

Relationship between Eustachian Tube Dimensions and Middle Ear Cholesteatoma

Filiz Gülüstan¹, Selçuk Güneş², Ömer Yıldız³, Zahide Mine Yazıcı¹,
Mehmet Akif Abakay¹, Ercan İnci³, İbrahim Sayın¹

1 Department of Otolaryngology Head and Neck Surgery, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey.

2 Department of Otolaryngology Head and Neck Surgery, Memorial Hizmet Hospital, Istanbul, Turkey.

3 Department of Radiology, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey.

Filiz Gülüstan, ORCID: 0000-0003-4857-214X

Selçuk Güneş, ORCID: 0000-0001-9458-5799

Ömer Yıldız, ORCID: 0000-0003-4774-9281

Zahide Mine Yazıcı, ORCID: 0000-0002-4164-3438

Mehmet Akif Abakay, ORCID: 0000-0003-0413-421X

Ercan İnci, ORCID: 0000-0002-3791-2471

İbrahim Sayın, ORCID: 0000-0003-3388-7835

Abstract

Objective: To compare intact and diseased ears for Eustachian tube (ET) length and width in patients with unilateral chronic otitis media (COM), and to assess the relationship between cholesteatoma spread, stapes erosion, lateral semicircular canal (LSCC) fistula and ET width and length retrospectively.

Methods: Subjects with unilateral COM (122 subjects with 244 ears) who underwent surgery for cholesteatoma were evaluated retrospectively for this study. The width of the distal orifice of the bony segment and the length of the bony segment of the ET for both the diseased and healthy ear were measured. Subjects' healthy and diseased ears were compared for ET length and width. The diseased sides were compared to assess the relationship between ET dimensions and cholesteatoma spread, stapes erosion and LSCC fistula.

Results: The mean ET length and width in healthy and diseased ears was 11.38 ± 1.7 and 1.43 ± 0.37 mm, and 10.99 ± 1.6 and 1.27 ± 0.35 mm, respectively; the difference was statistically significant ($p < 0.001$). No significant differences were found in terms of ET length and width between the subjects with and without stapes erosion and LSCC fistula ($p = 0.765$, $p = 0.573$, and $p = 0.436$, $p = 0.790$, respectively). No significant relation was found between cholesteatoma spread and ET length and width ($p = 0.647$).

Conclusion: ET dysfunction is frequently associated with COM. Chronic otitis media with cholesteatoma is significantly related to ET length and width. Measurement of ET length and width in CT scans is a basic method that can be used in clinical practice.

Keywords: Cholesteatoma, eustachian tube, multidetector computed tomography.



Introduction

Chronic otitis media (COM) is defined as inflammation of the middle ear and mastoid cavity that does not heal for at least three months, accompanied by tympanic membrane perforation and hearing loss.^[1] As a multifactorial disease, one of the most argued causes in the pathogenesis of COM is Eustachian tube (ET) dysfunction.^[2-4]

The major causes of ET dysfunction are septum deviation, nasal polyps, adenoid vegetation, concha hypertrophy, velopharyngeal insufficiency, cleft palate, nasal synechia and ciliary dyskinesia syndromes such as Kartagener's syndrome.^[5] Regardless of the etiology, ET dysfunction has been shown to be a major cause in the development of cholesteatoma.^[6-8] Measurement of the length of the bony part of the ET and the distal orifice diameter are important for evaluating the anatomic structure of ETs.

The aim of the present study was to compare the length and width of ETs of diseased ears with healthy ears of the same subjects, and to determine the role of ET size and width differences in the pathogenesis of COM with cholesteatoma. The present study also investigated the relationship between ET dimensions and cholesteatoma spread, stapes erosion and lateral semicircular canal (LSCC) fistula.

Materials and Methods

The present study was performed at a tertiary referral hospital between 2015 and 2018. The study protocol was approved by the Ethics Committee of the Bakırköy Dr. Sadi Konuk Training and Research Hospital (protocol no: 2018/99). Since our study was retrospective, and the data were taken from patient files, no informed consent was obtained from the patients. Subjects with unilateral COM who underwent surgery (radical or modified radical mastoidectomy) for cholesteatoma were retrospectively evaluated for the study. Subjects who were diagnosed as having a cholesteatoma according to the final histopathological examination, and subjects with accessible preoperative audiological assessments, preoperative computed tomography (CT) scans and operation notes were enrolled in the study. Subjects who had undergone previous ear and nasal surgery, subjects with a disease that would impair mucociliary clearance (e.g., allergic rhinitis, nasal polyps and immotile cilia), subjects with craniofacial and/or otologic anomalies, and those with congenital cholesteatoma were excluded from the study.

Multidetector CT (MDCT) examinations were per-

formed using a 128-slice MDCT scanner (SOMATOM Volume Zoom, Siemens Medical Solutions, Berlin, Germany) with the following parameters: slice thickness 0.5 mm and image interval 0.5 mm, with a bone algorithm. No contrast material was injected. The multiplanar reconstruction (MPR) technique was used to reconstruct images parallel and perpendicular to the long ET axis. The basal turn of the cochlea and internal acoustic canal was used for standardization during the reconstruction of MPR images as a reference structure. All images were transferred and measured at the Leonardo Workstation (Syngo MMWPVE52A software, Siemens, Germany) on axial plane images. Measurements were collected by one radiologist with ten years of experience in radiology in order to exclude person to person variation. The tympanic orifice and fibrocartilaginous junction of the ET were observed in sections perpendicular to the long axis of the ET in both axial and coronal slices. The length of the ET was measured as the distance from the tympanic orifice to the fibrocartilaginous junction. The narrowest zone of the ET was measured at the bony-fibrocartilaginous junction. Subjects' healthy and diseased ears were compared for ET length and width (Figure 1-2).

The diseased sides were compared to assess the relationship between ET dimensions and cholesteatoma spread, stapes erosion and LSCC fistula. Cholesteatoma spread was evaluated by considering the operation reports, preoperative CT and preoperative examination notes. Cholesteatoma spread was classified as follows: attic, attic+antrum, mesotympanum+hypotympanum, mesotympanum+hypotympanum+antrum and affecting all pneumatic parts of the mastoid bone. The ET length and width were also compared between the subjects with/without stapes bone erosion and with/without LSCC fistula.

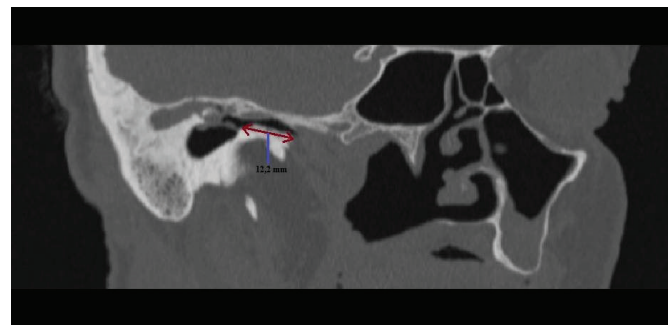


Figure 1. Measurement of ET length in axial-oblique CT images

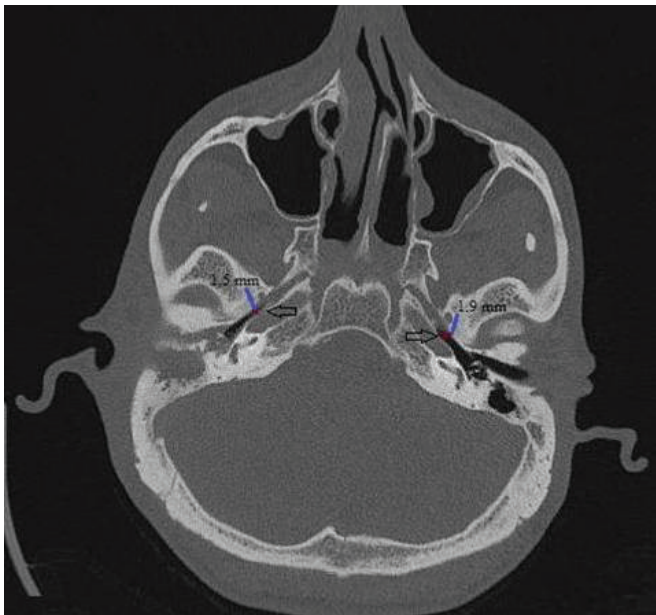


Figure 2. Measurement of ET orifice width in axial CT images

Statistical analysis

Statistical analyses were performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2013). Along with descriptive statistical methods (mean, SD, median, minimum, maximum), Mann-Whitney U test was used to compare two independent and non-normal distribution variables. A comparison of the two independent and normal distribution fit variables was performed using Student’s

t-test. Kruskal-Wallis test was used to compare two independent variables with non-normal distribution. One-way analysis of variance (ANOVA) was used to compare two independent variables with a normal distribution. Wilcoxon test was used for two variables that did not show dependency and normal distribution. Paired-samples t-test was used to compare two variables with dependent and normal distribution fit. Assessment of diagnostic performance was performed using receiver operating characteristics (ROC) analysis. Chi-square test (or Fisher’s exact test at appropriate locations) was used to examine the relationship between categorical variables. The confidence interval was 95% and p values less than 0.05 were considered to be significant.

Results

A total of 122 subjects with 244 ears were evaluated retrospectively. Sixty-seven (54.9%) out of 122 subjects were male and the remaining 55 (45.1%) were female. The mean age of the subjects was 32 ± 14.72 (range, 8-66) years. Twenty-eight (22.9%) of 122 subjects were pediatric patients (<18 years). COM with cholesteatoma affected the right ear in 75 (61.5%) subjects and the left ear in 47 (38.5%) subjects.

In healthy ears, the mean ET length was 11.38 ± 1.7 (range, 7.14-16.1) mm, and mean ET width was 1.43 ± 0.37 (range, 0.78-2.3) mm. In diseased ears, the mean ET length was 10.99 ± 1.6 (range, 6.6-14.71) mm and the mean ET width was 1.27 ± 0.35 (range, 0.56-2.58) mm. ETs were significantly longer and wider in healthy ears than in diseased ears ($p < 0.001$ for both comparisons) (Figure 3).

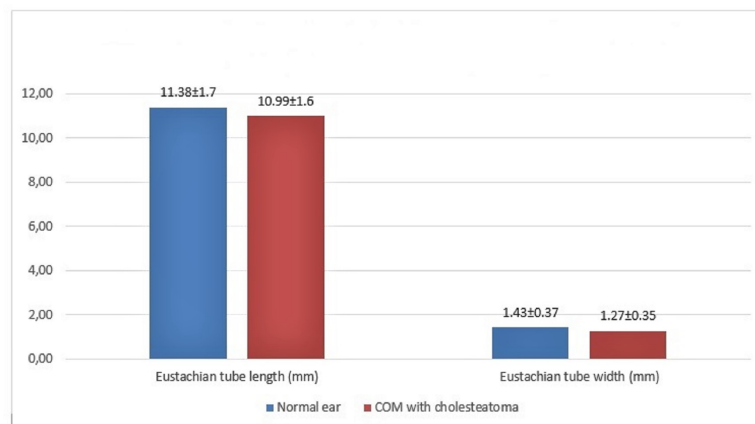


Figure 3. Comparison of ET length and width between healthy and diseased ears

Cholesteatoma was in the attic in 9 (7.4) subjects, in the attic and antrum in 37 (30.3%), in mesotympanum and hypotympanum in 7 (5.7%), in the mesotympanum-hypotympanum and antrum in 63 (51.6%), and all cells of the mastoid bone were affected in 6 (4.9%) subjects. No significant relation was found between cholesteatoma spread and ET length and width ($p=0.647$, $p=0.881$, respectively).

In the diseased ear of the subjects, 60.66% ($n=74$) had stapes erosion and 8.2% ($n=10$) had LSCC fistula. The ET length and width did not differ between subjects with/without stapes erosion and subjects with/without LSCC fistula ($p=0.765$, $p=0.573$, and $p=0.436$, $p=0.790$, respectively) (Table 1). Also, cut-off values were sought by creating ROC curves for ET lengths and widths of the diseased ears of subjects with LSCC fistula and stapes erosion; however, there was no statistically significant result to be evaluated ($p>0.05$).

Discussion

The function of the ET was first recognized by Duvernay in 1683.^[9] Duvernay reported that “the ET was neither an avenue for breathing nor of hearing, but one through which the air in the tympanum is renewed”. Since then, ET dysfunction has been the most commonly argued etiologic cause for COM. Our study compared ET lengths and widths between diseased and healthy ears of the same subjects. Our results demonstrated that healthy ears had a longer and wider ET structure, which was measured using CT scans of the subjects. We also evaluated the ET length and width according to cholesteatoma aggressiveness. In our study, cholesteatoma spread, stapes erosion and LSCC fistula were accepted as indicators for cholesteatoma aggressiveness. However, no significant relation was found between ET length/width and cholesteatoma aggressiveness in the present study.

Table 1. Evaluation of ET length and width according to cholesteatoma spread, condition of stapes and LSCC fistula

	ET width (mm) Mean±SD Med. (Min.Max)	p value	ET length (mm) Mean±SD Med. (Min.Max)	p value
Attic ($n=9$, 7.38%)	1.22±0.3 1.1 (0.9-1.7)		10.3±1.4 10.6 (8.1-11.8)	
Attic+Antrum ($n=37$, 30.33%)	1.32±0.3 1.3 (0.6-2.4)		11.1±1.6 11.2 (7.8-14.7)	
Cholesteatoma Spread	Mesotympanum+Hypotympanum ($n=7$, 5.74%)	0.881*	11.4±1.1 11.2 (9.4-12.8)	0.647*
	Mesotympanum+Hypotympanum+Antrum ($n=63$, 51.64%)		10.9±1.6 10.8 (6.6-13.9)	
	Affecting all pneumatic parts of the mastoid bone ($n=6$, 4.92%)		10.9±2.2 11.2 (7.4-13.4)	
Stapes Erosion	Absent ($n=48$, 39.4%)	0.573**	10.9±1.5 10.8 (6.6-13.9)	0.765**
	Present ($n=74$, 60.66%)		11±1.7 11.1 (7.4-14.7)	
LSCC Fistula	Absent ($n=112$, 91.8%)	0.790**	10.9±1.6 10.9 (6.6-14.7)	0.436**
	Present ($n=10$, 8.2%)		11.4±1.3 11.7 (9.2-13.3)	

*Kruskal-Wallis test **Mann-Whitney U test
(ET: Eustachian tube, Med: Median, mm: millimeter, Min: Minimum, Max: Maximum, LSCC: Lateral semicircular canal, SD: Standard Deviation)

In the literature, ET structure (length, width and angle) has been investigated in different studies. Dinç et al.^[10] evaluated the ET angle and length of diseased and healthy ears of 125 subjects. Diseased ears were those with different kinds of chronic suppurative otitis media (CSOM) (retraction pockets, central perforation, tympanosclerosis and cholesteatoma). Their results indicated that ET angles were significantly more horizontal in ears with CSOM than in healthy ears. In a subgroup analysis, ET length was significantly shorter in subjects with central perforations than in healthy ears or middle ears with tympanosclerosis. Subjects with cholesteatoma also had a shorter ET length than subjects with retraction pockets. Paltura et al.^[11] evaluated 232 subjects with unilateral COM. The mean width of the ET isthmus was 19.47 ± 0.52 mm for healthy ears and 17.88 ± 0.53 mm for diseased ears, which showed a significant difference. Shim et al.^[12] evaluated the cross-sectional area of the air space in the ET and compared the values between 80 ears of 80 subjects with COM and 100 healthy ears of 50 subjects. The mean cross-sectional ET airspace was significantly smaller in subjects with COM than healthy ears. Also, subjects with poor postoperative aeration were found to have significantly smaller air space than healthy ears in that study.

Short ET length is also related to poor ET function in children. Doyle and Swartz evaluated the vector relationships between the ET, tensor veli palatini muscle and cranial base in 18 children and 20 adults.^[13] ET length was found to be shorter in children, which was a cause for poor ET function. Takasaki et al.^[14] demonstrated that short ET length affected tensor veli palatini muscle function negatively. Age is a factor that affects ET measurements. In our study group, the age ranged between 8 and 66 years. Takasaki et al. reported that ET angle and ET length increased commensurate with age. The values of the size and position of the ET in children aged 6 or 7 years or older are similar to those in adults.^[15]

In contrast, some reports found no correlation of ET structure and COM. Habesoğlu et al.^[16] evaluated ET angles and mastoid aeration in 25 subjects with COM. They found a significant relationship between mastoid aeration and COM, but could not demonstrate a significant relationship between ET angles and COM. Hashimoto et al.^[17] evaluated the size (length, height and width) of the bony segment of the ET in 20 subjects with middle ear cholesteatoma and found no significant relation between COM and cholesteatoma and the size of the ET bony segment.

Our study did not evaluate ET function. Although we examined a strictly defined study group by excluding factors that could affect ET function (e.g., previous nasal surgery, allergic rhinitis, craniofacial abnormality), ET length and width alone may not reflect the complete ET function. However, related functional anatomy such as the relation of the ET with the tensor veli palatine muscle and other cranial base structures, as well as ET surface area, should be assessed through gross anatomic dissections and histologic studies. There is a need for noninvasive techniques to clarify the relationship between the ET and the pathogenesis of COM. Measuring the length of the bony segment of the ET and the width of the isthmus is an easy method to use. Measurement methods of ET length and width are more reliable and may be applied easily by the physician.

An additional limitation of the present study was that the lower limit of normal values and the upper limit of pathologic values were not given separately for male and female subjects due to the high standard deviation and the low number of subjects. The absence of a pediatric patient group was also another limitation of the present study since comparing pediatric and adult patient groups in terms of ET width and length may provide a better understanding of the relationship between age and ET function.

Conclusion

The results of our study suggest that ET length and width are closely related to COM with cholesteatoma presence but not cholesteatoma aggressiveness. Measurement of ET length and width in CT scans is a basic method that can be used in clinical practice.

Acknowledgments: We would like to thank Mr. David F. Chapman for editing the English of this article.

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the Bakırköy Dr. Sadi Konuk Training and Research Hospital (Approval number: 2018/99).

Informed consent: Written informed consent was not obtained due to the retrospective nature of the study.

Author Contributions: Designing the study – F.G., Z.M.Y., M.A.A., İ.S.; Collecting the data – F.G., Ö.Y., M.A.A., İ.S.; Analysing the data – S.G., Ö.Y., Z.M.Y., E.İ.; Writing the manuscript – F.G., S.G., M.A.A., İ.S.; Confirming the accuracy of the data and the analyses – S.G., Ö.Y., Z.M.Y., E.İ., İ.S.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declare that this study has received no financial support.

References

1. Kurtgöz S, Kökten N, Tekin M. Assessment of nasal airway resistances and nasal mucociliary activities of patients with unilateral chronic otitis media by acoustic rhinometry and saccharin test. *Acta Otolaryngol* 2014;134:898-903.
2. Fireman P. Otitis media and nasal disease: a role for allergy. *J Allergy Clin Immunol* 1988;82:917-26.
3. Gencer ZK, Özkiriş M, Okur A, Karaçavus S, Saydam L. The possible associations of septal deviation on mastoid pneumatization and chronic otitis. *Otol Neurotol* 2013;34:1052-7.
4. Verhoeff M, van der Veen EL, Rovers MM, Sanders EA, Schilder AG. Chronic suppurative otitis media: a review. *Int J Pediatr Otorhinolaryngol* 2006;70:1-12.
5. Tos M, Stangerup SE, Hvid G. Mastoid pneumatization. Evidence of the environmental theory. *Arch Otolaryngol* 1984;110:502-7.
6. Khalil HM, Saleh MA, Sakr AA. A clinico-radiological study of the contralateral ear in acquired unilateral cholesteatoma. *Rev Laryngol Otol Rhinol (Bord)* 2004;125:17-22.
7. Sadé J, Avraham S, Brown M. Atelectasis, retraction pockets and cholesteatoma. *Acta Otolaryngol* 1981;92:501-12.
8. Min HJ, Kim SG, Jung JH, Jeong JH, Lee SH, Park CW. Epitympanic Development and Mastoid Pneumatization in Chronic Otitis Media with and without Cholesteatoma. [Article in Korean] *Korean J Audiol* 2011;15:25-31.
9. Chauhan B, Chauhan K. A comparative study of eustachian tube functions in normal and diseased ears with tympanometry and videonasopharyngoscopy. *Indian J Otolaryngol Head Neck Surg* 2013;65:468-76.
10. Dinç AE, Damar M, Uğur MB, et al. Do the angle and length of the eustachian tube influence the development of chronic otitis media? *Laryngoscope* 2015;125:2187-92.
11. Paltura C, Can TS, Yılmaz BK, Dinç ME, Develioğlu ÖN, Külekçi M. Eustachian tube diameter: Is it associated with chronic otitis media development? *Am J Otolaryngol* 2017;38:414-6.
12. Shim HJ, Choi AY, Yoon SW, Kwon KH, Yeo SG. The Value of Measuring Eustachian Tube Aeration on Temporal Bone CT in Patients with Chronic Otitis Media. *Clin Exp Otorhinolaryngol* 2010;3:59-64.
13. Doyle WJ, Swartz JD. Eustachian tube-tensor veli palatini muscle-cranial base relationships in children and adults: an osteological study. *Int J Pediatr Otorhinolaryngol* 2010;74:986-90.
14. Takasaki K, Sando I, Balaban CD, Miura M. Functional anatomy of the tensor veli palatini muscle and Ostmann's fatty tissue. *Ann Otol Rhinol Laryngol* 2002;111:1045-9.
15. Takasaki K, Takahashi H, Miyamoto I, et al. Measurement of angle and length of the eustachian tube on computed tomography using the multi-planar reconstruction technique. *Laryngoscope* 2007;117:1251-4.
16. Habesoglu TE, Habesoglu M, Bolukbasi S, et al. Does auditory tube angle really affect childhood otitis media and size of the mastoid? *Int J Pediatr Otorhinolaryngol* 2009;73:747-9.
17. Hashimoto K, Yanagihara N, Hyodo J, Sakagami M. Osseous eustachian tube and peritubal cells in patients with unilateral cholesteatoma comparison between healthy and diseased sides using high-resolution cone-beam computed tomography. *Otol Neurotol* 2015;36:776-81.

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported (CC BY-NC-ND3.0) Licence (<http://creativecommons.org/licenses/by-nc-nd/3.0/>) which permits unrestricted noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Please cite this article as: Gülüstan F, Güneş S, Yıldız Ö, Yazıcı ZM, Abakay MA, İnci E, Sayın İ. Relationship between Eustachian Tube Dimensions and Middle Ear Cholesteatoma. *ENT Updates* 2020;10(2): 356-361.