Changes in Cochlear Orientation in Pediatric and Adult Populations

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Introduction

Cochlear Development

- Traditional teachings hold that the cochlea is a vestigial organ that reaches its adult size by 20 – 23 weeks gestation.  
- Early work on dimensional anatomic studies of the human cochlea was limited by small sample sizes and the use of corrosion casts.  
- More recent investigations using high-resolution computed tomography or magnetic resonance images have suggested that post-natal changes in the orientation of the cochlea does occur.  
- Cochlear development is influenced by the surrounding anatomic dimensions of the temporal bone and thus others have suggested post-natal dimensional changes in the cochlea could arise.  
- Lloyd et al demonstrated a significantly more obtuse angulation of the cochlear basal turn in children versus adults.  
- McRackan et al recently showed that facial recess was significantly more parallel to the basal turn in children versus adults, though the absolute difference in angles was < 4 degrees.  
- However, other investigators have not found significant post-natal development of cochlea using histologic series of pediatric temporal bones.  

Implications of Variable Cochlear Anatomy for Cochlear Implantation

- Verbit et al used a computer simulation to report on a non-continuous spiraling trajectory of the scala tympani which led to predictable basilar membrane pressure points during implantation.  
- Very recently, Singla et al described abnormal narrowing in 7.5% of the basal turns analyzed and a large span of outer diameter basal turn length, both of which could be related to electrode insertion-induced intracochlear trauma.  

Study Rationale

- Anecdotally, the orientation of the round window relative to other structures of the cochlea and temporal bone, is different in pediatric versus adult implant recipients.  
- Post-natal changes in positioning of the cochlea within the temporal bone might change with increasing age.  
- Differences in orientation and dimensions of the cochleovestibular apparatus in adults versus children are important to characterize in order to apply an electrode insertion technique that will produce the least trauma.  

Hypothesis

- We hypothesized that the cochlear orientation within the temporal bone would be different in children versus adults and in subjects with hearing loss versus normal hearing.

Materials & Methods

Subjects

- 82 adult patients with and without SNHL  
- 60 pediatric patients with and without SNHL

Human Subject Inclusion Criteria

- All pediatric and adult subjects with audiometric data (pure tone average (PTA) calculated for each ear with average of 500, 1000, 2000, and 4000 Hz).  
- High resolution axial and coronal CT temporal bone imaging with no evidence of chronic middle ear disease

PTA of SNHL (n=95 ears)

- Average Age: 66 mos. (range, 4-199)  
- PTA: 63 dBL HL (range, 20-120)

PTA of Control (n=31 ears)

- Average Age: 82 mos. (range, 10-216)  
- 3 Unilateral (1 dysplastic, 1 t-bone fx, 1 schwannoma)  
- 8 Unilateral Atresia

Adult SNHL (n=110 ears)

- Average Age: 63 years (19-90)  
- PTA: 75.5 dBL HL (range, 25-115)

Adult Control (n=57 ears)

- Average Age: 42 years (range, 36-45)  
- 5 Unilateral (3 Tbone fx, 1 SNHL, 1 Cholesteatoma)

Image Acquisition and Analysis

- Standard temporal bone imaging protocol: resolution of 0.6 mm by 0.6 mm collimator, adult and pediatric subjects scanned at 120 kV and 200 – 240 mAs with care dose.  
- Images processed with high resolution digital software (TeraRecon, Foster City, CA) to enable angular measurements  
- 6 separate angle measurements per ear chosen to represent important orientations encountered during cochlear implantation (Fig. 1).  
- Neuroradiologist blinded to clinical information calculated all angles for each CT image

Data Analysis

- One-way ANOVA for between group comparisons  
- Pearson’s r-correlations for comparison between age or degree of hearing loss and angular measurement  
- 4 Groups: Adult >18 yrs +/- SNHL and peds <18 yrs +/- SNHL  
- Hearing level (PTA) vs. Angular measurement  
- Age at date of imaging vs. Measurement  
- Adult SNHL vs. Adult control measurements  
- Peds SNHL vs. Peds control measurements

Results

- Age: No correlation in all adults and children for any of the 6 angular measurements
- Hearing (PTA): No correlation between hearing level in adults and children and all measurements
- Adults with SNHL vs. Normal Hearing Adults had a significantly different angle of the Axial Round Window vs. Basal Turn Measurement (p=0.0003).
- Adults with SNHL vs. Normal Hearing Adults had an angle of the Axial Round Window vs. Basal Turn compared to All Children (p=0.001).
- All Adults had a significantly different angle of the Axial Round Window vs. Basal Turn compared to All Children with SNHL (p=0.001).
- All Adult Controls had a significantly different angle of the Axial Round Window vs. Basal Turn compared to All Pediatric Controls (p=0.02).

Discussion & Conclusions

The main results and conclusions of this dataset are:

- All Children and adults with SNHL demonstrate variable anatomy in regards to cochlear orientation compared to their normal hearing counterparts that is consistent with anecdotal evidence of different electrode insertion angles between the two groups.  
- All adults have a different orientation of the round window relative to the basal turn comparison to children, which might necessitate different electrode insertion trajectories and approaches during cochlear implantation.  
- All adults with hearing loss have varied round window orientation compared to children with hearing loss.  
- Although there was no direct correlation between age and cochlear orientation, differences in measurements between these age groups (e.g., children versus adults) suggest that cochlear orientation may change with age.  
- Future studies using three-dimensional reconstructed CT images will enable more precise measurements of relevant cochlear orientation and allow validation of the two-dimensional measurements techniques used in many previous studies.

References