MEASURING THE INCUS-STAPES ANGLE

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Abstract

Background: The incus-stapes angle, which is important clinically and scientifically, is recognized to vary from ear to ear. An obtuse incus-stapes angle may make the positioning of a stapes prosthesis impossible.

Objectives: To quantitatively study the incus-stapes angle. Specifically, to elucidate observer agreement, bilateral symmetry, and the potential correlation of incus-stapes angle with the extent of mastoid pneumatization.

Study Design: Post-mortem material analysis.

Methods: Of 41 adult crania without clinical otitis, the five with the largest mastoids, and the five with the smallest mastoids, were assessed by high-resolution computed tomography, both direct and indirect. On the coronal image best depicting the long process of the incus, the angle to the midst of the oval window was measured.

Results: Intra-observer agreement for determining incus-stapes angle was only fair-moderate (Spearman r=.45 for all 20 angles, P=.05). Bilateral symmetry of incus-stapes angles was suggested. Spearman r = .45. However, we found no relationship of I-S angle with mastoid size.

Conclusions: The incus-stapes angle is clinically and scientifically important, but is difficult to measure with computed tomography. Bilateral symmetry of incus-stapes angles was suggested statistically, but no association with mastoid size was found. Better tools are needed for determining angles in the middle ear.

Introduction

The angle defined by the junction of the long process of the incus with the superstructure of the stapes is generally about 90 degrees, which is the optimal angle for the most effective transfer of acoustic energy. (Figure 1) As Skinner et al. point out in their study of 13 ears, few have addressed the incus-stapes angle. An acute angle, Figure 2, in which the long process extends inferiorly over the stapes, affords good access to the incus for attaching a stapes prosthesis, thereby forming the purportedly optimal right-angle relationship. An obtuse angle, anecdotally noted in cases of congenital aural atresia, may make even more challenging the accomplishment of a good hearing result.

- To additionally define the incus-stapes angle
- To address the hypothesis that incus-stapes angles have bilateral symmetry; and
- To address the hypothesis that the incus-stapes angle correlates with minimal temporal bone pneumatization, a correlate of childhood otitis media

Statistical analysis was non-parametric.

Materials & Methods

Institutional Review Board approval was determined, by the IRB, as not applicable to these post-mortem specimens.

From 41 clinically normal adult skulls, the five with the largest mastoids, and the five with the smallest mastoids, were assessed by high resolution computed tomography. Specimens were positioned in a custom cephalostat referencing Frankfurt plane. Two observers (AMR and NWT) independently measured the incus-stapes angle of each ear, using the computer workstation; for each ear, image window adjustment was done for optimal view. Each ear was initially considered by looking at the axial images. With the "mind's eye" idea of the orientation of the incus and stapes as seen on the axial images, the incus-stapes angle was measured on the coronal image best showing the long process of the incus. Mastoid pneumatization was quantitatively assessed by planimetry on Law lateral radiographs.

Discussion and Conclusion

Considering the ranges of variations found in normal human middle ears, the findings of this report are not surprising. The variations are unrelated to the small mastoid indicator of otitis in childhood. The data of this report suggest, though statistically not significant, that bilateral symmetry of incus-stapes angles is consistent with the idea that the angles are not happenstance, but in some way depict our ancestry.

Clinically abnormal ears probably have extremes of incus-stapes angles beyond what was found in these specimens. For example, obtuse incus-stapes has been noted in cases of congenital aural atresia. Several case series have identified family members with characteristic pinna deformities and incudo-stapedial joint failure causing a hereditary conductive hearing loss, suggesting a dominant inheritance pattern.

Determining the incus-stapes angles on computed tomographic images proved difficult, and somewhat arbitrary. We suspect similar difficulty exists intra-operatively: observer agreements would not be impressively good. Of course, the perspective from which the incus-stapes angle is viewed affects the measurement; only a view perpendicular to the plane of the incus-stapes joint angle yields a valid assessment. Better tools are needed for measuring angles in the middle ear.

Tables

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<tr>
<th>Measurement</th>
<th>Repeatability, statistical, r&lt;sub&gt;p&lt;/sub&gt;, probability</th>
<th>Repeatability, practical</th>
<th>Minimum</th>
<th>1st quartile</th>
<th>Median</th>
<th>3rd quartile</th>
<th>Maximum</th>
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<tr>
<td>Mastoid area, right, all crania</td>
<td>98, N=41, P&lt;.01</td>
<td>31/41 ± 2 cm²</td>
<td>2.4 cm²</td>
<td>5.7 cm²</td>
<td>9.6 cm²</td>
<td>12.4 cm²</td>
<td>14.2 cm²</td>
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<tr>
<td>Mastoid area, left, all crania</td>
<td>98, N=41, P&lt;.01</td>
<td>34/41 ± 2 cm²</td>
<td>2.0 cm²</td>
<td>7.5 cm²</td>
<td>10.0 cm²</td>
<td>11.6 cm²</td>
<td>16.0 cm²</td>
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<tr>
<td>Mastoid area, right, studied crania</td>
<td>98, N=10, P&lt;.01</td>
<td>8/10 ± 2 cm²</td>
<td>2.4 cm²</td>
<td>4.6 cm²</td>
<td>9.2 cm²</td>
<td>13.3 cm²</td>
<td>13.8 cm²</td>
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<tr>
<td>Mastoid area, left, studied crania</td>
<td>95, N=10, P&lt;.001</td>
<td>8/10 ± 2 cm²</td>
<td>2.3 cm²</td>
<td>3.9 cm²</td>
<td>9.2 cm²</td>
<td>14.0 cm²</td>
<td>18.0 cm²</td>
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<tr>
<td>Incus-stapes angle, right, studied crania</td>
<td>98, N=10, P=14</td>
<td>6/10 ± 10°</td>
<td>52°</td>
<td>64°</td>
<td>72°</td>
<td>62°</td>
<td>94°</td>
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<tr>
<td>Incus-stapes angle, left, studied crania</td>
<td>98, N=10, P=16</td>
<td>6/10 ± 10°</td>
<td>58°</td>
<td>72°</td>
<td>77°</td>
<td>53°</td>
<td>96°</td>
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Tables

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<tr>
<th>PARAMETERS</th>
<th>Spearman r (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Mastoid Pneumatization</td>
<td>.66 (.05 to .92)</td>
</tr>
<tr>
<td>Incus-stapes angle</td>
<td>.45 (-.24 to .84)</td>
</tr>
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</table>

References


Limitations

Limitations of this study included the lack of specific information about the age, sex, race and otologic history of the specimens. Computed tomography was done only for ten of the 41 crania whose mastoid sizes were at the extremes of large and small. Delimitations, factors set by the researcher that narrow the scope of the study, were that each ear's mastoid radiograph was made once, though measured twice; and, that the coronal images were perpendicular to the Frankfurt plane, not necessarily in the line of the incus' long process and the stapes.