

The Relationship Between Eustachian Tube Diameter and Chronic Otitis Media Development

Östaki Tüp Çapının Kronik Otitis Media Gelişimi ile İlişkisi

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ABSTRACT Objective: To evaluate the diameter of the narrowest portion of the eustachian tube [osseo-cartilaginous (OC) junction] in unilateral chronic otitis media (COM) patients to determine whether this portion plays a role in the etiology. **Material and Methods:** A retrospective review was made of 146 patients who had undergone surgery for unilateral COM. The patients were separated into 2 groups; patients who had undergone tympanoplasty for COM without cholesteatoma (TP group) and patients who had undergone tympanoplasty and mastoidectomy for cholesteatoma (CH group). The contralateral healthy sides of the patients constituted the control group (CG). **Results:** In the TP group (89 patients), the mean diameter of the OC junction was 1.61±0.49 mm on the diseased side and 1.65±0.50 mm on the healthy side. In the CH group (57 patients), the mean diameter of the OC junction was 1.62±0.47 mm on the diseased side and 1.65±0.47 mm on the healthy side. Although the mean diameter was higher on the healthy side in both groups, the comparisons of the healthy side and diseased side did not show statistical significance in the TP and CH groups (respectively p=0.627; p=0.739). No statistically significant difference was determined between the TP and CH groups in respect of the OC junction diameter on the diseased side (p=0.915). **Conclusion:** The present study has shown that OC diameter is similar in different cases of unilateral COM and in healthy ears. OC diameter may be an important factor on the etiology of COM but we could not demonstrate it in our heterogenic study group.

Keywords: Eustachian tube; chronic otitis media; cholesteatoma; tomography

ÖZET Amaç: Tek taraflı kronik otitis media (KOM) hastalarında, östaki tüpünün [osseo-kartilajinöz (OK) birleşkesi] en dar kısmının çapını ölçmek ve bu bölümün etiolojide rol oynayıp oynamadığını belirlemek. **Gereç ve Yöntemler:** Tek taraflı KOM ameliyatı geçiren 146 hasta, retrospektif olarak incelendi. Hastalar 2 gruba ayrıldı; kolesteatom olmadan KOM için timpanoplasti geçiren hastalar (TP grubu) ve kolesteatom için timpanoplasti ve mastoidektomi geçiren hastalar (CH grubu). Hastaların kontralateral sağlıklı tarafları, kontrol grubunu (CG) oluşturdu. **Bulgular:** TP grubunda (89 hasta), OK birleşkesinin ortalama çapı hastalıklı tarafta 1,61±0,49 mm ve sağlıklı tarafta 1,65±0,50 mm idi. CH grubunda (57 hasta), OK birleşkesinin ortalama çapı hastalıklı tarafta 1,62±0,47 mm, sağlıklı tarafta ise 1,65±0,47 mm idi. Her 2 grupta da ortalama çap, sağlıklı tarafta daha geniş olmasına rağmen sağlıklı taraf ve hastalıklı tarafın karşılaştırmasında TP ve CH gruplarında istatistiksel olarak anlamlılık tespit edilmedi (sırasıyla p=0,627; p=0,739). TP ve CH gruplarının, kendi aralarında hastalıklı taraftaki OK birleşke çapı açısından da istatistiksel olarak anlamlı bir fark bulunmadı (p=0,915). **Sonuç:** Bu çalışma, OK birleşke çapının tek taraflı farklı KOM vakalarında ve sağlıklı kulaklarda benzer olduğunu göstermiştir. OK çapı, KOM etiolojisinde önemli bir faktör olabilir, ancak heterojenik çalışma grubumuzda bunu gösteremedik.

Anahtar Kelimeler: Östaki tüpü; kronik otitis media; kolesteatoma; tomografi

The Eustachian tube (ET), which is essential for middle ear aeration, has bony and cartilaginous parts. The anatomic or functional obstruction of the tube results in a series of symptoms and ear diseases, starting with middle ear effusion and with persisting

dysfunction, chronic otitis media (COM), retraction and perforation of the tympanic membrane, ossicle erosions and cholesteatoma formation can develop.^{1,2} The incidence of ET dysfunction in adults is approximately 1% and this increases to 70% in patients who

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undergo tympanoplasty and cholesteatoma surgeries.^{3,4} In addition, ET function has been reported to be a determinant of the success of the surgery.^{5,6}

The most common findings of ET dysfunction are mucosal edema and cartilaginous portion obstruction.^{2,7} Therefore, balloon dilatation with eustachian tuboplasty has emerged as a novel treatment modality to optimize tube function through dilation of the cartilaginous portion and remodelling of the mucosal cellular architecture.⁸ There are also conventional treatments intended to normalize middle ear pressure, including medical therapy with nasal topical corticosteroids, myringotomy and grommet tube insertion.

The junction of the bony section of the Eustachian tube with the fibrocartilaginous section constitutes the narrowest part [osseocartilaginous (OC) junction] of the canal. Therefore, this segment is the most vulnerable to mucosal inflammation. Regardless of the etiology of mucosal swelling such as allergy, infection and laryngopharyngeal reflux, the anatomic features such as the original size of the bony frame of the ET may increase the susceptibility to chronic otitis media. It has previously been suggested that a decrease in junction diameter might be an independent factor in the development of chronic otitis media.⁹ Another study claimed that the thickened mucosa of the bony segment and Eustachian tube orifice in the middle ear may act as a barrier to middle ear ventilation and thus, might be the key factor in Eustachian tuboplasty failure and this view has been supported by other studies.^{7,10,11} However, radiological studies have stated that the osseous portion of the ET is not frequently and obviously involved in this process.^{12,13}

In order to contribute to this controversial topic, the aim of this study was to investigate the diameter of the narrowest section of the ET (OC junction) in unilateral chronic otitis patients to determine whether this plays a role in the etiology.

MATERIAL AND METHODS

The study was conducted in the Department of Otolaryngology and Radiology, Ankara Numune Training and Research Hospital, Ankara, Turkey and was

approved by the Local Ethics Committee (Approval number: E1-030-2019). All procedures were applied in accordance with the principles of the Declaration of Helsinki. A retrospective evaluation was made of consecutive preoperative temporal bone CT scans of patients who had undergone surgery for COM in the Department of Otolaryngology between 2014-2018. Inclusion criteria were patients with unilateral COM, aged >18 years, with no previous trauma or otological surgery history and availability of 0.5mm multi-slice CT images. A total of 146 patients were included for the bilateral measurement of the ET OC junction. The COM patients were separated into two groups; Group 1 (TP) included patients applied with tympanoplasty for COM without cholesteatoma and Group 2 (CH) included patients who underwent tympanoplasty and mastoidectomy for cholesteatoma. The contralateral healthy sides of the patients in both groups constituted the control group (CG).

MEASUREMENTS

A 64-slice multidetector CT system (Aquilion, Toshiba Medical Systems, Shimoishigami, Otawara-Shi, Japan) was used for CT imaging and these images were evaluated and the parameters measured on the Aquarius Workstation V3.6 (TeraRecon, San Mateo, CA, USA). The imaging parameters included a slice thickness and reconstruction interval of 0.5 mm, and a field of view of 21.8 x 28.8 cm. The images were evaluated and measured separately by two experienced radiologists and the mean values were included in the statistical analysis. The OC diameters were measured on axial plane images as described in a previous study.⁹ The narrowest section of the ET (OC junction) on axial CT images was defined and the diameter of this segment was measured as demonstrated in [Figure 1](#).

STATISTICAL ANALYSIS

Data obtained in the study were analyzed statistically using SPSS version 22 software (SPSS, Chicago, IL, USA). Conformity of the data to normal distribution was assessed using the Kolmogorov–Smirnov test. Continuous variables were presented as mean \pm standard deviation values and discrete variables as frequencies and percentages. The mean diameter of the Eustachian tube OC junction of the healthy and dis-

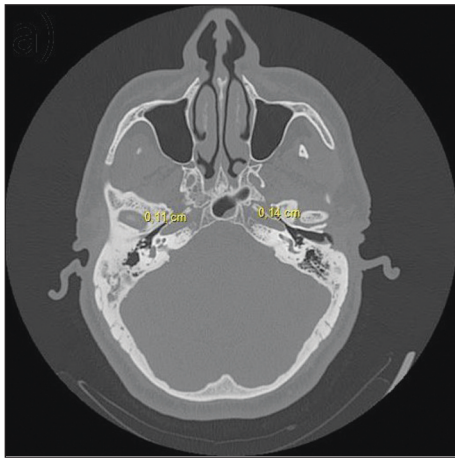


FIGURE 1: Axial images from a 48-year old patient with right-side diseased ear (cholesteatoma) and left-side healthy ear, showing the measurement of OC diameters.

eased sides was compared with the Student’s two-tailed t-test in both COM groups and the study sample as a whole. The mean OC junction diameters of both COM groups and the whole control group were compared with One-way analysis of variance (ANOVA). A value of $p < 0.05$ was considered statistically significant.

RESULTS

The present study included 146 patients [78 (53%) male, 68 (47%) female] and the mean age was 42.0 ± 13.1 years (range, 18-69 years). The tympanoplasty without cholesteatoma (TP) group of 89 patients (60%) comprised 42 (47%) males and 47 (53%) females with a mean age of 41.0 ± 13.0 years (range, 18 -68 years). The cholesteatoma surgery (CH) group of 57 (40%) patients comprised 31 (55%) males and 26 (45%) females with a mean age of 43.4 ± 13.3 years (range, 18- 69 years). The TP and CH groups were similar in terms of age and gender. ($p=0.283$ and $p=0.588$, respectively).

In the TP group, the mean diameter of the OC junction on axial CT images was 1.61 ± 0.49 mm (range, 0.70 - 3.30 mm) on the diseased side and 1.65 ± 0.50 mm (range, 0.70- 3.30 mm) on the contralateral healthy side. No statistically significant difference was determined between the OCT junction diameter values of the healthy side and diseased side in the TP group ($p=0.627$).

In the CH group, the mean diameter of the OC junction on axial CT images was 1.62 ± 0.47 mm (range, 0.80 - 2.80 mm) on the diseased side and 1.65 ± 0.47 mm (range, 0.70 -2.80 mm) on the contralateral healthy side. No statistically significant difference was determined between the OCT junction diameter values of the healthy side and diseased side in the CH group ($p=0.739$).

The comparison between the TP and CH groups of the OC junction diameter on the diseased side did not show statistical significance ($p=0.915$). The mean OC junction diameter values were higher on the healthy sides, but comparisons between the TP group, CH group and the whole control group showed no statistical significance ($p=0.825$). The analyses between the diseased side mean diameter and the contralateral healthy side mean diameter did not show a statistical significance ($p=0.538$) in the entire study group as tabulated in Table 1.

DISCUSSION

The results of the present study show that the diameter measurement of the narrowest section (OC junction) of the Eustachian tubes (ET) on CT scans does not reflect ET function and does not play a role in the development of unilateral chronic otitis media with or without cholesteatoma.

The Eustachian tube is a functional organ between the middle ear and the nasopharynx. It has three critical functions in middle ear physiology, of middle ear protection, clearance and pressure regulation. Impairment of Eustachian tube functions results in serous otitis media since the negative pressure and contamination with micro-organisms

TABLE 1: The mean diameter of the Eustachian tube osseo-cartilaginous (OC) junction in the study groups.

	Mean diameter of OC junction	Compare Means
TP (n:89)	1.61 ± 0.49 (0.70-3.30)	} $p=0.835^*$
CH (n:57)	1.62 ± 0.47 (0.80-2.80)	
CG (n:146)	1.65 ± 0.49 (0.70-3.30)	
Diseased side:146)	1.62 ± 0.48 (0.70-3.30)	} $p=0.538^+$
Healthy side (n:146)	1.65 ± 0.49 (0.70-3.30)	

* One Way ANOVA + Independent student T test.

TP: Tympanoplasty group, CH: Cholesteatoma group, CG: Control group.

result in acute otitis media. If Eustachian dysfunction persists, this process becomes chronic and complications might occur such as adhesive otitis media, tympanic membrane perforation, ossicular erosion and cholesteatoma.² Cholesteatoma etiology remains unclear and several theories have been suggested, the most convincing of which is ET dysfunction and this has been shown to be an independent risk factor.¹⁴ In addition, although the risk factors of COM such as recurrent upper airway infections, parental age, passive smoking, lower socioeconomic level and allergies are expected to affect both ears, they may also be seen in unilateral middle ear diseases.¹⁵

The importance of the ET in the middle ear has been demonstrated in many studies.^{14,16} The distal cartilaginous section of the ET has been primarily held responsible for obstructive ET dysfunction.^{17,18} In contrast, there are also studies claiming that the area where most obstruction occurs is the bony section of the ET.^{7,11} Other studies have reported that the narrowest section, the osseo-cartilaginous junction, is the most obstructed part leading to ET dysfunction.⁹ Other studies have focused on the length and angle of the ET and have shown with special MPR reconstruction that a shorter and more horizontal ET is seen more in diseased ears.¹⁹

Conventional techniques include tympanometry, Toynbee test and the Valsalva test to measure the ventilator function of ET. Recently there have been efforts to optimize and find an objective tool, with trials of questionnaires and video endoscopies.²⁰ In recent years, there have also been increasing radiological studies to evaluate ET function and Valsalva CT has been described to detect distal obstruction and it has been shown that the distal part of the ET can be examined in the great majority of the population.^{7,21} Shim et al used the largest cross-sectional area of ET on coronal images and indicated that this parameter can be used to predict postoperative middle ear aeration.²² Paltura et al reported that the OC diameter measurement was narrower on the diseased side compared with the healthy side in unilateral chronic otitis media patients.⁹ All these studies have attempted to clarify the role of ET on middle ear

pathologies and on surgical success of surgeries, as currently it is not known which part is more responsible for ET function and there is no gold standard test to evaluate this function.

The most plausible reason for using the OC diameter measurement is that it is the narrowest section of the ET and therefore could be the most vulnerable area. The underlying rationale is similar to that of the labyrinthine part of the facial nerve, which is the area most vulnerable to Bell's palsy as it is the narrowest part of the fallopian canal. In addition, it can be measured and used by the surgeon as a practical parameter without any need for extra imaging which would expose the patient to radiation. In this study, the OC junction diameter was evaluated in patients who had undergone tympanoplasty and cholesteatoma surgeries. However, in contrast to previous study results where the OC diameter has been found to be narrower on the side with middle ear pathology compared to the healthy side, in the current study, no statistically significant difference was determined between the COM side and healthy side and there was only seen to be a mild narrowness in the COM side.⁹ The two different stages of COM were compared with each other in terms of OC diameter in this study and no statistically significant difference was determined between the groups. Therefore, as the results showed no difference in OC diameter in different cases of COM and healthy ears, it was concluded that OC diameter alone is not a reliable parameter in respect of indicating ET function.

There were some limitations to this study, primarily that it was retrospective in design and so other ET functional and imaging tests could not be evaluated together with OC diameter. The study period and patient numbers could be increased to provide more robust results. However, every contribution to this controversial topic is very important to understand the physiology of ET and the pathophysiology of middle ear diseases.

CONCLUSION

The results of this study showed that OC diameter is similar in different cases of unilateral COM and in

healthy ears. OC diameter may be an important factor on the etiology of COM but we could not demonstrate it in our heterogenic study group.

Ethics Committee Approval

Ethics committee approval was received for this study from the Clinical Research Ethics Committee of University of Health Science, Ankara Numune Training and Research Hospital, (Approval number: E1-030-2019).

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: Fakih Cihat Eravcı, Mustafa Çolak; **Design:** Fakih Cihat Eravcı, Kürşat Murat Özcan, Selçuk Parlak; **Control/Supervision:** Kürşat Murat Özcan, Selçuk Parlak; **Data Collection and/or Processing:** Fakih Cihat Eravcı, Gülsüm Kübra Yıldırım, Mustafa Çolak; **Analysis and/or Interpretation:** Fakih Cihat Eravcı, Hacı Hüseyin Dere, Selçuk Parlak; **Literature Review:** Fakih Cihat Eravcı, Mustafa Çolak, Gülsüm Kübra Yıldırım; **Writing the Article:** Fakih Cihat Eravcı, Gülsüm Kübra Yıldırım, Mustafa Çolak; **Critical Review:** Kürşat Murat Özcan, Selçuk Parlak, Hacı Hüseyin Dere.

REFERENCES

- Schilder AGM, Bhutta MF, Butler CC, Holy C, Levine LH, Kvaerner KJ, et al. Eustachian tube dysfunction: consensus statement on definition, types, clinical presentation and diagnosis. *Clin Otolaryngol.* 2015;40(5):407-11.[Crossref] [PubMed] [PMC]
- Schröder S, Lehmann M, Ebmeyer J, Upile T, Sudhoff H. Balloon eustachian tuboplasty: a retrospective cohort study. *Clin Otolaryngol.* 2015;40(6):629-38.[Crossref] [PubMed]
- Choi SH, Han JH, Chung JW. Pre-operative evaluation of eustachian tube function using a modified pressure equilibration test is predictive of good postoperative hearing and middle ear aeration in type 1 tympanoplasty patients. *Clin Exp Otorhinolaryngol.* 2009;2(2):61-5.[Crossref] [PubMed] [PMC]
- Todd NW. There are no accurate tests for eustachian tube function. *Arch Otolaryngol Head Neck Surg.* 2000;126(8):1041-2.[Crossref] [PubMed]
- Dörrie A, Dommerich S, Pau HW. [Early postoperative middle-ear ventilation--risk for the transplant or guarantee for aeration of the tympanic cavity?]. *Laryngorhinootologie.* 2003; 82(2):102-4.[Crossref] [PubMed]
- Sato H, Nakamura H, Honjo I, Hayashi M. Eustachian tube function in tympanoplasty. *Acta Otolaryngol Suppl.* 1990;471:9-12.[Crossref] [PubMed]
- Tarabichi M, Najmi M. Site of eustachian tube obstruction in chronic ear disease. *Laryngoscope.* 2015;125(11):2572-5.[Crossref] [PubMed]
- McMurrin AEL, Hogg GE, Gordon S, Spielmann PM, Jones SE. Balloon eustachian tuboplasty for eustachian tube dysfunction: report of long-term outcomes in a UK population. *J Laryngol Otol.* 2020;134(1):34-40.[Crossref] [PubMed]
- Paltura C, Selçuk Can T, Yılmaz BK, Dinç ME, Develioğlu ÖN, Külekçi M. Eustachian tube diameter: is it associated with chronic otitis media development? *Am J Otolaryngol.* 2017;38(4):414-6.[Crossref] [PubMed]
- Christov F, Gluth MB. Histopathology of the mucosa of eustachian tube orifice at the middle ear in chronic otitis media with effusion: possible insight into tuboplasty failure. *Ann Otol Rhinol Laryngol.* 2018;127(11):817-22.[Crossref] [PubMed]
- Linstrom CJ, Silverman CA, Rosen A, Meiteles LZ. Eustachian tube endoscopy in patients with chronic ear disease. *Laryngoscope.* 2000;110(11):1884-9.[Crossref] [PubMed]
- Smith ME, Scoffings DJ, Tysome JR. Imaging of the eustachian tube and its function: a systematic review. *Neuroradiology.* 2016;58(6): 543-56.[Crossref] [PubMed] [PMC]
- Jen A, Sanelli PC, Banthia V, Victor JD, Selsnick SH. Relationship of petrous temporal bone pneumatization to the eustachian tube lumen. *Laryngoscope.* 2004;114(4):656-60. [Crossref] [PubMed]
- Jain S, Singh P, Methwani D, Kalambe S. Role of eustachian dysfunction and primary sclerotic mastoid pneumatization pattern in aetiology of squamous chronic otitis media: a correlative study. *Indian J Otolaryngol Head Neck Surg.* 2019;71(Suppl 2):1190-6.[Crossref] [PubMed] [PMC]
- Fliss DM, Shoham I, Leiberman A, Dagan R. Chronic suppurative otitis media without cholesteatoma in children in southern Israel: incidence and risk factors. *Pediatr Infect Dis J.* 1991;10(12):895-9.[Crossref] [PubMed]
- Wolfman DE, Chole RA. Experimental retraction pocket cholesteatoma. *Ann Otol Rhinol Laryngol.* 1986;95(6 Pt 1):639-44.[Crossref] [PubMed]
- Takahashi H, Honjo I, Fujita A. Endoscopic findings at the pharyngeal orifice of the eustachian tube in otitis media with effusion. *Eur Arch Otorhinolaryngol.* 1996;253(1-2):42-4.[Crossref] [PubMed]
- Edelstein DR, Magnan J, Parisier SC, Chays A, Isaacs RS, Gignac D, et al. Microfiberoptic evaluation of the middle ear cavity. *Am J Otol.* 1994;15(1):50-5.[PubMed]
- Dinç AE, Damar M, Uğur MB, Öz II, Eliçora SŞ, Bişkin S, et al. Do the angle and length of the eustachian tube influence the development of chronic otitis media? *Laryngoscope.* 2015;125(9):2187-92.[Crossref] [PubMed]
- Han WG, Yoo J, Rah YC, Chang J, Im GJ, Song JJ, et al. Analysis of eustachian tube dysfunction by dynamic slow motion video endoscopy and eustachian tube dysfunction questionnaire in chronic otitis media. *Clin Exp Otorhinolaryngol.* 2017;10(4):315-20.[Crossref] [PubMed] [PMC]
- Tarabichi M, Najmi M. Visualization of the eustachian tube lumen with valsalva computed tomography. *Laryngoscope.* 2015;125(3):724-9.[Crossref] [PubMed]
- 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(2):59-64.[Crossref] [PubMed] [PMC]