Extent of Middle Ear Aeration in Congenital Aural Atresia
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Abstract
Objectives: To determine the extent of middle ear aeration in patients with aural atresia and to assess how aeration increases with age. To examine the role of middle ear aeration as an adjunct measure in the assessment of aural atresia and the determination of surgical candidacy for aural atresia patients.

Study Design: Retrospective review of children with aural atresia in a tertiary academic pediatric otolaryngology practice. Methods: High resolution multiplanar CT scans of the temporal bones were analyzed for middle ear volume and staged according to existing clinical grading scales. Atretic ears were compared to the nonatretic ears of the same patient as well as to ears of cochlear implant patients, which served as a control population. Results: The average age of patients at the time CT was performed was 4.7 years (range <0.1-13.8 yrs). The average middle ear volume of the atretic ears was 0.34 cubic centimeters compared to an average of 0.51 cubic centimeters for the nonatretic ears. The mean ratio of the atretic to nonatretic volume was 0.67. Higher ratio of aeration was correlated with surgical candidacy. In patients who underwent serial scans, no statistically significant difference in the rates of growth was found between atretic and non-atretic ears. Middle ear volume measurements correlated well with clinical grading scales.

Conclusions: The middle ear volumes expand over the course of child development equally in atretic and non-atretic ears. Middle ear aeration correlates with classification systems designed to assess operative candidacy. The practitioner may be better able to assess surgical candidacy by supplementing classic atresia classification systems with middle ear volume measurements.

Background
Congenital aural atresia (CAA) describes the condition of an embryonically malformed external auditory canal. The widely accepted incidence of aural atresia is one in 10,000 to 20,000 live births. The incidence of unilateral aresia is roughly three times greater than bilateral atresia, and there is a slight male predominance. CAA is often associated with auricular and middle ear deformities and there appears to be a correlation between the degree of external deformity and internal deformity. The etiology is multifactorial with genetic components, exogenous environmental factors, and sporadic developmental insults all thought to contribute to CAA.

A significant conductive hearing loss resulting in an air-bone gap of forty to fifty decibels often accompanies CAA. The goal of surgical intervention for CAA is to correct this conductive hearing loss and bestow serviceable hearing upon the affected ear. Not all patients who possess aural atresia are suitable candidates for atresia repair. High resolution CT (HRCT) scanning has become an essential tool in the preoperative evaluation of patients to determine their candidacy for surgical intervention. The Jahrsdoerfer scale is based on anatomic characteristics that are assessed clinically and via HRCT, and this scale provides a numerical grade of the severity of CAA. Recently, a score of seven or higher on the Jahrsdoerfer scale has been promoted as a threshold to establish suitable candidacy for surgical repair of CAA.

One component of the Jahrsdoerfer scale is middle ear volume. The measurement of this component of the scale is subjective and relies upon the experience of the examiner, although this component has been suggested as an important factor in determining the outcome of aural atresia surgery. Previous studies have used representative cross-sectional area measurements to demonstrate that middle ear volumes in atretic ears are smaller than developmentally normal ears. No formal volumetric study of the middle ear space of atretic ears has been undertaken to date. Furthermore, there has been no study that attempts to establish a suitable threshold for middle ear volume in relation to surgical candidacy. Here we formally measure the middle ear volumes of atretic ears and compare them to those of normal middle ears. Furthermore, we provide preliminary results quantifying the degree of middle ear aeration that leads better outcomes in surgical correction of aural atresia.

Results

Table 1. Comparison of the volumetric and growth characteristics.

<table>
<thead>
<tr>
<th>Volume range (cc)</th>
<th>Normal</th>
<th>Atretic</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume range (cc)</td>
<td>0.23 – 0.82</td>
<td>0.01 – 0.68</td>
<td>0.29 – 0.71</td>
</tr>
<tr>
<td>Mean volume (cc)</td>
<td>0.51</td>
<td>0.34</td>
<td>0.48 (NS)</td>
</tr>
<tr>
<td>Growth rate (cc/yr)</td>
<td>0.028</td>
<td>0.02 (NS)</td>
<td>0.02 (NS)</td>
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</tbody>
</table>

Figure 1. Middle ear volumes as a function of age. Normal (◊) and atretic (●) ear volumes are plotted with respect to age. Regression lines were drawn demonstrating that there is no significant correlation of middle ear volume with age.

Figure 2. Middle ear volumes as a function of Jahrsdoerfer score. Middle ear volumes of atretic ears are plotted with respect to their Jahrsdoerfer score. A regression line is drawn (R²=0.68) to demonstrate that a correlation exists between volume and Jahrsdoerfer score.

Table 2. Comparison of surgical candidates and noncandidates with respect to Jahrsdoerfer score and middle ear volume

<table>
<thead>
<tr>
<th>Surgical candidates (n=17)</th>
<th>Noncandidates (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Jahrsdoerfer Score</td>
<td>8.4</td>
</tr>
<tr>
<td>Mean volume (cc)</td>
<td>0.41</td>
</tr>
<tr>
<td>Mean volume (cc)</td>
<td>4.2 (p&lt;0.001)</td>
</tr>
<tr>
<td>Mean volume (cc)</td>
<td>0.28 (p&lt;0.005)</td>
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</table>

Conclusions
1. Nonatretic ears of patients with aural atresia appear to have the same middle ear volumes as control ears
2. Both atretic and nonatretic ears show a small and similar rate of growth with age
3. Middle ear volume correlates with overall Jahrsdoerfer score in ears with aural atresia
4. A middle ear volume that is greater than the average for atretic ears (>0.35cc) is associated with candidacy for surgical correction of atresia

Future directions
2. Large scale correlation of pre-operative volumetric measurements with audiologic outcomes of atresia repair.

References