Sonnenburg et al. have reported that 0.3 mm bone thickness below the magnet and absence of an implant well on computed tomography are necessary to safely perform MRI. We report safety and imaging outcomes in a cohort of pediatric CI patients who underwent MRI after binding of the implant.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Device</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Type of MRI</th>
<th>Adverse Events</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Nucleus Freedom, unilateral</td>
<td>18</td>
<td>M</td>
<td>Chest, without contrast</td>
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</tr>
<tr>
<td>2</td>
<td>Nucleus Freedom, unilateral</td>
<td>7</td>
<td>F</td>
<td>Brain, with and without contrast</td>
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</tr>
<tr>
<td>3</td>
<td>Nucleus Freedom, bilateral</td>
<td>1</td>
<td>F</td>
<td>Brain, with and without contrast</td>
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</tr>
<tr>
<td>4</td>
<td>Med-El, unilateral</td>
<td>3</td>
<td>M</td>
<td>Brain, with and without contrast</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>Med-El, bilateral</td>
<td>8</td>
<td>M</td>
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</tr>
</tbody>
</table>

Figure 1. T1 and T2 MRI of the brain with a right-sided cochlear implant after magnet removal.

1A. Sagittal T1 sequence demonstrates artifacts from the CI in the right parietal, temporal, occipital, and cerebellar regions. T1 images were diagnostic in areas not affected by artifacts. 1B. Axial T2 sequence demonstrates mild focal artifacts from the CI in the right cerebellar regions. T2 images were diagnostic in areas not affected by artifacts including the posterior fossa.

Figure 2. T2 MRI of the brain with unilateral and bilateral cochlear implants.

2A. Axial FLAIR sequence of a patient with a right cochlear implant demonstrates artifacts from CI in the right parietal, temporal, and occipital regions. FLAIR images were diagnostic in areas not affected by artifacts. The artifacts were less severe on the axial FLAIR sequences. 2B. Axial T2 sequence of a patient with bilateral cochlear implants. Artifacts were more significant in this patient, limiting diagnostic quality of brain images. However, images were adequate to answer the clinical question of stability of the white matter lesions.

Discussion

In this series, pediatric patients with cochlear implants safely underwent 1.5 T MRI after having the magnet bound with mold material and a compressive dressing. There were no observed events of pain, magnet demagnetization, magnet dislocation, or device malfunction. It appears that pediatric patients with CIs as young as the age of 1 can undergo MRI when strict safety protocols are followed. Imaging without magnet removal is preferable in that it avoids the risks associated with magnet removal, and there is no delay in performing MRI for emergent indications (e.g. spinal cord compression). In addition, despite the artifacts seen from the cochlear implants, MRI was diagnostic in all patients with a single CI. In patients with bilateral CIs, image quality is more limited.

Conclusion

Pediatric patients with cochlear implants may safely undergo 1.5 T MRI without removal of the magnet if the device is tightly bound and strict safety protocols are followed. There are limitations in brain imaging due to artifacts from the CI. However, depending on the region of interest, imaging may still be diagnostic.

References

5. Walton J, Donnelly NP, Tam YC et al. B Walton J, Donnelly NP, Tam YC et al. Department of Otolaryngology—Head and Neck Surgery, UT Southwestern Medical Center, Dallas, TX.