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Eustachian tube diameter: Is it associated with chronic otitis media development?

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ABSTRACT

Objective: To evaluate the effect of ET diameter on Chronic Otitis Media (COM) pathogenesis.
Study design: Retrospective.
Subjects and methods: Patients with unilateral COM disease are included in the study. The connection between fibrocartilaginous and osseous segments of the Eustachian Tube (ET) on axial Computed Tomography (CT) images was defined and the diameter of this segment is measured. The measurements were carried out bilaterally and statistically compared.
Results: 154 (76 (49%) male, 78 (51%) female patients were diagnosed with unilateral COM and included in the study. The mean diameter of ET was 1947 mm (Std. deviation ± 0.5247) for healthy ears and 1788 mm (Std. deviation ± 0.5306) for diseased ears. The statistical analysis showed a significantly narrow ET diameter in diseased ear side ($p < 0.01$).
Conclusion: The dysfunction or anatomical anomalies of ET are correlated with COM. Measuring of the bony diameter of ET during routine Temporal CT examination is recommended for our colleagues.

1. Introduction

Chronic Otitis Media (COM) is a multifactorial disease with a complex nature of occurrence. Upper airway infections, recurrent otitis media, dysfunction of the Eustachian tube (ET) and nasopharynx, ciliary dysfunction, and allergy are among the investigated probable risk factors [1]. COM is defined as the chronic infection and inflammation of the middle ear and mastoid cavity lasting more than 3 months and causing ear discharge, hearing loss and tympanic membrane perforation [2].

The Eustachian Tube (ET), involves a critical role in development of COM [3,4,5]. Pressure equalization, mucociliary clearance and protection of the middle ear are the three main functions of the ET [4,6]. The ET is composed of fibrocartilaginous and bony segments. The bony segment is completely located in the petrous portion of the temporal bone and it lies on the anterior wall of the middle ear [7]. In healthy individuals, the bony segment is always open but the fibrocartilaginous portion is closed at rest and opens during swallowing, yawning, sneezing or by Valsalva Maneuver [7]. The bony and fibrocartilaginous segments meet by an irregular bony structure [7].

The current medical literature supports the evidence that anatomic and functional problems of ET may play a role in COM pathogenesis [1–7]. Doyle [8] reported an animal study that concludes failure of the ET to open causes an inflammation and leads to mucosal disturbances similar to that of otitis media with effusion (OME). He also concluded that the duration of the obstruction is correlated with the severity of the disease. Also in some patients who have structural anomalies of ET, like Down Syndrome or craniofacial anomalies, there is an increased risk of development of middle ear disease [9].

The ET anatomy, physiology and function need to be clarified to understand the pathogenesis of COM. In this retrospective research we measured the bony segment diameter of the ET bilaterally with Temporal Bone Computed Tomography (CT) right at the connection between bony and fibrocartilaginous segments in patients with unilateral COM. Only unilateral COM patients were included to our study because our aim was to evaluate the effect of ET diameter on COM.

2. Material and method

The study was reviewed and approved by the institutional review board at the GOP Taksim Education and Research Hospital (32/10.08.2016). Our data is obtained from the Ear Nose and Throat and Radiology Departments of Haseki Education and Research Hospital, in between June 2015 and January 2016. The patients who were both clinically and radiologically diagnosed with unilateral COM (tympanic membrane perforation with or without purulent discharge) and had

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undergone Tympanoplasty with or without Mastoidectomy were enrolled in this study. The Temporal bone CT's of patients who had soft tissue inflammation or infection at middle ear and/or mastoid cavities were included to study. The patients with bilateral disease, tympanic membrane perforation without mastoid or middle ear inflammation, craniofacial anomalies and ET obstruction were excluded. The junction between bony and fibrocartilaginous segments of the ET were measured bilaterally and diseased and healthy sides were compared for the statistical analysis.

3. Measurement

The measurements are collected by only one radiologist for excluding person to person variation. A multidetector CT system (Brilliance 64, Philips Medical System Cleveland Ohio) was used for CT imaging. Imaging parameters included a slice thickness and reconstruction interval of 0.5 mm, a pitch of 0.652, and a field of view of 25 × 25 cm. Images were transferred to an offline Picture Archiving and Communication System (PACS). ET bony diameters were measured on axial plane images. The connection between fibrocartilaginous and osseous segments of the ET which is the most irregular and narrowest portion on axial CT images was defined and the diameter of this segment is measured (Fig. 1, Fig. 2). The measurements were carried out bilaterally.

4. Statistical analysis

Normalisation control is undergone by drawing graphics with single-sample Kolmogorov Smirnov test, histogram, Q-Q plot and box plot. The data are given as standard deviation, minimum, maximum, frequency and percentage. The differences between the healthy and diseases ET diameters are evaluated by paired *t*-test. Significance interval is taken with $p < 0.05$ and bidirectionally. NCSS 10 program is used for analysis.

5. Results

154 (76 (49%) male, 78 (51%) female) patients were diagnosed with unilateral COM and included in the study. The mean age was 38,55 with a range of 9 to 81 years (median age 39). The mean age was 37,80 for males and 39,27 for females. Of these patients, 74 (48%) had right ear disease and 80 (52%) had left ear disease. The mean diameter of ET was 1947 mm (Std. deviation ± 0.5247) for healthy ears and 1788 (Std. deviation ± 0.5306) for diseased ears. The statistical analysis showed a significantly narrow ET diameter in diseased ear side ($p < 0.01$) (Table 1).

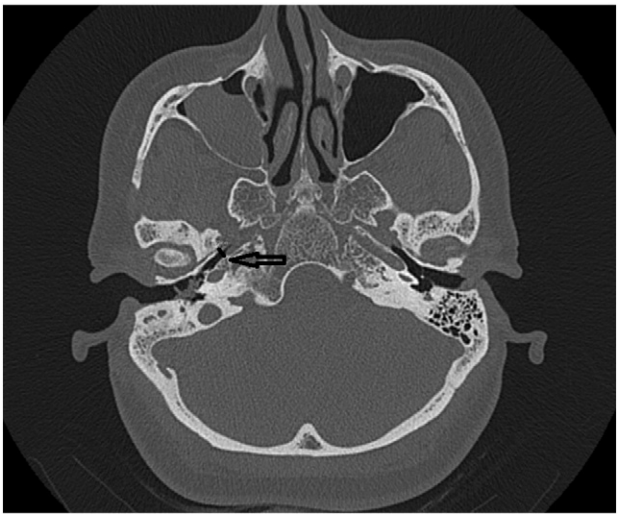

Fig. 1. Arrow head showing the narrowest portion of the bony Eustachian tube.

Fig. 2. Right diseased and left healthy ears ET diameter measurement.

6. Discussion

Patency of ET is not the only key point in the pathogenesis of COM but its dysfunction or inflammation increases the risk of the disease [3,7]. According to Schilder et al. [4] there are three types of ET dysfunction. These are dilatory dysfunction, baro-challenge-induced dysfunction and patulous dysfunction. ET dysfunction causes a negative pressure in the middle ear which can be a reason for COM, otitis media with effusion, retraction pocket or atelectasis.

The basic definition of COM is chronic inflammation of the middle ear and/or mastoid mucosa in which the tympanic membrane is not intact and there is hearing loss [9]. History of acute and recurrent otitis media, parental history of chronic otitis media, and crowded conditions are significant risk factors for COM [10]. But also there are some other risk factors such as recurrent upper airway infections, sex, parental age, passive smoking, dysfunction of the ET and nasopharynx, ciliary dysfunction, and allergy [10]. All of these factors cause bilateral disease but why some patients develop COM unilaterally question remains unexplained. Agius et al. [11] found that reduced ciliary function of the middle ear and ET mucosa impairs the clearance of middle ear secretions and this may facilitate the progression from acute otitis media or otitis media with effusion into COM. This ciliary inactivity lead researches to examine mucociliary activities of patients who had unilateral COM [1,2,6]. Kurtgoz [2] and Cingi et al. [6] found significant decreased mucociliary activity at diseased side but Toros et al. [1] could not got the same result. In those studies function of the ET in terms of correlation with unilaterality was evaluated. The role of anatomic abnormalities in pathogenesis was remained unanswered.

Kanzaki et al. [12] was first to use computerized tomography (CT) to detect ET anatomy and its role in patients with COM. They inserted contrast material through ET to see middle ear anatomic structures. Şırıkcı et al. [13] used Temporal bone CT scans to measure the distance between the Henle spine and sigmoid sinus and the angle of the auditory tube and their significance. Later Satar et al. [14] found narrow ET to tympanic cavity angle in patients with adhesive otitis media. Habeşoglu et al. [15] again used CT to detect ET angle in patients with COM. Dinç et al. [16] compared the ET angle and length of ears with and without COM to determine the relationship between ET anatomy and the

Table 1
The diameter measurement and comparison between the diseased side ET and healthy side ET.

	Number	Mean	Median	Std. deviation	*P* value
Diseased side ET	154	1788	1800	±0,5306	
Healthy side ET	154	1947	1900	±0,5247	
Difference	154	−0.1591		±0,5050	0,000

development of COM. They found shorter ET with horizontal configuration in patients with diseased ears [16]. Our study in some way resembles in purpose with this study. We used CT to measure the ET bony diameter to find any explanation in patients with unilateral COM. This measurement is very simple and not time consuming. The measurement can be done with temporal CT scans that we already used preoperatively. It does not need any extra shot or radiation. It can be one of the sentences that found in routine CT reports to inform the surgeon for the anatomy of ET. Reduced diameter of the bony segment on the diseased side may not be the only cause of COM by itself. This reduced diameter may be the result of a long standing ET dysfunction which can inhibit the growth of bony segment. As long as the duration of COM is not known, the exact mechanism could not be presumed. But ET dysfunction is one of the accepted mechanisms. In this study we found a positive correlation between the size of the ET bony segment and COM on the affected side which brings a perspective in expounding the effect of anatomic causes in COM pathophysiology. This result can be interpreted in two ways. First one is a genetically malformed ET may lead to COM and second one is the ET dysfunction at these patients may inhibited the growth of ET.

The ET anatomy can also help to predict the surgical result. In a similar research Shim et al. [17] found that larger cross-sectional area of ET on the preoperative coronal images is associated with better postoperative results. They suggested us to examine patients CT's for ET aeration prior to surgery to get better results.

The diameter of ET may play a role in the pathophysiology of COM and also may influence surgical results. During temporal CT examinations the diameter or surface area of ET can be one of the parts that could be examined. We wanted to take an attention to the importance of this simple technique in routine CT evaluation for the diagnosis and surgical outcome.

There were some limitations to this study. First of all we didn't know the time of onset or duration or extent of COM at these patients. Some patients may had COM since childhood which might prevent the growth of bony segment. Some patients might have more extensive disease than others. To minimize these problems we included patients who had radiologically diseased middle and/or mastoid cavities. The patients with bilateral disease or without any inflammation at these cavities were excluded. Even so future studies should include patients from the start of the disease and examine patients till adulthood when all the bony maturation stops.

7. Conclusion

ET plays an important role in COM pathophysiology. ET has bony and fibrocartilaginous parts. For its proper function these parts should be anatomically and functionally patent. As the dysfunction of ET can lead to COM formation, anatomical anomalies of ET are correlated with COM. As a conclusion we suggest our colleagues to measure the bony diameter of ET during routine Temporal CT examination and include this measurement in preoperative work-up.

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