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Computed Tomography Analysis of the Anterior Epitympanic Recess and Sinus Tympani Depths Among Filipino Adults at the De La Salle University Medical Center

ABSTRACT

Objective: To assess the depths of the anterior epitympanic recess (AER) and the sinus tympani (ST) among Filipino adults and to classify the AER and ST according to grade and type, respectively.

Methods:

Design: Retrospective Review of CT Scans

Setting: Tertiary Private Teaching Hospital

Participants: Scans of 182 non-pathologic ears from patients aged 18 and above with non-pathologic temporal bones (paranasal sinus, screening sinus, temporal bone, facial and cranial) with 0.62mm cuts seen from CT scans from January 01, 2010 to September 31, 2022 were analyzed. The depths of the AER and ST were measured separately and classified according to AER grade and ST type.

Results: The mean depth of the AER (AER-D) was 3.64 mm (SD 1.17). No significant difference was seen between right and left ears. The AER grading of the anterior-posterior depth was found to be Grade 1 (<3mm) in 54 ears (29.7%), Grade 2 (3-5mm) in 106 ears (58.2%), and Grade 3 (>5mm) in 22 ears (12.1%). The mean depth of the sinus tympani (ST-D) was 3.30 mm (SD 0.80). Out of the 182 ears, 121 (66.5%) had Type A, 50 (27.5%) had Type B while 11 (6%) had Type C.

Conclusion: Majority of the AER depths measured 3-5mm while most of the sinus tympani were Type A. These hidden recesses should be separately analyzed in preoperative planning for cholesteatoma surgery in order to prepare the adequate equipment to be used and approach towards these areas thereby reducing the risk for residual cholesteatomas and recurrence.

Keywords: sinus tympani; anterior epitympanic recess; tomography, spiral computed; temporal bone

Hidden recesses of the middle ear such as the sinus tympani and the anterior epitympanic recess are among the areas that should not be missed by an ear surgeon.¹⁻³ If these areas are not inspected carefully preoperatively and intraoperatively, residual cholesteatoma may be left behind. Residual cholesteatoma is related to insufficient local resection of pathological epidermis.² The only treatment of cholesteatomas remains surgical removal.⁴ Inadequate removal of cholesteatoma can lead to several morbid complications due to its ability to destroy bone and to permit the spread of infection to adjacent structures such as the semicircular canals, sigmoid sinus and the brain.

A clear three-dimensional understanding of these structures using radiographic studies is necessary to remove disease safely from these areas and minimize the risk of facial nerve injury. There are two hidden recesses for cholesteatoma to extend to, the anterior epitympanic recess and the sinus tympani.^{1,5} The anterior epitympanic recess (AER) is a small space located anterior to the malleus head and is separated from the epitympanum by the cog.^{1,6} The sinus tympani (ST) is a recess located medial to the pyramidal eminence and the facial nerve, and is lateral to the posterior semicircular canal.^{1,3,7,8}

There is scarce literature regarding radiographic studies done on Filipinos' hidden recesses of the temporal bone. A literature search was conducted in HERDIN Plus for full-text studies published between January 01, 1980 to January 30, 2021 using "sinus tympani" and "anterior epitympanic recess" as search terms yielded no results. Among the studies^{1,3,6-9} that measured these areas, race was not mentioned.

The objective of this study is to measure the average depth of the AER and ST among adult Filipinos with non-pathologic temporal bones, as well as to classify the AER according to grade and ST according to type and determine which among the AER grades and ST types were most frequent and if there was a relationship between AER grade and ST type.

METHODS

After obtaining approval from the De La Salle Medical and Health Sciences Institute Independent Ethics Committee (2022-27-01-A) a retrospective review of computed tomography scans of patients showing temporal bones obtained at the De La Salle Medical and Health Sciences Institute from January 01, 2010 to September 31, 2022 was performed. Computed Tomography scans of all patients aged 18 and above with non-pathologic temporal bones seen from CT scans (paranasal sinus, screening sinus, temporal bone, facial and cranial) with 0.62mm cuts were considered for inclusion. Scans of patients with previous surgery or trauma to the skull base, congenital inner ear and craniofacial anomalies, middle ear pathologies, and paranasal sinus tumors were excluded.

The computed sample size with a 95% level of confidence was 46 patients (92 ears) using the standard deviation from the study by El-Anwar *et al.*¹ that measured the sinus tympani and the anterior epitympanic recess.

All measured CT scans used the same 64-row detector Revolution™ EVO CT Scanner (GE Healthcare Japan Corporation, Hino-Shi, Tokyo, Japan) employing 0.625mm section thickness, 120kV tube voltage, 1s Helical revolution time, 512 x 512 matrix resolution, 0.531:1 pitch factor, and 20mm field of view parameter.

Complying with the provisions of DLSUMC's ethics committee, the Digital Imaging and Communications in Medicine (DICOM) files with redacted names and patient IDs were extracted and read using RadiAnt DICOM Viewer version 2002.1.1 (Medixant, Poznan, Poland) with a 4000 window width and 1000 window level. Asymmetry in patient's positioning was corrected by using multiplanar reconstructions of the coronal, axial, and sagittal views of the temporal bone. This was achieved by modifying the method done by El-Anwar *et al.*¹ The horizontal semicircular canals were aligned in the axial plane, followed by aligning the patient in the Frankfort horizontal plane, which is a plane connecting the uppermost portion of the external auditory canal to the inferior most portion of the infraorbital rim. The sagittal plane was perpendicular to the axial plane and was aligned by a line connecting the top of the crista galli and the midpoint between the right and left foramen spinosum. The coronal plane was defined as a line connecting the right and left foramen spinosum that is perpendicular to both the sagittal and axial plane. Measurements were done in millimeters by the researcher using RadiAnt's measuring tool. All measurements were verified by a radiology resident by reviewing the measurements done by the researcher before being recorded.

Anterior epitympanic recess depth (AER-D) was evaluated by measuring anteroposterior diameter which is represented by a line parallel to the axis of incudomalleolar articulation from the most anterior point of the AER to the line passing through the cog in axial plane. (Figure 1) After measuring the depth patients were classified based on AER grading by El-Anwar *et al.*¹ (Figure 2):

- Grade 1 AER - depth less than 3 mm
- Grade 2 AER - depth ranged between 3 and 5 mm
- Grade 3 AER - depth more than 5 mm

Measurement of ST depth (ST-D) is represented by the anteroposterior diameter of ST, from a tangential line passing through the anterior aspect of the facial nerve canal and the promontory to the deepest point of ST. (Figure 3) After measuring the ST depth, patients were classified based on ST types by Marchioni *et al.*¹⁰ (Figure 4):

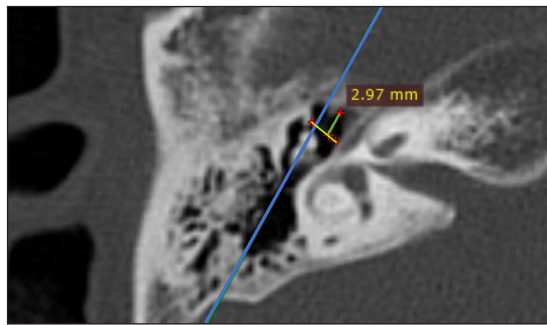


Figure 1. Measurement of the Anterior Epitympanic Recess (AER) Depth. Axial cut showing the AER depth (green line) measured as the line parallel to the axis of the incudomalleolar articulation (blue line) from most anterior point to the line passing through the cog (yellow line).

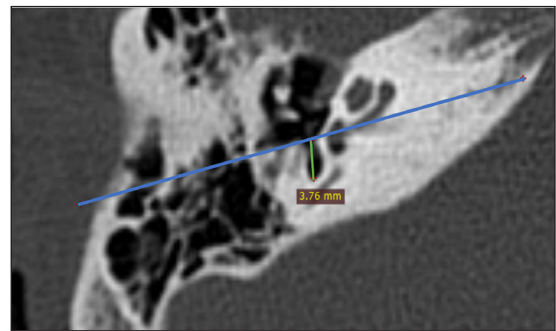


Figure 3. Measurement of the Sinus Tympani (ST) Depth. Axial cut showing the ST depth (green line), anteroposterior diameter of ST, from a tangential line passing through the anterior aspect of the facial nerve canal and the promontory (blue line) to the deepest point of ST).

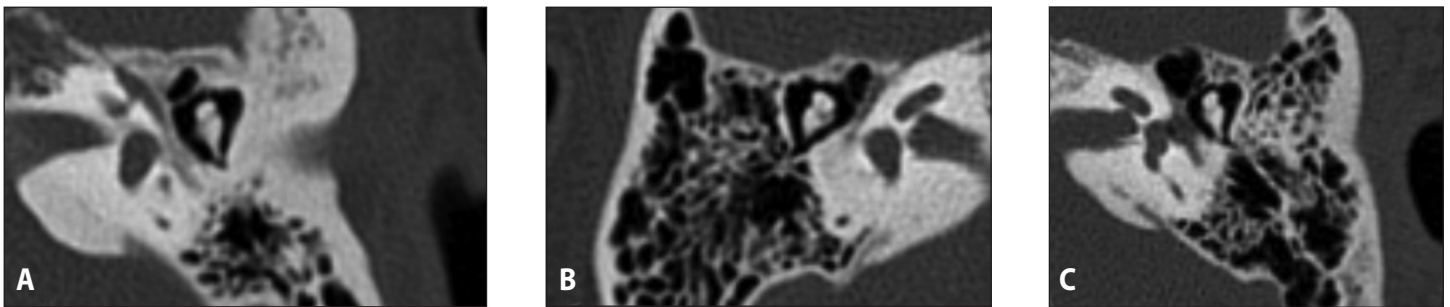


Figure 2. Temporal bone CT scan images with axial cuts showing different AER depths. **A.** Grade 1; **B.** Grade 2; and **C.** Grade 3

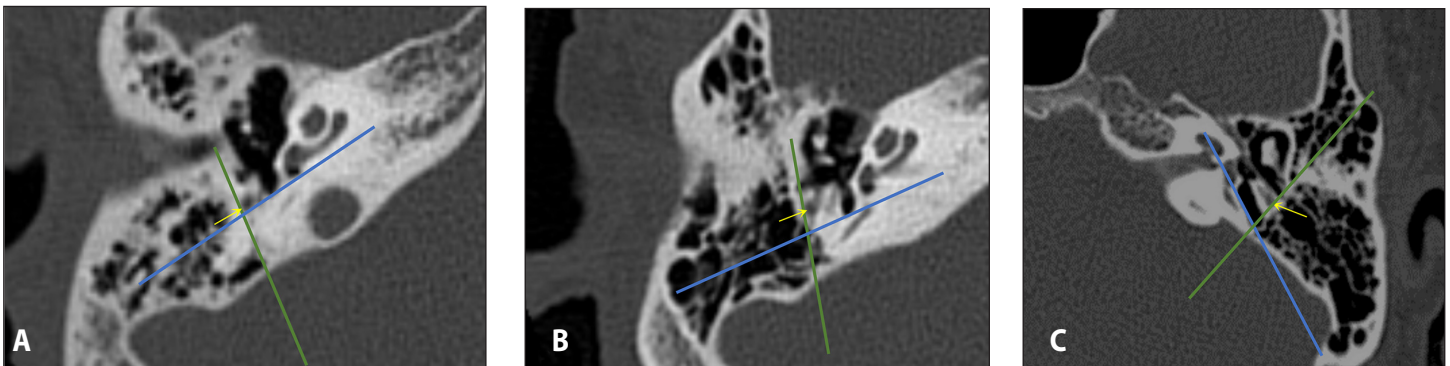


Figure 4. Temporal Bone CT scans showing the different Sinus Tympani (ST) types. The different types are compared by showing the relation of the facial nerve (yellow arrow) to the floor of the ST (blue line) and the outer wall of the facial nerve canal (green line) **A.** Type A ST; **B.** Type B ST; and **C.** Type C.

- Type A - small or limited, sinus tympani is bounded by the anterior vertical segment of the pyramidal eminence posteriorly and medially
- Type B – deep, the medial portion of the pyramidal eminence is the medial limit
- Type C – deep with posterior extension, the pyramidal eminence is the posterior and medial boundary of the sinus tympani

Measurements and demographic data of patients were recorded in Microsoft Excel Version 2212 Build 16.0.15928.20278 (Microsoft Corporation, Redmond, WA, USA). Descriptive statistics were presented as means and standard deviation, and two-sample t-test with assumed equal variances were computed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). The relationship between AER and ST were also compared using Pearson Chi-Square. All tests were performed with a 95% confidence interval and a level of significance of 0.05.

RESULTS

Scans of 182 ears of 91 individuals (55 females and 36 males) were included in this study. Ages ranged from 18 to 90 years with a mean age of 40 (SD 16.05) years.

The mean depth of the AER (AER-D) was 3.64 mm (SD 1.17) with a range of 1.38 – 11.60mm. The mean AER-D in males, 3.93 mm (SD 1.27), was significantly deeper compared to females 3.44 mm (SD 1.07), where in $p < .006$. The mean AER-D of the right ear was 3.71 mm (SD 1.24) and on the left ear it was 3.56 mm (SD 1.11). No significant difference was seen between right and left ears. The AER grading of the anterior-posterior depth was found to be Grade 1 (<3mm) in 54 ears (29.7%), Grade 2 (3-5mm) in 106 ears (58.2%), and Grade 3 (>5mm) in 22 ears (12.1%).

The mean depth of the sinus tympani (ST-D) was 3.30 mm (SD 0.80) with a range of 1.56 – 7.30 mm. The mean ST-D for females, 3.30 mm (SD 0.83) was only slightly deeper than for males, 3.29 mm (SD 0.75), but no significant difference was observed. The same was observed for the left ear with mean of 3.51 mm (SD 0.89) compared to 3.44 mm (SD 1.15) for the right ear. The mean depth for the right and left ear had no significant difference. Out of the 182 ears, the different types of sinus tympani classified according to Marchioni et al.⁷ (Table 2) revealed 121 (66.5%) had Type A, 50 (27.5%) had Type B while 11 (6%) had Type C.

No significant relationship was detected between AER-D grading and ST-D type in our study ($p = .143$; $X^2 = 6.872$).

DISCUSSION

This study measured the depths of the AER and ST in Filipino adults with non-pathologic temporal bones. The mean depth of the AER was 3.64 mm while the mean depth of the sinus tympani was 3.30 mm. Majority of the AER measured 3-5mm, while majority of the ST were Type A.

Several studies that measured the anterior epitympanic recess gave different average depths. Petrus and Lo⁶ observed the average AER-D 3.30 mm among participants aged 6 months to 80 years. Marchioni et al.³ separately measured the AER-D for healthy ears, 5.10 mm and pathologic ears, 3.10 mm among individuals with a mean age 35.7 years. El-Anwar et al.¹ measured mean AER-D as 4.17 mm among participants with a mean age of 38. Hong et al.¹¹ did not mention the average age for their study but provided an range of 3.11 – 4.04 mm among different age groups. These studies only factored in the age of the patients without any mention of their race.

Having no previous studies regarding the depth of the AER and the ST of Filipinos, this would serve as a baseline measurement for ear surgeons. Majority (n= 128, 70.0%) of the ears measured would have a deeper AER, with ≥ 3 mm AER-D. This is important to note because if preoperative CT scans are not carefully analyzed, a deeper AER could be overlooked and any cholesteatoma from these areas can be missed as well.

The anatomy of the anterior epitympanic recess may vary in terms of its size and shape. In a retrospective review of CT scans of temporal bones,⁶ it was found out that the anterior epitympanic recess may either be single celled or multicelled. Marchioni et al.³ found that the anterior epitympanic recess was observed to be smaller in pathologic ears than in non-pathologic ones. They postulated that a smaller AER may have limited middle ear pressure buffering effect which may preclude formation of retraction pockets, leading to cholesteatoma formation. A deeper AER may mean that there is a lesser chance of cholesteatoma formation due to the middle ear pressure buffering effect. The measured AER depths from male patients in this study was observed to be significantly ($p < .006$) deeper than those of female patients. But El-Anwar et al.¹ found no significant difference between the ears of males and females. Based on this information, female Filipinos may have a higher chance of cholesteatoma formation than males due to their smaller AER.

Studies that measured sinus tympani depth had a shallower ST-D than our study. Bekci et al.⁸ separately measured the mean ST-D among those with pneumatized petrous apices, 2.17mm (mean age 37) and those in temporal bones without pneumatized petrous apices, 1.69 mm (mean age 38). Baklaci et al.⁹ on the other hand measured the mean ST-D in pneumatized mastoids, 1.59mm (mean age 34.52); in diploic

Table 1. Analysis of AER and ST depth measurements in millimeters

	Total	Male	Female	Right ear	Left ear	
Subjects	91	36	55	91	91	
Ears	182	71	110	91	91	
AER -L	Mean±SD	3.64±1.17	3.93±1.27	3.44±1.07	3.71±1.24	3.56±1.11
	Range	0.84-7.54	1.79-7.54	0.84-6.30	3.57-8.96	0.84-6.32
	P-value (t-test)		0.006		0.409	
ST - L	Mean±SD	3.30±0.80	3.29±0.75	3.30±0.83	3.44±1.15	3.51±0.89
	Range	1.56-7.30	1.74-4.96	1.56-7.30	1.38-11.60	1.97-7.25
	P-value (t-test)		0.980		0.543	

AER-L Anterior epitympanic recess depth, ST-L Sinus tympani depth, SD Standard deviation

Table 2. Chi-square Analysis of AER grading in relation to Sinus tympani types

AER-D		ST-D			TOTAL
		A	B	C	
AER-D	1	36	17	1	54
	2	67	29	10	106
	3	18	4	0	22
Total		121	50	11	182
p = .143 X ² = 6.872					



mastoids, 1.10mm (mean age 36.31), and in sclerotic mastoids, 0.53mm (mean age 39.42). Lastly, El-Anwar *et al.*¹ measured 2.52 mm as the average ST-D among individuals with a mean age of 38.

Although our sample size might not be reflective of the Filipino population's normative values in the measurement of the ST-D, it is worth noting that the Filipinos' sinus tympani although limited or Type A, might be deeper. Among the 110 ears with cholesteatoma analyzed by Volgger *et al.*,⁴ 45.5% had cholesteatoma in the sinus tympani. In addition, they also observed that there was a fourfold increased risk of residual cholesteatoma if the disease was located in the sinus tympani over those that were confined to the attic and mesotympanum.

Das *et al.*¹² reported that 86.96 % of patients had residual cholesteatoma in the sinus tympani while 43.48% was seen in the anterior epitympanic recess. They also mentioned that the most likely places for intractable disease include both the sinus tympani and the anterior epitympanic recess. The occurrence of petrous apex pneumatization⁷ and those with pneumatized mastoids⁸ can mean a larger or deeper sinus tympani leading to greater risk of residual cholesteatoma. Because our present study did not find any significant relationship between AER-D and ST-D, these areas should be analyzed separately in each patient undergoing cholesteatoma surgery since a deeper AER-D does not directly translate to a deeper ST-D.

With these findings in mind, it might be more advisable to use an endoscopic approach with or without an angled scope to check for deeper anterior epitympanic recess and sinus tympani rather than traditional microscopic ear surgery. It has been consistently mentioned in a systematic review regarding endoscopic techniques used in management of cholesteatoma¹³ that it is more advantageous to use endoscopes in identifying the hidden areas. Better yet, endoscopes should be used as an adjunct to microscopic ear surgery.

This study has been limited to measuring non-pathologic temporal bones of adult patients. A larger sample size and measurements from different institutions may be more reflective of the Filipino population. It is highly recommended that future studies be done comprising of CT scans from multiple institutions including those of pathologic ears and those of the pediatric population. This study also only focused on the depth of the most common areas of residual cholesteatoma, it is highly recommended to do a three-dimensional measurement, if not, include the width and the height of these hidden areas as well. Additional variables to consider would be petrous apex pneumatization and the degree of pneumatization of the mastoid.

In conclusion, our study found that among the scans of adult Filipinos analyzed, majority of the AER depths measured 3-5mm while most of the sinus tympani were Type A. These hidden recesses should be separately analyzed in preoperative planning for cholesteatoma

surgery in order to prepare the adequate equipment to be used and approach towards these areas thereby reducing the risk for residual cholesteatomas and recurrence.

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