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External auditory canal: Inferior, posterior-inferior, and anterior canal wall overhangs

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ABSTRACT

Objectives: To characterize anatomic variants of the external ear canal (EAC), specifically canal wall overhangs. EAC overhangs are problematic since they obstruct the view of the tympanic membrane (TM) and middle ear, possibly creating diagnostic and surgical difficulties.

Methods: We reviewed pre-operative temporal bone CTs from children with cholesteatoma, and no history of EAC erosion or surgery. We measured the anterior canal wall overhang (ACOH), inferior (ICOH), and posterior-inferior (PICOH). A smaller angle means more EAC overhang. Angles > 180° counted as 180° since they are non-obstructing. Analysis was performed between angular measurements and clinical and demographic data.

Results: 86 patients (88 ears total) were studied. Mean age was 8.3 years. Only obstructing angles were analyzed statistically (< 180°). The ICOH was most severe and occurred in 72/88 (81.8%) ears with a mean of 145.9 ± 12.8SD° (range 102–171°). ACOH occurred in 60/88 (68.2%) ears with a mean of 148.3 ± 10.9SD° (range 120–169°). PICOH occurred in 59/88 (67%) ears with a mean of 150.4 ± 9.2SD° (range 124–169°). Overall, ICOH was significantly more severe than PICOH (P = 0.026). ICOH had more Severe (142-102°) overhangs (27/88, 30.7%) than ACOH (17/88, 19.3%) or PICOH (11/88, 12.5%), but these were not significantly different. Analysis of clinical data showed that as the ICOH overhang became more severe, there was a history of significantly more (p = 0.039, r = −0.209) tympanostomy tubes placed.

Conclusions: The greatest prevalence and severity of EAC overhang was the ICOH with a mean angle of 145.9°, compared with 148.3° and 150.4° for the ACOH and PICOH, respectively. This anatomic study demonstrates that ICOH and PICOH are prevalent anatomic variants and may possibly cause similar difficulties in otoscopic diagnosis and surgical TM and middle ear exposure as the well-known ACOH.

1. Introduction

In the external auditory canal (EAC), the Anterior Canal Overhang (ACOH) has been well described [1–5] as a bony overhang that has an acute angle or bulge lateral to the tympanic membrane (TM). This bony EAC overhang can prevent complete evaluation of the TM and medial EAC during otoscopy. This not only produces an obstacle in diagnosing middle ear diseases, such as early cholesteatoma [6], but also leads to difficulties in performing middle ear surgery. This is because an EAC overhang can block the ability to directly view a portion of the TM, medial EAC, annulus, and middle ear during surgery.

The Inferior Canal Overhang (ICOH) and Posterior Inferior Canal Overhang (PICOH) have not been reported but are fairly common anatomic variants that we have observed to also lead to difficulties raising the canal skin/TM flap. They may also interfere with exposure during otologic surgery. Our goal is to define the prevalence and severity of ICOH, PICOH, and ACOH, and thus more clearly characterize the anatomy of the EAC in a series of children who had CT scans of the ears prior to surgery for cholesteatoma. Identification and characterization of these common EAC bony overhangs will allow better anticipation of surgical difficulties and planning for procedures such as the use of transcanal ototelescopes, drilling off the bone of the overhangs, and/or a postauricular approach [1–5,7] to improve exposure and avoid difficulties such as torn tympanomeatal flaps or incomplete removal of tissue that was intended for complete excision.

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2. Materials and methods

Approval of the Institutional Review Board at the University of Pittsburgh Medical Center (UPMC) was obtained for this study. The Children's Hospital of Pittsburgh of UPMC medical record database was searched for all patients with a diagnosis of cholesteatoma presenting to a group of 4 Pediatric Otologists between 2012 and 2013. Patients 18 years and younger with a pre-operative high resolution temporal bone CT scans with axial and coronal reconstructions were included in our study. Exclusion criteria included patients > 18 years old, EAC erosion due to cholesteatoma, or previous otologic surgery other than tympanostomy tubes.

Unenhanced CT scans were performed with a slice thickness of 0.6 mm and spacing of 0.3 mm. Characteristic imaging parameters included a kVp of 120 and an mA of 95. Coronal and sagittal reformatted images are routinely performed at our institution. The CT scans were used to measure: ACOH, ICOH, and PICOH. We observed clinically that superior EAC overhang almost never occurred and thus was not included in the measurements. Measurements were made on the ear(s) with cholesteatoma. EAC overhang was measured as the angle between the bony os of the EAC, the point of maximal overhang of the EAC, and the tympanic annulus (see Figs. 1 and 2). A smaller angle (more acute) means more overhang or bulge of the EAC. Angles ≥180° were recorded as 180° since they are non-obstructing. Thus, the measurements were taken from the surgeon's perspective, from within the EAC. All measurements were made by a single dedicated head and neck radiologist (BFB) with 15 years of experience interpreting temporal bone CTs.

EAC overhangs were measured on CTs of temporal bones of children undergoing cholesteatoma surgery. Clinical data was collected retrospectively including age at CT, sex, right versus left ear, history of otitis media (yes or no), and number of tympanostomy tubes placed in the affected ear. All personal identifiers were removed from the data set.

Analysis of demographic data was performed on the entire study group, including age at CT, sex, right versus left ear, history of otitis media, and number of tympanostomy tubes placed in the affected ear. For statistical analyses of overhangs other than the overall prevalence of obstructing versus non-obstructing overhangs, the non-obstructing overhangs (≥180°) were excluded because our goal was to characterize the prevalence and severity of the obstructing (< 180°) overhangs. Also, to include the ≥180° overhang data, would introduce unwanted variability into the data. Thus, other than for incidence data, we were interested in only analyzing the obstructing cases and avoiding introducing variability by including the > 180° cases.

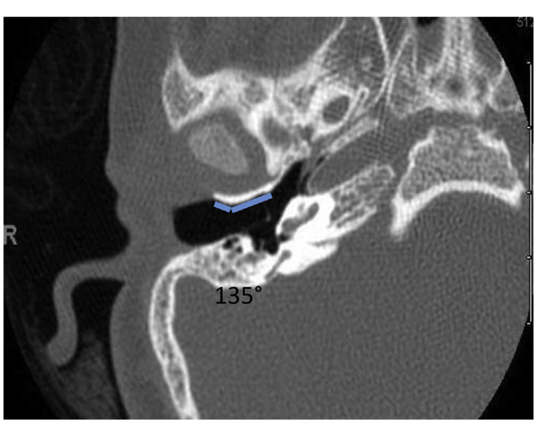

Fig. 1. Axial CT temporal bone. Angle of this example of anterior external auditory canal overhang is 135°.

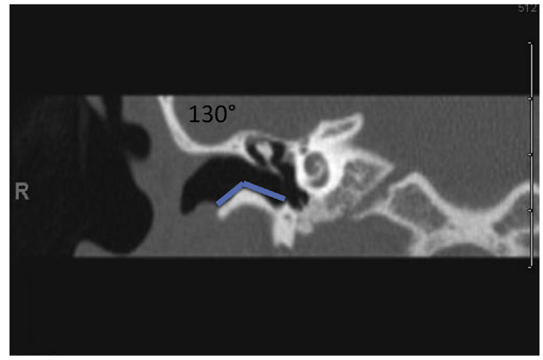

Fig. 2. Coronal CT temporal bone. Angle of this example of inferior external auditory canal overhang is 130°.

3. Results

The cholesteatoma cases for 4 Pediatric Otologists were searched for in the Children's Hospital of Pittsburgh of UPMC medical records from 2012 until 2013 until a convenience sample of 143 ears was identified. Of these patients, 86 met the criteria for our study. Two patients (2.3%) had bilateral cholesteatoma, resulting in a total of 88 CT scans (ears) for review. There were 56 (65%) males and 30 (35%) females. Age ranged from 1.7 to 18.5 years at the time of CT scan, with a mean of 8.3 ± 4.3SD years old (Table 1).

Only obstructing angles were analyzed (< 180°) statistically. Of the 3 EAC angles measured, the ICOH was most severe and occurred in 72/88 (81.8%) ears with a mean of 145.9 ± 12.8SD° (range 102–171°). ACOH occurred in 60/88 (68.2%) ears with a mean of 148.3 ± 10.9SD° (range 120–169°). PICOH occurred in 59/88 (67%) ears with a mean of 150.4 ± 9.2SD° (range 124–169°) (Table 2).

Table 3 shows that the obstructing EAC overhang angles for ICOH were statistically significantly ($P = 0.026$, *t*-test) more severe (more acute angles and more obstructing) than PICOH. ICOH obstructing overhang angles were not statistically different from ACOH obstructing overhang angles.

To better characterize the distribution and severity for each of the 3 sites of obstructing EAC overhang angles, the cases for each site were also divided into a Milder group, a more Severe group, and a Normal (non-obstructing) group. (Tables 4–7). These analyses were performed since a Milder EAC overhang may cause little difficulty or be relatively easily managed with a simple maneuver such as repositioning the otomicroscope or ototelescopes to see past the overhang. In contrast, the Severe EAC overhangs will likely be more difficult to surgically manage and require additional maneuvers (see Discussion).

The full range of obstructing overhang angles for all sites combined, ranged from 171 to 102°. A Milder EAC overhang was defined as having angles from 179 to 143° and included the milder half of severity of angles. A Severe EAC overhang was defined as having angles from 142 to 102°, and included the more severe half of the angles. Thus the overhangs were divided into the Milder and Severe groups based on

Table 1
Demographics and clinical data.

Total Patients n = 86	Mean Age = 8.3 years
Total Ears n = 88	Range = 1.7–18.5 years
Male Patients n = 55 (64%)	Right Ears n = 41 (46.6%)
Female Patients n = 31 (36%)	Left Ears n = 47 (53.4%)
History of Otitis Media	Number of Tympanostomy Tubes Placed in Surgical Ear(s):
Yes n = 73 (85.7%)	One or More Tubes Placed n = 59/86 (68.6%)
No n = 12 (14.3%)	No Tubes placed n = 27/86 (31.4%)
1 case unknown	Mean = 2.0 Range 0-12
	2 cases unknown