Objective: To describe the straight-into-cochlea line that affords the best access for an electrode array to enter via the round window, as the line relates to the facial nerve, the incus, and mastoid site. The straight-into-cochlea line is important to minimize cochlear trauma and maximize the likelihood of placement into the scala tympani.

Study Design: Postmortem CT scan study of cadaveric crania.

Methods: From a series of 41 crania with clinically ear-normal temporal bones, high resolution CT scans were obtained for those with extremes of large (N=5) and small (N=5) mastoid pneumatization. Using Fiji, a publicly available software program, the straight-into-cochlea insertion line was determined by defining the x-y-z coordinates of the midst of the round window and a point 6.0 mm into the cochlea on its centripetal wall. Then, from the extended straight-into-cochlea insertion line, we determined the shortest perpendicular distance to the midst of the Fallopian canal, and from that “Fallopian point” to the apex of the posterior process of the incus.

Results: Repeatability of assessments was good. The extended straight-into-cochlea insertion lines were routinely close to or in the midst of the Fallopian canal (50% ± 1.0mm), were 4.7 to 7.8 mm from the apex of the posterior process of the incus, but were not related to mastoid pneumatization. For the distance “Fallopian point” to incus, bilateral symmetry was suggested.

Conclusions: Per landmarks registered in x-y-z coordinate system, avoiding bias by adjacent structures, straight-into-cochlea insertion via the round window puts the facial nerve at risk.

Key words: cochlear implant, electrode, round window, facial nerve, mastoid pneumatization

INTRODUCTION

Poster Print Size:
- 200 pixels in -
- 44" wide. It can be used to print any

Electrode placement into the scala tympani yields better auditory outcomes than placement into the scala vestibuli. The round window approach has been found to have a higher rate of insertion into the scala tympani and may also be less traumatic to the basal turn. Atraumatic insertion necessitates that electrode trajectory is in line with the longitudinal axis of the lower basal turn of the scala tympani and that the array does not contact either the modiolar or the basilar membrane. The-to-cochlea insertion vector utilized in this “straight shot” approach ideally is a straight extension of the straight-into-cochlea insertion line. The relationship of this insertion vector to the apex of the posterior process of the incus is unknown as is any potential relationship to mastoid pneumatization.

Goals:
- To describe, using computed tomography, the extended straight-into-cochlea insertion line relative to the facial nerve
- To describe the distance from the “Fallopian point” (where the extended straight-into-cochlea insertion line is nearest the midst of the Fallopian canal), to the apex of the posterior (short) process of the incus
- To address the hypothesis that there is bilateral symmetry of:
  - the distance from the extended straight-into-cochlea insertion line to the “Fallopian point”
  - the distance from the “Fallopian point” to the apex of the posterior process of the incus
- To address the hypothesis that minimal temporal bone pneumatization (which is a correlate of childhood otitis media) is associated with:
  - the distance from the extended straight-into-cochlea insertion line to the “Fallopian point”
  - the distance from the “Fallopian point” to the apex of the posterior process of the incus

METHODS AND MATERIALS

Emory University Institutional Review Board determined that IRB approval was not required.

From a series of 41 clinically normal adult crania, the S with the largest and the S with the smallest areas of mastoid pneumatization underwent computed tomography

○ The x-y-z coordinates of the round window membrane (RWM) and the apex of the posterior process of the incus were determined using the software program Fiji

○ The x-y-z coordinate of a site on the lateral wall of the cochlea 6.0 mm away was determined; this is the site at which the electrode tip inserted through the facial recess approach in a “straight shot” reaches before needing to bend. (Figure 1)

○ The line connecting the RWM and lateral wall landmarks is the optimal “straight-into-cochlea insertion line” (Figure 2)

○ This line was extended and the closest perpendicular distance to the midst of the facial nerve within the Fallopian canal – the “Fallopian point” – was measured

○ The distance from the “Fallopian point” to the apex of the posterior process of the incus (identified with x-y-z coordinates) was determined

RESULTS

- Wide ranges found for the shortest perpendicular distance from the extended straight-into-cochlea insertion line to the Fallopian point (0.17 – 1.87 mm), and from the Fallopian point to the incus apex (4.74 – 7.79 mm) (Table 1)

- Bilateral symmetry found for mastoid sizes ($r = 0.64, 95\% CI .41 to .79$) and suggested for the distance from the Fallopian point to the apex of the posterior process of the incus ($r = .62, .01 to .90$) (Table 2)

- No suggestion of a relationship of mastoid size with either extended straight-into-cochlea insertion line perpendicular to facial nerve ($r = .34$ for right ears, $- .23$ for left ears), or distance from the Fallopian point to the incus ($r = .43$ for right ears, .30 for left ears)

- No significant differences in measurements between the small and large mastoid groups.


discussion

The facial nerve is in the extended straight-into-cochlea insertion line in about half of cases, putting it at risk of injury during this approach.

Injury to the facial nerve can either be due to direct nerve trauma in the facial recess or a result of heat from burs causing vasodilation and edema.

Copious irrigation is important if this approach is utilized in order to prevent overheating of the burs.

The extended straight-into-cochlea insertion line is closer to the short process of the incus than usually depicted.

Though many surgeons preserve an incus buttress, better operative exposure for implant insertion via the round window may be afforded by removing the burs at the fossa incudis.

As there was no association of the studied relationships with mastoid pneumatization, childhood otitis media (with its concomitant lifelong small mastoid) appears not to be associated with our findings.

Since the distance from the Fallopian point to the apex of the incus is suggested to have bilateral symmetry, the “settedness” of the cochlea (per its extended in-cochlear insertion line) relative to the posterior process of the incus may be genetically determined

Table 1: Repeatability and 5-number summary of the distribution of each measurement. Each 5-number summary is the mean of two independent measurements.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Repeatability, r</th>
<th>Repeatability, practical</th>
<th>Min.</th>
<th>1st quart.</th>
<th>Median</th>
<th>3rd quart.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastoid area, all crania</td>
<td>.31, .41</td>
<td>.41</td>
<td>2.4 cm$^2$</td>
<td>5.7 cm$^2$</td>
<td>9.6 cm$^2$</td>
<td>12.4 cm$^2$</td>
<td>14.2 cm$^2$</td>
</tr>
<tr>
<td>Mastoid area, left crania</td>
<td>.32, .41</td>
<td>.41</td>
<td>2.0 cm$^2$</td>
<td>7.5 cm$^2$</td>
<td>10.0 cm$^2$</td>
<td>11.6 cm$^2$</td>
<td>18.0 cm$^2$</td>
</tr>
<tr>
<td>Straight shot line to facial nerve, right</td>
<td>.51, .10, -.06</td>
<td>.01</td>
<td>-0.5 mm</td>
<td>-0.5 mm</td>
<td>-0.5 mm</td>
<td>-0.5 mm</td>
<td>-0.5 mm</td>
</tr>
<tr>
<td>Straight shot line to facial nerve, left</td>
<td>.32, .10, .41</td>
<td>.26</td>
<td>12 mm</td>
<td>41 mm</td>
<td>123 mm</td>
<td>146 mm</td>
<td>174 mm</td>
</tr>
<tr>
<td>Fallopian point to apex of incus, right</td>
<td>.83, -.10, -.43</td>
<td>.06</td>
<td>4.74 mm</td>
<td>5.32 mm</td>
<td>5.64 mm</td>
<td>6.23 mm</td>
<td>7.07 mm</td>
</tr>
<tr>
<td>Fallopian point to apex of incus, left</td>
<td>.38, -.10, -.35</td>
<td>.09</td>
<td>10.3 mm</td>
<td>5.08 mm</td>
<td>5.54 mm</td>
<td>5.94 mm</td>
<td>7.79 mm</td>
</tr>
</tbody>
</table>

CONCLUSIONS

- Straight-into-cochlea insertion via the round window puts the facial nerve at risk, as this insertion approach routinely comes close to the midst of the Fallopian canal
- It may be beneficial routinely to take down the incus buttress in implant approaches via the round window, so as to have more operative exposure through the posterior tympanotomy and minimize risk to the facial nerve

LIMITATIONS

- No information about age, sex, race and otologic history of the specimens was available
- Determining the coordinates of the “midst of the round window” and “lateral wall” landmarks was tedious, as was determining the closest perpendicular distance from the extended straight-into-cochlea insertion line to the Fallopian point
- Clinically abnormal ears likely have extremes of “extended in-cochlear insertion lines” beyond what was found in these specimens

Table 2: Bilateral symmetry of measurements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation coefficient, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastoid pneumatization</td>
<td>$r = .84$, N=41, .41 to .79</td>
</tr>
<tr>
<td>Distance from straight shot line to Fallopian point</td>
<td>$r = -.76$, N=10, .51 to .30</td>
</tr>
<tr>
<td>Distance from Fallopian point to incus</td>
<td>$r = .80$, .01 to .89</td>
</tr>
</tbody>
</table>

REFERENCES