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Original Article

Evaluation of the Peritubal Region Between the Osseous Eustachian Tube and the Internal Carotid Artery: Usefulness of Oblique Temporal Computed Tomography with Valsalva Maneuver

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BACKGROUND: As indications for surgical Eustachian tube (ET) procedures have been expanded, it is essential to understand the anatomy of ET surroundings for safe ET interventions.

METHODS: We evaluated the peritubal region using oblique planes of temporal computed tomography (CT) with the Valsalva maneuver and classified the peritubal region between the osseous ET and the internal carotid artery (ICA) into 5 types: 1. bony prominence; 2. air cell; 3. absence of peritubal structures (3a. thick canal [>0.5 mm], 3b. thin canal [≤0.5 mm], 3c. dehiscence).

RESULTS: Bony prominence and air cell types were observed in 41.0% (50/122 ears) and 13.1% (16/122 ears), respectively. The ICA was located directly medial to the osseous ET in 39.4% (48/114 ears), of which thick and thin canal types were found in 23.8% and 15.6%, respectively. Internal carotid artery canal wall dehiscence was observed in 8 ears (6.6%). The shortest perpendicular distance between the osseous ET and ICA was 1.6 (range: 0.4-4.9) mm and 2.7 (range: 1.3-5.8) mm in the bony prominence and air cell types, respectively. Osseous ET-ICA distances were 1.2 (range: 0.6-3.6) mm and 0.4 (range: 0.1-0.5) mm in thick and thin canal types, respectively.

CONCLUSION: Distinct peritubal structure types were observed on oblique CT planes with Vasalva maneuver. Bony prominence and air cell types provide a protective layer between the osseous ET and ICA. Imaging information on peritubal structures may help to better understand the anatomy of the ET pathway, leading to safe and accurate surgical approaches to the osseous ET.

KEYWORDS: Eustachian tube, peritubal, internal carotid artery, Valsalva maneuver, computed tomography

INTRODUCTION

The Eustachian tube (ET) and its surrounding structures have complex anatomic relationships. The narrow and curved canal extends from the nasopharynx to the middle ear and constantly opens and closes. Recently, the number of trials aiming toward the development of diagnostic and therapeutic interventions for ET dysfunction has been increasing. Many studies have shown favorable outcomes by dilating obstructive ETs via the nasopharyngeal ostium or transtympanic cavity.[1-3] In addition, patulous ET can be treated by intraluminal blocking or peritubal injection using materials like cartilage or fat. Preoperative computed tomography (CT) is recommended for safely approaching the ET, especially to prevent injuries to the internal carotid artery (ICA). Eustachian tube surgery is not indicated in ears with possible bone dehiscence near the ICA, and a recent publication reported massive ear bleeding following ICA rupture induced by ET catheterization.[4] Such ICA complications are the main reason for concern when performing ET procedures.

The ICA is one of the largest arteries located near the tympanic cavity. The vertical segment of the ICA bends to the horizontal segments, and this posterior genu of the ICA lies directly medioposterior to the ET.[5] The boundary between the ICA and the ET cannot be accurately assessed via traditional temporal CT. In traditional axial CT images, the horizontal ICA seems to occupy the posterior

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wall of the entire ET, whereas the ET descends from the tympanic cavity at a more inclined angle than the horizontal ICA, such that only the osseous portion of the ET is in the proximity of the genu of the ICA.[1] Because of the different angles of the 2 structures (ET and ICA), the boundaries between ET and ICA (peritubal region) are likely to be misrecognized as the ET, especially when a bony prominence occupies the peritubal region.

This study aimed to evaluate the peritubal region, an anatomical boundary between the osseous ET and the ICA, by using oblique views of temporal CTs during the Valsalva maneuver in the temporal bone with aerated mastoid. The knowledge of the anatomy of the ET and its surrounding structures may be informative for therapeutic interventions targeting the ET.

MATERIAL AND METHODS

Temporal CT scans with Valsalva maneuver were performed in Eulji Medical Center to evaluate simultaneously the middle ear, mastoid cavity, and ET status in patients with suspected or underlying diseases such as otitis media, ET disorder, or chronic otalgia. We retrospectively evaluated patients whose temporal CT showed an absence of soft-tissue density in the middle ear and mastoid cavity, as well as a well-visualized ET pathway from the nasopharyngeal ostium to the tympanic cavity.

Temporal Computed Tomography with Valsalva Maneuver

A Valsalva temporal CT image is a reconstructed image from a traditional temporal CT with no specific consideration other than the Valsalva maneuver performed during the CT scan. We evaluated the ability to perform the Valsalva maneuver and educated patients on how to perform the Valsalva maneuver before the temporal CT scan. The Valsalva maneuver, an active forced expiration against a closed airway, increases the pressure within sinuses and middle ears. The axial dataset was obtained as overlapping sections of 0.67 mm thickness with 0.5 mm increment. The axial plane images were tilted anteromedially to visualize the entire passage of the ET using multiplanar reconstruction (Figure 1A). The rotation center was positioned at the fundus of the nasopharyngeal ostium of the ET in the axial plane.

Patients and Measurements

We reviewed CT images of 122 ears from 61 patients (24 men and 37 women) in whom the ET passage from the nasopharyngeal ostium to the tympanic cavity was adequately visualized on axial CT images with more inclined angles. First, the total distance (*T*) from the nasopharyngeal ostium (NO) to the tympanic ostium (TO), that meets the line extending at the posterolateral end of the posterior ICA genu, was measured (Figure 2A and B). Also, the shortest perpendicular distance (*P*) between the osseous ET and the posterior genu of the ICA was determined (Figure 2C). The safe distance *(S*) was measured from the NO to the point where the shortest perpendicular distance was 3 mm (P3mm, Figure 2A and B). The safe distance S indicates the intraluminal approach distance from the nasopharyngeal ostium. As the balloons currently used for ET dilation range between 3 and 7 mm in diameter, we selected 3 mm as the shortest safe distance between the ET and ICA (Figure 2A and B).

Subsequently, the anatomic structures between the osseous ET and the ICA in the peritubal region were evaluated (Figures 3 and 4). The peritubal regions between the ET and the ICA were classified into 5 categories: 1. bony prominence type, 2. air cell type, and 3. absence of a peritubal structure (3A. thick canal type [>0.5 mm], 3B. thin canal type [≤0.5 mm], and 3C. dehiscence type). Type 3 is subcategorized according to the thickness of the canal wall of the ICA. Possible or definite ICA dehiscence was defined as missing bony coverage of the ICA bordering the ET.

Statistical Analysis

Statistical Package for the Social Sciences Statistics software version 21.0 (IBM SPSS Corp.; Armonk, NY, USA), was used for all statistical analyses. The 2-sample *t*-test was used to compare the measured distances between the sexes. Total distance, *P*, and *S* were evaluated for each group, and the results according to the types of peritubal structure were compared using analysis of variance. In this study, $P < .05$ was considered statistically significant. This study was approved by the Institutional Review Board of Daejeon Eulji Medical Center (Approval No: 2021-11-002). Because of the retrospective nature of the study, informed consent was waived.

RESULTS

The study included 122 ears (24 men and 37 women) in whom Valsalva CT showed the entire ET pathway to determine the anatomical relationship between the ICA and the ET. The patients' age ranged from 18 to 76 years, with a mean age of 46.1 years. Each ear was evaluated individually.

Valsalva CT showed the ET in a more detailed manner than traditional temporal CT. The inclination angles of the axial plane of the temporal CT ranged from 42.0° to 58.8° (average 51.3°). White arrows (↑, Figure 1A) in axial temporal CT indicate air spaces that resembles an ET; however, the ETs actually lie below the white arrowheads (△) indicating the tensor tympani muscle. Figure 1B shows the oblique plane of the same patient, and the entire ET pathway is visible, extending from the nasopharynx to the tympanic cavity. The structure of the bony prominence with peritubal space (↑, Figure 1B) separates the ICA from the osseous ET (*).

Tables 1 and 2 list the results of various parameter measurements. The mean total ET length (*T*) was 33.1 (range: 26.7-39.5) mm. This total length was significantly different between male and female participants ($P < .001$). The safe ET distance (*S*) ranged from 20.7 mm to 37.0 mm, and the mean safe distance was 27.2 mm. A statistically significant difference in safe distance was observed between

MAIN POINTS

- The study identifies various types of peritubal structures between the Eustachian tube (ET) and the internal carotid artery (ICA) based on CT findings.
- The most common peritubal structure was the bony prominence type, followed by the bony canal wall and air cell types. Bony prominence and air cell structures serve as a protective barrier separating the osseous ET from the ICA.
- Understanding the variability in peritubal structures is crucial for assessing ET patency and guiding surgical decision-making and enhancing patient safety.

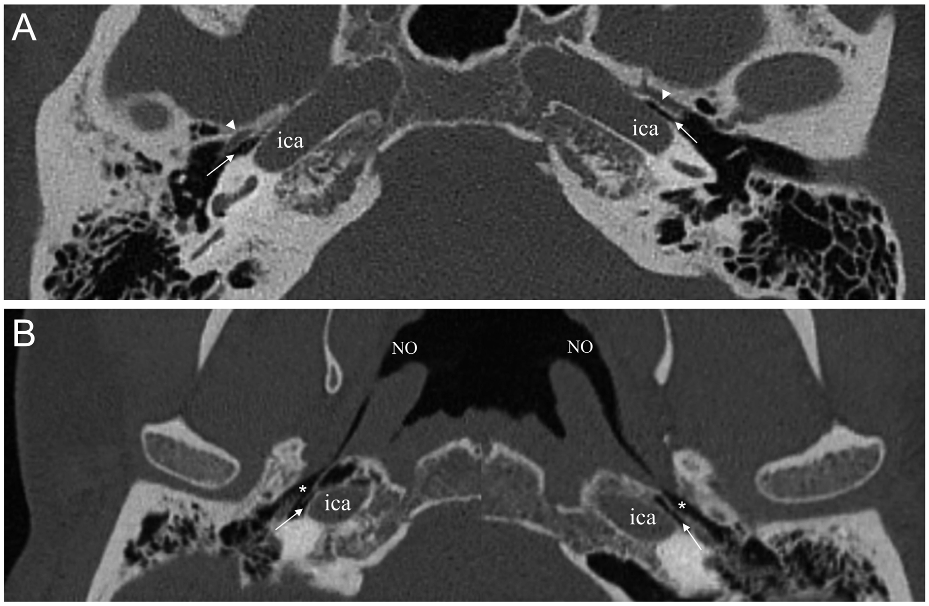

Figure 1. A) Axial image of traditional temporal computed tomography (CT). The horizontal portion of the internal carotid artery appears to occupy the entire Eustachian tube (ET) passage, but white arrows (↑) are air spaces, not ETs. White arrowheads (△) indicate the tensor tympani muscle, and ETs are below the tensor tympani. B) Valsalva oblique CT shows the entire passage of the ET. The axial plane is tilted anteroinferior until the ETs are visualized. White asterisks (*) indicate ETs, and white arrows (↑) indicate air spaces medial to the ET. ica, internal carotid artery; NO, nasopharyngeal ostium.

male and female individuals. The shortest perpendicular distance (*P*) between the bony ET and posterior genu of the ICA was 1.6 (range: 0.0-5.8) mm.

Figures 3 and 4 show the different types of peritubal structures between the ICA and osseous ET based on CT findings. The distribution of these types is presented in Figure 5. A bony prominence was observed in the peritubal region between the ET and the ICA in 50 ears (41.0%). Figure 3A shows a representative example of this type. Two pneumatic spaces formed by the bony septum can be observed anterior to the ICA, and the lateral space corresponds with the osseous ET (*, white asterisk). Air cell structures between the ICA and the ET were present in 16 ears (13.1%), providing a more protective barrier (Figure 3B). Thick bony canal walls of the ICA (≥0.5 mm) were found in 29 ears (23.8%; Figure 3C). In 19 ears (15.6%), less than 0.5 mm thickness of the thin bony wall separated the ET lumen from the ICA (Figure 3D). Internal carotid artery dehiscence (Figure 4) was found in 8 ears (6.6%). One ear had 3.6 mm dehiscence of the posterior ICA genu but a thin bony plate with air space (white arrowhead, Figure 4) anterior to the 3.6-mm dehiscence, reducing the possibility of ICA injury. In the other 3 ears of the ears with dehiscence, bony defects of various sizes (1.9-5.3 mm) were found on the anterior wall of the posterior genu, which requires special precaution when performing surgery. Seven of the 8 dehiscence type ears were found in female participants.

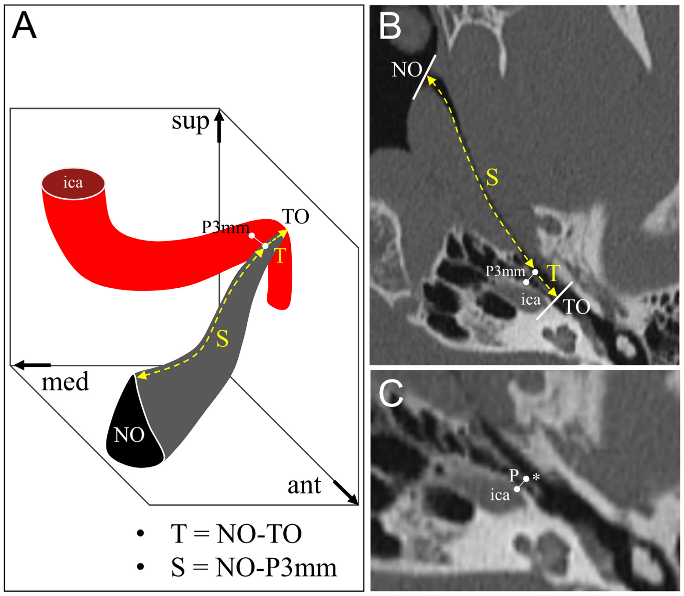

Figure 2. A) The paths of the internal carotid artery (ICA) and Eustachian tube (ET). B) Oblique computed tomography image of the left ear. The total ET length (T) from the nasopharyngeal ostium (NO) to the tympanic ostium (TO) is indicated. The safe distance (S) is defined as the distance from the ostium to the point (P3 mm) at which the perpendicular distance from the ICA is 3 mm. C) Shortest perpendicular distance (P) between the osseous ET and ICA. ant, anterior; ica, internal carotid artery; med, medial; sup, superior.

In the comparison of peritubal structure types, total distance (*T*) showed no significant difference among the 5 types, whereas the bony prominence and air cell types showed significantly longer safe distances (*S*) than the thin canal type. Moreover, the perpendicular distance (*P*) was longer in the bony prominence and air cell types than in the thin canal and dehiscence types.

DISCUSSION

Recently, surgical procedures directly targeting the ET have arisen as a promising therapeutic option for patients with ET dysfunction. For safe and effective surgical approaches to the ET, the relationship of the ET with its surrounding structures should be evaluated on preoperative images to avoid complications by intraluminal ET procedures. The close anatomical relationship between the ET and ICA has been reviewed in previous studies, but it was evaluated on images

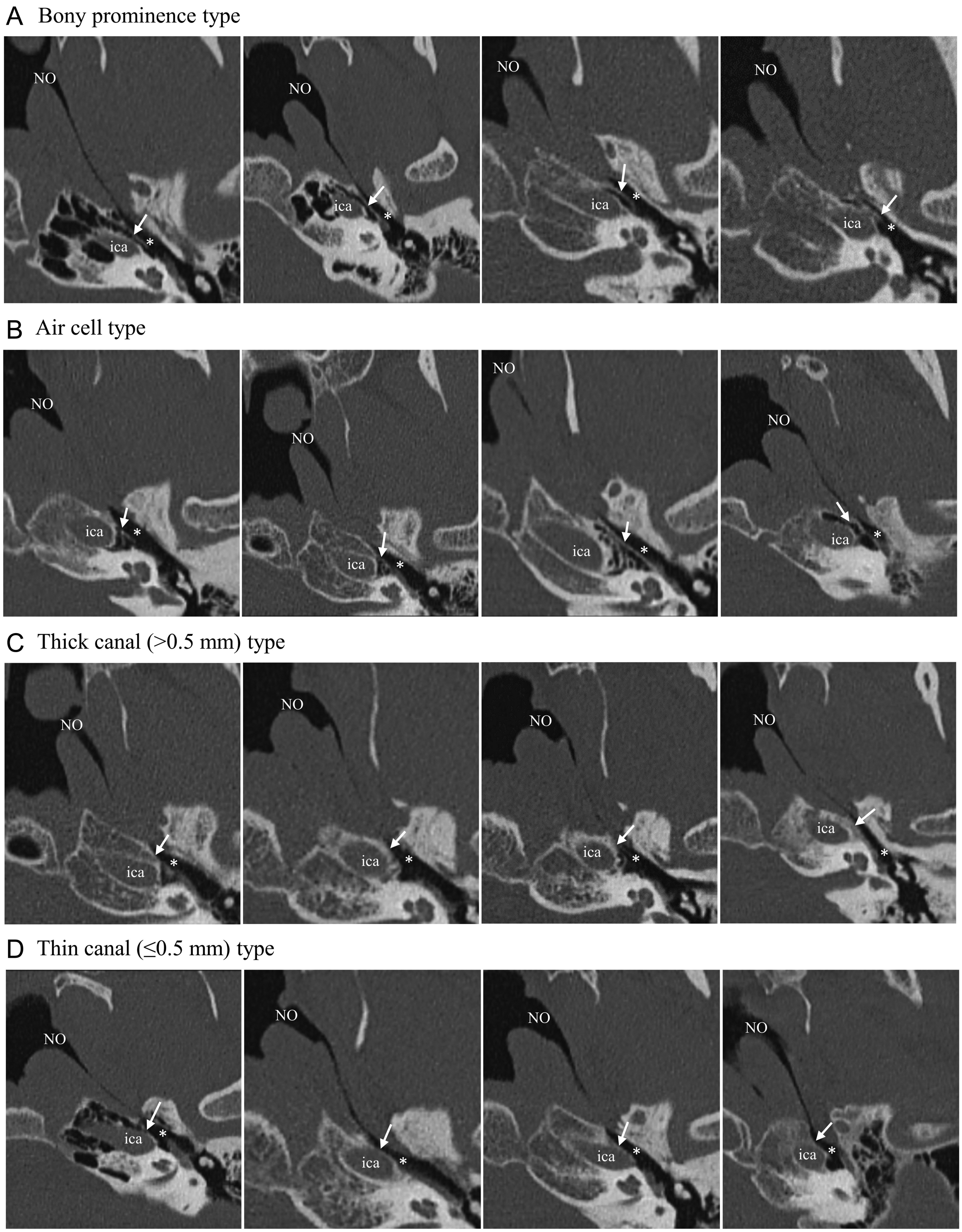

Figure 3. Structure types according to the anatomy between the posterior genu and the osseous Eustachian tube (ET) in the protympanic space. A) Bony prominence type, characterized by a bony prominence (arrow) between the ET (*) and the internal carotid artery (ICA). B) Air cell type, characterized by air cells (arrow) between the ET (*) and the ICA. C) Thick canal type, characterized by thick carotid canal walls (≥0.5 mm, arrow) of the ICA. D) Thin canal type, characterized by thin carotid canal walls (<0.5 mm, arrow) of the ICA. ica, internal carotid artery; NO, nasopharyngeal ostium.

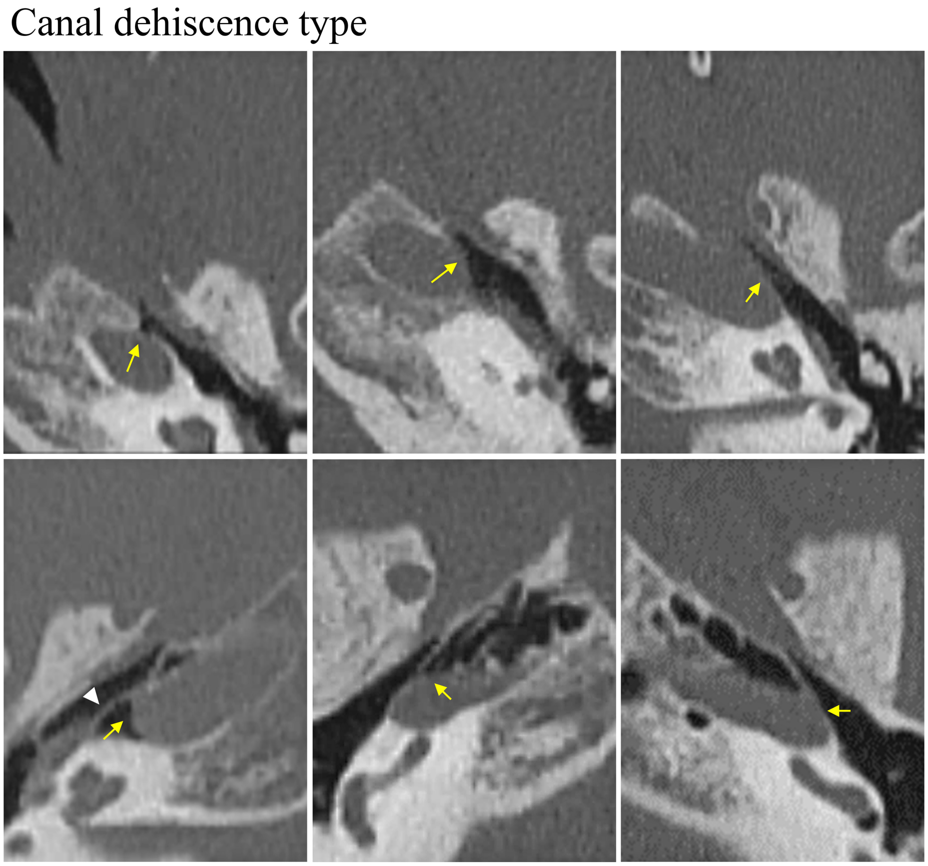

Figure 4. Various cases with internal carotid artery (ICA) canal dehiscence. Yellow arrows indicate the dehiscence of the ICA canal wall, and the white arrowhead indicates a bony plate with air cells over the canal wall dehiscence.

with closed ET lumina. Therefore, it was assessed mainly based on the line of the presumed ET pathway between 2 identifiable points, the nasopharyngeal ostium and the bony ostium. In addition, the ET is inclined at an angle of 45°; therefore, conventional axial and coronal images may result in measurement errors.[6] The novelty of our study is that we evaluated the anatomical relationship between the opened ET and the ICA using oblique CT images during the Valsalva maneuver. The ET lumen is closed under resting conditions and cannot be visualized in regular imaging studies. The measurement of the opened ET on CT planes with inclination caused differences between our data and previous findings. We observed and categorized the boundary between the ICA and osseous ET (peritubal region) and measured the ICA-ET distance. We further evaluated the total ET distance and safe approachable intraluminal distance according to the type of peritubal structure.

Table 1. Summary of the Independent *t*-Test Results for the Gender Comparison About the Measured Distances.

Parameter	All Patients (122 Ears)	Male (48 Ears)	Female (74 Ears)	*P*
Age (years)	45.7 ± 16.1 (18.0-76.0)	45.0 ± 17.7	46.1 ± 15.5	.700
Total distance of ET [T, mm]	33.1 ± 2.8 (26.7-39.5)	34.5 ± 3.0	32.2 ± 2.3	<.001**
Safe distance of ET [S, mm]	27.2 ± 3.9 (20.7-37.0)	28.3 ± 3.9	26.5 ± 3.7	.015*
Distance o-ET to ICA [P, mm]	1.6 ± 3.2 (0.0-5.8)	1.6 ± 1.4	1.2 ± 1.0	.079

ET, Eustachain tube; o-ET, osseous Eustachian tube; ICA, internal carotid artery.

Oblique Temporal Computed Tomography with Valsalva Maneuver for the Evaluation of Eustachian Tube Surroundings

Adbel-Aziz et al[7] reported that temporal bone CT cannot predict intraoperative difficulties during Eustachian tuboplasty and that

Table 2. Comparison of the Total Distance (T), Safe Distance (S), and the Shortest Perpendicular Distance (P) from Osseous Eustachain Tube to Internal Carotid Artery Between the 5 Groups.

Type	Total Distance of ET [T, mm]	Safe Distance of ET [S, mm]	Distance o-ET to ICA [P, mm]
Bony-prominence	32.9 ± 2.4	27.8 ± 3.9	1.6 ± 1.0 (0.47-4.97)
Air-cell	32.8 ± 2.8	29.3 ± 5.0	2.7 ± 1.4 (1.38-5.76)
Thick-canal	33.3 ± 2.8	26.8 ± 3.5	1.2 ± 0.9 (0.37-3.65)
Thin-canal	33.5 ± 3.6	25.3 ± 2.4	0.4 ± 0.1 (0.1-0.82)
Dehiscence	33.2 ± 2.9	24.7 ± 2.5	<0.1 (unmeasurable)
F (*P*-value)	0.229 (0.922)	3.572 (0.009*)	15.212 (<0.001**)
Post hoc (Bonferroni)	-	Type 1 > 4, 2 > 4	Type 1 > 4, Type 1 > 5 Type 2 > 1, Type 2 > 3 Type 2 > 4, Type 2 > 5

Mean scores ± SD of 5 groups and results of analysis of variance and the post-test.
ET, Eustachain tube; o-ET, osseous Eustachian tube; ICA, internal carotid artery.
*$P < .05$
**$P < .001$

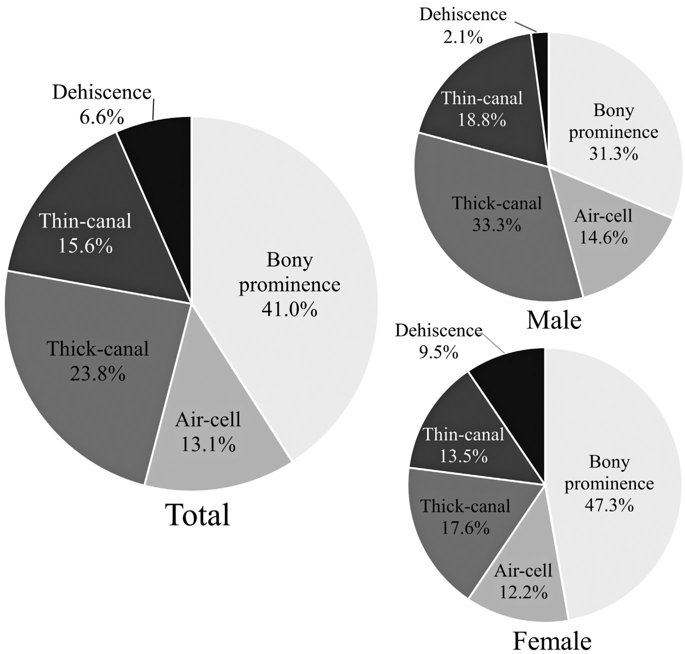

Figure 5. Distributions of cases according to the peritubal structure types between the osseous Eustachian tube and internal carotid artery.

inserting the catheter too deep should be prevented to reduce ICA complications. They also showed that traditional temporal CT is not sufficient for understanding the relationship between the ICA and ET because the ICA takes a different plane and direction from those of the ET passage. The ET is a complex and 3-dimensional pathway that is usually closed; therefore, visualization of the ET remains challenging to date. An air-filled ET lumen during the Valsalva maneuver is the simplest and least-invasive method to date for ET visualization. Moreover, the presence of pneumatic spaces around the ET can impede the identification of the ET passage. We categorized 1 patient as canal dehiscence type because, although the bony covering of the ICA was missing, ICA canal dehiscence was visible against the peritubal air cell, not the ET lumen. This demonstrates that oblique CT images during the Valsalva maneuver can show the accurate anatomy of ET surroundings, facilitating a safe approach to the ET.

Comparison to Previous Studies

According to Jung et al,[8] the closest ET-ICA distance was 5.00 ± 1.85 mm, measured from the osseous ET to the ICA throughout the presumed ET passage. In our measurements on Valsalva CT images, the closest distance between the osseous ET and the ICA was 1.63 ± 1.33 mm, which was substantially lower than the value reported by Jung et al.[8] Furthermore, the direct distances between the ET torus and the vertical segment of the ICA were 27.77 ± 3.20 mm and 23.5 mm (minimum: 10.4 mm) in previous publications.[9,10] We also measured the distance from the ET torus to the posterior genu of the ICA along the open ET passage, resulting in a higher value (33.3 mm) than those reported in previous studies.

Olander et al[11] determined the perpendicular distance between the ET and the ICA using sagittal oblique reconstructions of magnetic resonance images. They measured the presumed length along a line between these 2 points. The perpendicular distance between the junctional point of the ET and the vertical segment of the ICA was 4.2 (2-10) mm, which was considerably higher than our mean value of 1.63 mm. The distance from the vertical ICA to the nasopharyngeal ostium was in their study 61.9 mm, again much higher than our value (33.3 mm). They stated that identifying the ET passage on magnetic resonance images was more difficult than on temporal CT, and that from the entire ET passage, they only identified the nasopharyngeal ostium and bony isthmus.

In a histopathologic study of ten adult temporal bones, Ozturk et al[12] reported findings similar to ours. The distance between the horizontal ICA and the cartilaginous ET was 5.8 mm, and the distance at the bony part of the ET from the ICA was 1.39 mm.[11]

Categorization of Structure Types in the Peritubal Region

The present study also categorized the peritubal structures between the osseous ET and ICA in the protympanic space. The most common peritubal structure type was the bony prominence type. In the study by Kapadia et al,[1] a pneumatic space was described as a medial false passage, and a bony prominence separated this pneumatic space from the osseous ET. Based on surgical endoscopy observations, they reported that 30% of the 100 ears had a bony ridge anterior to the ICA.[12] We found that 41.0% of ears had a bony septum anterior to the ICA based on CT image analyses. The presence of the pneumatic structure guarantees a greater distance between the ICA and ET, but it could sometimes be sometimes mistaken for an incorrect passage when inserting the ET balloon via transtubal approach from the tympanic cavity. Therefore, using various imaging modalities for a 3-dimensional understanding of the ET and its surrounding structures near the ICA is essential before approaching the ET.

We expected differences in total ET pathway distance according to the peritubal structure type, but the total distance from the ET ostium to the tympanic cavity was similar in all types. Of the included ears, 76.9% had protective structures in proximity to the ICA, such as a bony prominence (41.0%), air cells (13.1%), or thick carotid walls (23.8%). The presence of these structures allows safe intraluminal access to the osseous ET, avoiding proximity to the ICA because they have a thick wall, composed of a bony plate and air cells, from at least 0.5 to 5.8 mm. Of these structures, the air cell type had the longest distance between the ICA and osseous ET and the longest safe distance, providing a safe intraluminal approach.

Limitations and Future Directions

Temporal CT with Valsalva maneuver has a potential weakness in that the maneuver may not be accurately performed. In this study, we only included patients with pneumatic mastoid and middle ear cavities and clear air pathways of the ET. Therefore, it is likely to include more patients with normal ET function or patulous ET. In patients with purely obstructive ET dysfunction, there may be differences in our findings regarding the prevalence of peritubal structure types and other measured distances.

Furthermore, patients requiring intraluminal procedures mostly have obstructive ET disorders, possibly impeding Valsalva CTs and the subsequent evaluation of anatomical structures surrounding the ET. However, even if the ET is not accurately visualized, the ET pathway and ET-ICA distance can be predicted based on the peritubal structure types defined in our study. Future research may explore the effects of the peritubal structure type on actual ET function, e.g., identify the peritubal structure types more commonly observed in obstructive or patulous ET dysfunction, as well as the relationship between the type of peritubal structures and the predicted success of ET surgery. In addition, the comparison of imaging observations with endoscopic findings in the peritubal region can provide more detailed information about the safety during ET surgery.

The osseous portion of the ET intersects with a segment of the ICA (i.e., the posterior genu of the ICA), and distinct types of peritubal structures between the ET and ICA were identified. Especially, a bony prominence and air cells in the peritubal region provide additional distance and a protective layer separating the ICA from the osseous ET. Therefore, the risk of ICA injury is expected to be low in most cases of intraluminal ET surgery. Nevertheless, the blind introduction of a catheter into the ET and exerting pressure in that space can increase the risk of injury. The present study using oblique CT with Valsalva maneuver provides additional information on the ET and its surrounding anatomical structures (i.e., the peritubal region) for a safe and accurate intraluminal access to the ET.

Ethics Committee Approval: This study was approved by the Ethics Committee of Daejeon Eulji Medical Center, Eulji University (Approval No: 2021-11-002, Date: November 9, 2021).

Informed Consent: N/A

Peer-review: Externally peer-reviewed.

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Declaration of Interests: The authors have no conflicts of interest to declare.

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REFERENCES

1. Kapadia M, Arsiwala Z, Tarabichi M. Endoscopic transtympanic Eustachian tube dilatation: an overview of evaluation methods and dilatation technique. *World J Otorhinolaryngol Head Neck Surg*. 2019;5(3):152-159. [CrossRef]
2. Poe DS, Silvola J, Pyykkö I. Balloon dilation of the cartilaginous eustachian tube. *Otolaryngol Head Neck Surg*. 2011;144(4):563-569. [CrossRef]
3. Ockermann T, Reineke U, Upile T, Ebmeyer J, Sudhoff HH. Balloon dilatation eustachian tuboplasty: a clinical study. *Laryngoscope*. 2010;120(7):1411-1416. [CrossRef]
4. Hyakusoku H, Tsuchiya Y, Matsushita Y, Nakayama M. Petrous internal carotid artery aneurysm rupture induced by Eustachian tube catheterization: case report. *J Laryngol Otol*. 2023;137(5):588-590. [CrossRef]
5. Vijaywargiya M, Deopujari R, Athavale SA. Anatomical study of petrous and cavernous parts of internal carotid artery. *Anat Cell Biol*. 2017;50(3):163-170. [CrossRef]
6. Alzahrani HJ, Alzahrani AJ, Ramadan WS. Topographical anatomy and morphometrical analysis of the pharyngeal orifice of the Eustachian tube: A cadaveric study. *Int Res J Med Med Sci*. 2020;8(3):97-108. [CrossRef]
7. Abdel-Aziz T, Schröder S, Lehmann M, Gehl HB, Ebmeyer J, Sudhoff H. Computed tomography before balloon eustachian tuboplasty–a true necessity? *Otol Neurotol*. 2014;35(4):635-638. [CrossRef]
8. Jung JH, Goh EK, Lee IW, Jung JH, Oh SJ, Kong SK. Anatomical relationships between Eustachian tube and internal carotid artery using computed tomography. *Korean J Otorhinolaryngol-Head Neck Surg*. 2015;58(12):848-854. [CrossRef]
9. Bergin M, Bird P, Cowan I, Pearson JF. Exploring the critical distance and position relationships between the Eustachian tube and the internal carotid artery. *Otol Neurotol*. 2010;31(9):1511-1515. [CrossRef]
10. Janzen-Senn I, Schuon RA, Tavassol F, Lenarz T, Paasche G. Dimensions and position of the Eustachian tube in Humans. *PLOS ONE*. 2020;15(5):e0232655. [CrossRef]
11. Olander H, Järnstedt J, Poe D, Kivekäs I. Critical distance between the cartilaginous Eustachian tube and the internal carotid artery. *Eur Arch Otorhinolaryngol*. 2017;274(1):73-77. [CrossRef]
12. Ozturk K, Snyderman CH, Gardner PA, Fernandez-Miranda JC. The anatomical relationship between the eustachian tube and petrous internal carotid artery. *Laryngoscope*. 2012;122(12):2658-2662. [CrossRef]