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An Anatomical Study of the Cochlea among Filipinos using High-Resolution Computed Tomography Scans

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ABSTRACT

Objective: To describe the cochlear anatomy among Filipinos through high resolution computed tomography (HRCT) imaging.

Methods:

Design: Retrospective Study

Setting: Tertiary Private University Hospital

Patients: Cochlear images retrospectively obtained from computed tomography (CT) scans of subjects who underwent cranial, facial, paranasal sinus and temporal bone computed tomography from October 2009 to July 2010 were reconstructed and analyzed.

Results: 388 cochlear images were obtained from the scans of 194 subjects (101 males and 93 females, aged 1 to 90 years old, mean = 52 years) and reconstructed for analysis. The mean coiled cochlear height measured 4.36 mm on the right (A.D.) and 4.34 mm on the left (A.S.). Measurement from the oval window to the distal end of the basal turn (equivalent to the horizontal dimension of the cochlea or the mean length of the basal turn) was 7.55 mm A.D. and 7.60 mm A.S. The vertical and horizontal dimensions of right and left cochleas were identical in all subjects (S.D. = 0.35). The right and left cochlear turns were identical in each subject, exhibiting 2 ½ turns in 92.3% of subjects and 2 ¾ turns in 7.7% of subjects.The cochlear dimensions were similar in all subjects, regardless of age. No cochlear ossification or malformation was noted on any CT image.

Conclusion: The 7.55 mm mean length of the cochlear basal turn among Filipinos in this study was 1.24 mm shorter than the average length of the basal turn of 8.81 mm reported elsewhere. Further studies of the cochlear dimensions in specific age groups and its correlation to audiometric status are recommended to determine other significant physiologic correlations.

Keywords: *cochlea, cochlear turn, high-resolution computed tomography (HRCT), magnetic resonance imaging (MRI)*

The cochlea and its anatomic details are difficult to study due to its minute size and remote location. It is surrounded almost entirely by dense bone of the otic capsule and has 2 ½ to 2 ¾ coils. Before the advent of high resolution CT imaging, anatomical studies of the human cochlea

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were mostly cadaveric, making comprehension of human cochlear details and correlating histological findings with cochlear functional status more difficult.[1] Today, computed tomography and magnetic resonance imaging can provide quality cochlear and temporal bone images indispensible in the practice of otology, but no local studies have been reported. Because further information and knowledge of cochlear dimensions among Filipinos is important especially in cochlear implantation, we aimed to describe the cochlear anatomy among Filipinos through high resolution computed tomography (CT) scan.

METHODS

Computed tomography (CT) scans of 194 subjects who underwent cranial, facial, temporal bone, paranasal sinus and orbital examinations for different indications between October 2009 to June 2010 at the University of the East - Ramon Magsaysay Memorial Medical Center were retrospectively obtained for temporal bone image isolation, in compliance with the hospital ethics committee. All scans used the same 64 detector-row Aquilon 64 (Toshiba Medical Systems Corp., Tokyo, Japan) employing 120 kV, 350 mA, 512 x 512 matrix dimension, 0.5 mm section thickness, 0.85 pitch and 70 mm field of view parameters. One hundred ninety four (194) temporal bone images with these parameters were obtained from 137 cranial, 24 temporal bone, 22 paranasal, 8 orbital, 2 facial and 1 mandibular scan(s) and were transferred to the Vitrea® 2: version 4.1.20 (Vital images, Inc., Minnesota, USA) workstation for further image isolation. Multi-planar reconstruction (MPR) and 3D reconstruction of the cochlea were done with a 4000 window width and 700 window levels. Multi-planar reconstruction with double oblique coronal and single oblique settings were employed along the short and long axis of the cochlea as standard cochlear imaging.[2] *(Figure 1)* Reconstructed cochlear images were trimmed and sculpted manually with the Vitrea® 2 workstation for optimal 3D visualization.

The horizontal and vertical dimensions of each reconstructed coiled cochlea were measured with the Vitrea® 2 workstation internal scale along its orthogonal views *(Figure 2.A)*. The widest horizontal dimension of the coiled cochlea was measured on axial view from the highest point of the helicotrema to the inferior margin of the basal turn while the widest vertical dimension was measured on axial view from the oval window to the widest margin of the basal turn which is equivalent to the length of the cochlear basal turn *(Figure 2.B)*. Conversely, the cochlear turn was measured on the axial-oblique view of the reconstructed cochlear image from the helecotrema to the round window *(Figure 3)*. A line created through the reference point acted as the center of the modiolus and a complete cochlear turn was defined as the reference line run parallel to the basal and apical segments of the cochlea.[3] Data gathered were tabulated for comparison of the vertical dimension, horizontal dimension and turns of the left and right cochlea. Presence or absence of cochlear deformities, ossification and other anomalies were also noted.

RESULTS

A total of 388 cochlear images were obtained from the CT scan images of 194 subjects (101 males and 93 females, aged 1 to 90 years, mean age = 52 years) and reconstructed for analysis. The vertical dimension of the cochlea equivalent to the coiled cochlear height ranged from 3.30 mm to 5.10 mm on the right (mean = 4.37 mm) and 3.40 mm to 5.20 mm on the left (mean = 4.34 mm) with a difference of 0.02 mm (S.D. = 0.38, AD and 0.36, AS). The coiled cochlear widest dimension which is equivalent to the length of the basal turn ranged from 7.00 mm to 8.00 mm on the right (mean = 7.55 mm) and 6.00 mm to 8.00 mm on the left (mean = 7.60 mm) with a difference of 0.05 mm (S.D. = 0.33, AD and 0.36, AS). The number of turns of the right and left cochlea in each of the subjects was identical, exhibiting 2 ½ turns in 92.3% of the subjects (n = 179) and 2 ¾ turns in 7.7% of the subjects (n = 15). The cochlear dimensions were similar in all subjects, regardless of age. No cochlear ossification or malformation was noted in any image.

DISCUSSION

Inner ear surgery has become more frequent and continues to advance over the past decade requiring otolaryngologists particularly neuro-otologists to have more detailed knowledge of cochlear anatomy. Detailed comprehension of the anatomy of the human cochlea has lagged behind that of other sensory systems because of technical difficulties in examining inner ear structures. Previous cadaveric model studies were time consuming, expensive and did not permit physiological correlation.

The mean length of the cochlea is about 33.01 mm (S.D. 2.31 mm)[4] and is normally known to demonstrate 2 ½ to 2 ¾ turns to allow its full dimensions to be accommodated in the temporal bone. A study comparing eight adult cochleas with eighteen formalin-fixed fetal specimens at the Carnegie Embryological Collection of normal fetuses using plain radiography, computed tomography (CT) and magnetic resonance (MR) imaging showed that the mean length of the cochlear basal turn is 7.86 mm and 8.81 mm in the fetal and adult subjects respectively which is 0.29 mm to 1.24 mm longer than the cochlear basal turn length noted in this study.[5]

In the present local clinical setting, CT and MRI are the imaging modalities used for assessing the cochlea, with MRI as the imaging method of choice for assessing the spiral canal, especially in cochlear implant candidates.[6] However, recent improvements in CT imaging

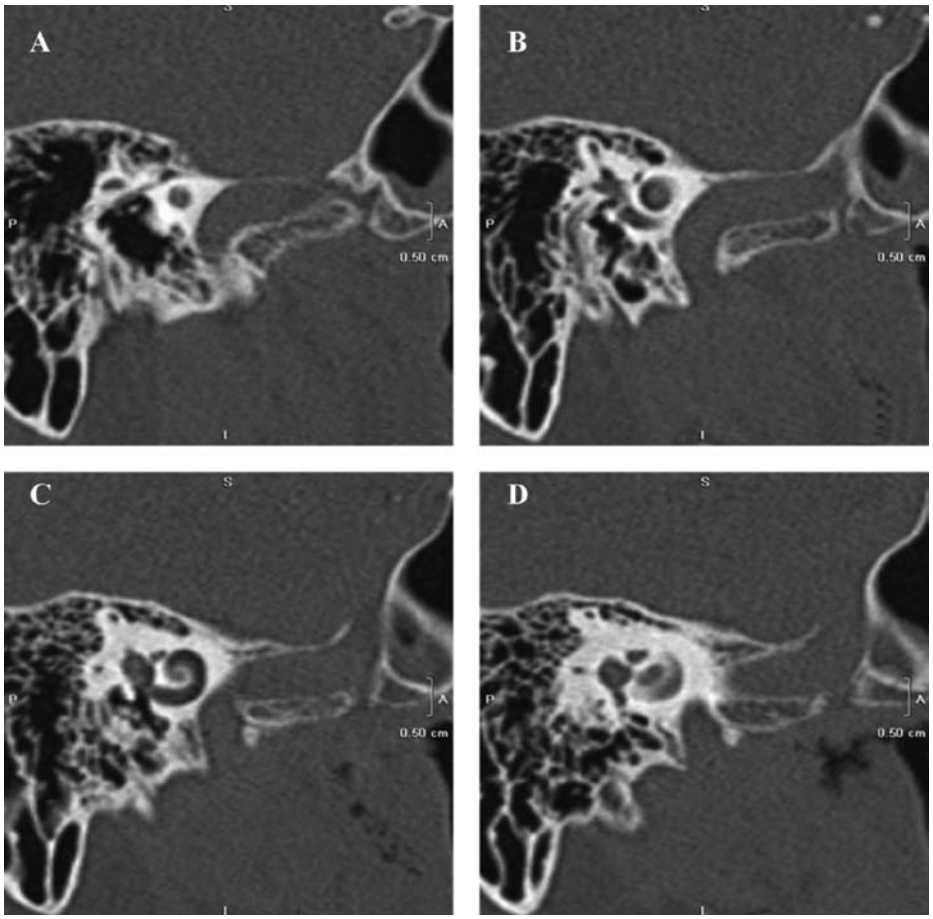

Figure 1. Double oblique coronal view of the R temporal bone showing the cochlear dimensions. *A. apical turn; B. middle turn C. basal turn. D. cochlear base*

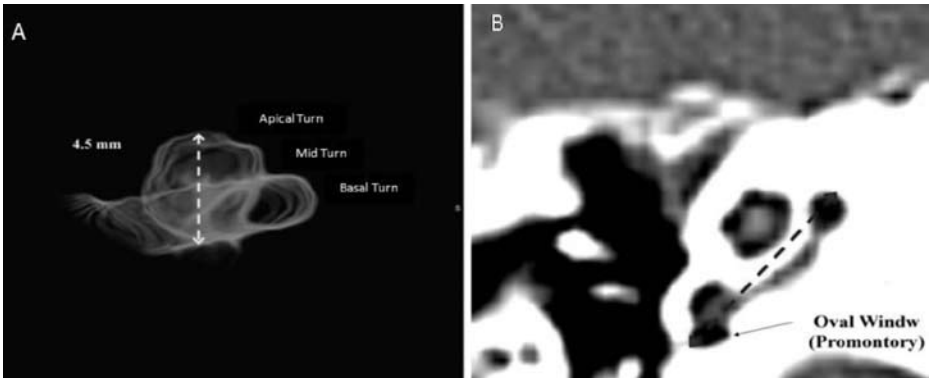

Figure 2. Measurement of the coiled cochlear dimensions. *A. Orthogonal view of the 3D reconstructed cochlea showing the measurement of the coiled cochlear vertical dimension from the helicotrema to the lowest margin of the basal turn. B. Coronal view of the cochlea showing the measurement of the coiled cochlear horizontal dimension from the promontory to the most lateral portion of the basal turn.*

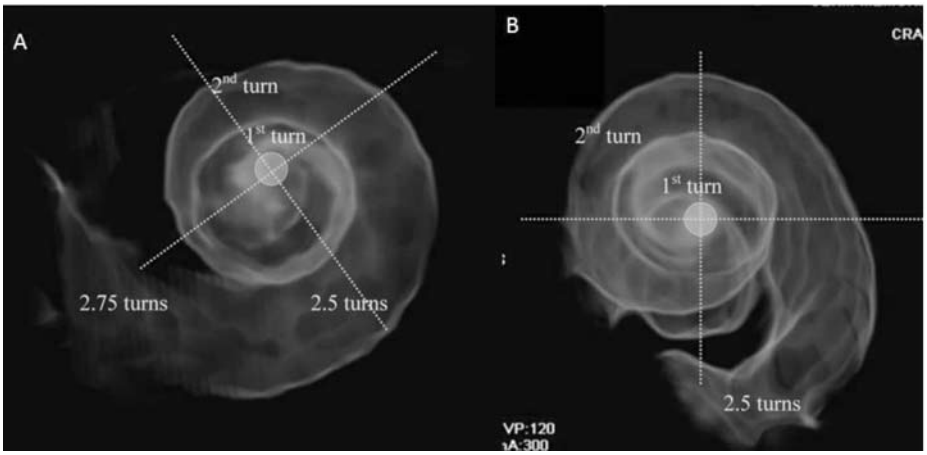

Figure 3. Measurement of the cochlear turns through the 3D reconstructed cochlea. *Cochlea with A. 2 ¾ turns and B. 2 ½ turns.*

technology may now facilitate visualization of the inner ear at resolutions sufficient to assess the basic structural anatomy of the coiled cochlea at lower costs than MRI providing opportunities to validate existing knowledge on human cochlear dimensions, turns, details, variations and anomalies. Recent anatomical studies of the human cochlea with CT scans have also increased recognition of inner ear malformations in subjects with normal hearing and in those with hearing impairment.[7]

The use of high-resolution CT in studying the cochlear anatomy is a feasible and relatively inexpensive means that may be correlated with other functional or audiometric studies and experiments, an aspect that is difficult to match with cadaveric cochlear studies. The measurements of coronal cochlear height and other bony inner ear structures particularly the lateral semicircular canal have excellent reproducibility and sensitivity in detecting inner ear malformations.[8,9] High-resolution CT also avoids image artifices with an acquisition of submillimetrical slices with optimum resolution[10] and may be valuable in the advancement of cochlear implantation and engineering future implants.[11]

It is recommended that in future studies, the age and audiometric status be stratified and classified for better correlation with the minute inner ear structures and to minimize systemic biases.[12] Further studies with better comparison of the cochlear dimensions in specific age groups and its correlation to audiometric status are recommended to determine other significant physiologic correlations.

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