ORIGINAL ARTICLE

The evaluation of the angles of Eustachian tubes in the patients with chronic otitis media on the temporal computerized tomography

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Abstract

Introduction: Chronic otitis media (COM), affecting all over the world and in a wide range of age groups in Turkey, is an important cause of ear discharge and hearing loss. The main clinical manifestations are tympanic membrane perforation, ear, nose and throat problems. On the tympanic membrane perforation becomes persistent and cholesteatoma development, there are a lot of opinions today. Especially in the pathology associated with otitis media with effusion eustachian tube, it is known that COM and cholesteatoma develop.

Materials and Methods: In our study, we interpreted 210 patients' temporal computed tomography (CT). Seventy of these 210 patients had otitis media with cholesteatoma, 70 patients had only otitis media without cholesteatoma, and 70 patients had no otitis media. The eustachian tubes were evaluated using temporal CT multiplanar reconstruction method. Angles with the horizontal plane of the eustachian tube and Reid and tubotympanic angles were measured.

Results: The angles between eustachian tube and horizontally oriented Reid plane of the patients with cholesteatoma were found to be significantly lower than the patients with otitis media without cholesteatoma and the patients with no history of otitis media. For the tubotympanic angle, no statistically significant differences were observed between the groups.

Conclusion: These results suggest that the decrease in the angle with the horizontal plane of Reid in the eustachian tube in adults may play a significant role in the etiology of cholesteatoma.

Key words: Cholesteatoma, chronic otitis media, eustachian tube, eustachian tube dysfunction, high-resolution temporal computerized tomography, rekonstructionmultiplanar technique

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Introduction

Chronic otitis media (COM) is characterized by hearing loss, chronic infection, and inflammation of the middle ear and mastoid air space. COM in our country is still a common disease. The detection time of COM is important because medical and surgical treatment can prevent intracranial–extracranial complications of this disease. Relationship between COM with the eustachian tube anatomical and physiological abnormalities has been described in many studies before. There are many factors in the COM. One of these factors is dysfunction of the eustachian tube. In

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particular, the results of the eustachian tube dysfunction, atelectasis, and going cholesteatoma are supported by studies.[1] Anatomy of eustachian tube is associated with otitis media. The studies about the anatomy of eustachian tube show us that the differences of the physiology of eustachian tube due to anatomical variants may result otitis media. The eustachian tube as it is known has important tasks on middle ear function and physiology. Middle ear ventilation, drainage, and protection of the middle ear to pathogens are major functions of the eustachian tube. Earlier studies showed that the eustachian tubes were shorter and were more horizontally located in children than in adults.[2] This condition might increase otitis media in children.

The angles relative to the plane of the eustachian tube have previously been measured in a lot of work. These measurements were obtained in mostly cadaver studies. In various studies with the temporal bone computed tomography (CT), the eustachian tube placement was assessed according to the relationship to other structures.[3,4]

Reid horizontal plane was found in 1962 by the world federation of radiology, bilateral inferior orbital wall and superior walls of the bilateral external ear canal.[5,6] This plane is considered to be the position at which the head in a neutral anatomical position. Reid plane-eustachian tube angle is defined as the angle between tympanic pharyngeal orifice and Reid plane. Tubotympanic angle is an angle more recently associated with COM and cholesteatoma. This angle is defined as the angle of the longitudinal axis of the eustachian tube along the tympanic orifice and the longitudinal axis of the center the bony external ear canal of the bone in the axial plane.

The purpose of this study is to measure the angles of Reid horizontal plane with the eustachian tube and tubotympanic angles in patients with COM with or without cholesteatoma and in the patients with no history of COM and to determine whether there is a relationship between these angles.

Materials and Methods

This is a retrospective study. In this study, 140 patients with a diagnosis of chronic otitis media (70 of them cholesteatoma, the other 70 patients without cholesteatoma) 70 patients with no history of COM. These patients were chosen retrospectively by the interpreting of temporal CT scans. Forty-nine patients had unilateral cholesteatoma and 21 patients had bilateral cholesteatoma. In the other group with COM without cholesteatoma, 48 patients had unilateral disease and the rest 22 patients had bilateral disease.

The patients' ages were between 13 and 72. In all groups male to female ratios were approximately 1. Patients with COM with cholesteatoma and COM without cholesteatoma were studied in two groups. The diagnosis of cholesteatoma is made by mastoidectomy results or physical findings examination and imaging features. Patients with COM who do not cholesteatoma were selected among the patients with no findings of cholesteatoma in the physical examination and imaging, and with a history of type 1 tympanoplasty. For the normal individuals, patients were chosen among the patients with no history of COM and had a temporal CT examination for another reason. Patients who had undergone tympanomastoidectomy are not included in the study.

For the temporal CT scanning, a multislice CT (Siemens Somatom Sensation 40/64, Erlangen, Germany) was used. The slice thickness was 1 mm. CT scans were analyzed at a workstation. First of all, tympanic and pharyngeal orifices of the eustachian tubes were determined in the axial slices. The horizontal plane, crossing bilateral inferior orbital wall and the bilateral upper wall of the external ear canal bilateral plane known as "Reid horizontal plane," is selected. The orifices of eustachian tubes can be seen in the same section by using multiplanar reconstruction technique in the coronal images. Pharyngeal and tympanic orifices of the eustachian tubes were demonstrated exactly at the same section. This direction was determined as the line of the eustachian tube. The angle was measured between the horizontal plane and this line [Figure 1].

In addition, tubotympanic angle was measured in all patients. Tubotympanic angle was considered the angle between the line extending through the tympanic orifice of the eustachian tube and the center of the longitudinal axis drawn from the bony external ear canal center [Figure 2].

Measurements were performed separately by two different physicians by consensus. COM with and without cholesteatoma patients and normal subjects were compared. Then, the angles were compared with healthy ear in individuals with unilateral disease.

Statistical evaluation

Number Cruncher Statistical System 2007 Statistical Software (Utah, USA) was performed with the program package.

Descriptive statistical methods for the evaluation of the data (mean, standard deviation) as well as comparisons between groups in the one-way analysis of variance sub-group comparisons Tukey's multiple comparison test, independent *t*-test to compare the two groups, left–right comparison measurements by matched *t*-test, Chi-square comparisons of qualitative data test were used. The intraclass reliability for measuring the correlation coefficient was calculated. The $P < 0.05$ level was assessed at 95% confidence.

Results

In this study, 70 patients with COM with cholesteatoma, 70 individuals with COM without cholesteatoma, and 70 patients without any types of otitis media (acute, chronic, serous and adhesive otitis media) in temporal CT have been viewed from a total of 210 individuals. Men and women were included equally in the study.

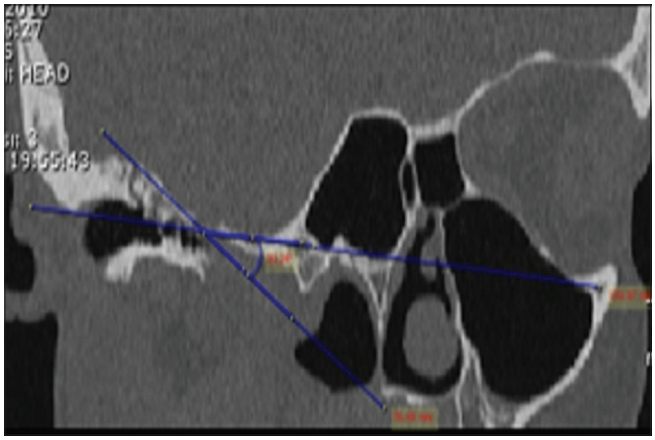

Figure 1: The measurement of the angle of between eustachian tube and Reid plane in a 25-year-old male patient

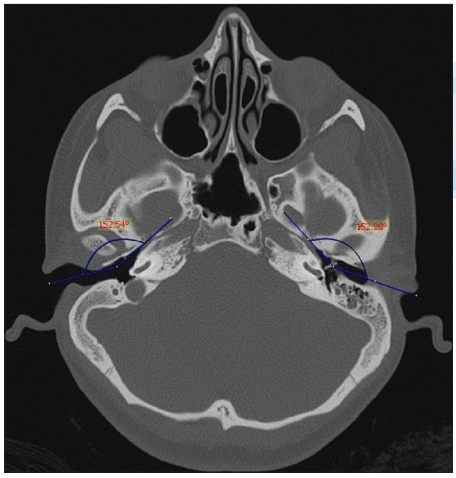

Figure 2: The measurement of tubotympanic angle in a 25-year-old female patient

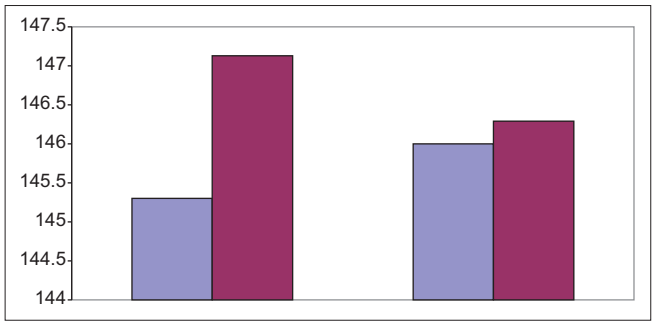

Figure 3: Angles according to reid (column with dark pink color: Healthy ear), chronic otitis media with cholesteatoma, chronic otitis media without cholesteatoma

The mean angles between the plane of the eustachian-Reid in the patients with COM and cholesteatoma were statistically significantly lower than ($P < 0.05$) the other groups [Figure 3].

There was statistically no difference between the normal and diseased angles of the planes of the eustachian-Reid in the patients with COM and cholesteatoma ($P > 0.05$).

There was statistically no difference between angles of the planes of the eustachian-Reid of the healthy and diseased ears in the patients with COM but without cholesteatoma ($P > 0.05$).

In patients with cholesteatoma, tubotympanic angles of diseased ears were statistically significantly lower than the healthy ear ($P < 0.05$).

In the COM patients without cholesteatoma, tubotympanic angles of diseased ears were statistically significantly lower than the healthy ear ($P < 0.05$).

There is statistically significant difference between the ears of COM with cholesteatoma, COM without cholesteatoma and normal ears ear ($P < 0.05$).

The mean value of eustachian-Reid angles in the patients of COM with cholesteatoma was statistically significantly lower than the angles of the patients with COM without cholesteatoma and normal ears ($P < 0.05$).

There was no statistically meaningful difference between the COM without cholesteatoma and normal ears ($P > 0.05$).

There is no statistically significant difference between the tubotympanic angles of COM with cholesteatoma, COM without cholesteatoma, and normal ears ear ($P > 0.05$).

Discussion

Although it is a common problem throughout the world, the etiology of COM is still not able to be clarified. Genetic and/or environmental factors are thought to increase the progression of chronic conditions. According to the genetic theory of the temporal bone pneumatization, the pneumatization is genetically determined and bad pneumatized ears are candidates for COM.[7] The environmental theory supporters claim that environmental factors such as frequent upper respiratory tract infections, poor living conditions and smoking that causes chronic otitis make development make reduced temporal air

pneumatization.[8,9] Another theory that there may be associated variations in the craniofacial anatomy of middle ear disease.[10,11] Many studies about craniofacial anatomic variations and their relationship between otitis media are available. These middle ear atelectasis of the lower mastoid pneumatization studies, cholesteatoma, and effusion has been shown to be associated with COM.[12-14] Usually, COM is observed in patients with sclerosis of the mastoid air cells usually. But the development of chronic otitis due to reduced mastoid pneumatization or undeveloped mastoid mastoid air cells caused by COM in the air system is still a controversial issue. Todd *et al*. in their study on 35 adult cadavers showed that interaural short distance and shortness of the eustachian tube are associated with otitis media.[11] In a study by Corns *et al.*, of the 30 children with otitis media and 30 healthy children comparing the children with otitis to healthy childrens' nasomaxillary complex, bony portion of the eustachian tube, vertical portion of the mastoid and pneumatic systems, development of the process of the tensor veli palatine muscle assessed by lateral cephalografi and these parameters were lower compared with normal children.[15] Due to the relationship with otitis media, the eustachian tube is the most studied anatomical structure on it. Anatomy of the studies carried out in children and in adults, and the eustachian tube physiology focuses on the differences and susceptibility to otitis media may be related to these differences. In one study, the angle of infants according to the horizontal plane of the eustachian tube is approximately 10° and in adults it is reported to reach up to about 45°.[16] In another study in adults in the sagittal plane, the angle is 45°, in the horizontal plane it is reported to be between 30° and 40°.[17] Also Schwalbe found this average angle as 30° in adults.[18] Graves and Edwards found as the 30°–40°.[19] These differences between children and adults are not limited to angles. Other differences compared adults to children and infants; the eustachian tube is shorter and looser in the children.[20] Studies of the eustachian tube in children show that reaches the same features of adult eustachian tube approximately 7 years old.[20,21] Another angle defined in relation to the eustachian tube is tubotympanic angle. There are a lot of studies in the literature related to this angle. In children and infants, eustachian tube angulation is different from the adult. This makes a less stable relationship between tensor veli palatini muscle and eustachian tube. This is thought to cause otitis media related to dysfunction of eustachian tube and middle ear clearance problems.[22,23] In the same way, Swarts and Rood showed that there are more stable tensor veli palatine muscles in adults compared to children.[24] Infants and susceptibility to otitis media in infants are associated with the eustachian tube and the children. Proctor *et al*. studied on the angular measurements of adults eustachian tube.[16] These measurements are measurements in normal children and adults. Therefore there is unclear relationship between the angles and eustachian otitis media. Indeed Takasaki *et al*., search to demonstrate a relationship in their study on the children with or without otitis media and measured the angles to the horizontal of the eustachian tube and they do not see the difference.[25] The eustachian tubes in both groups are short and horizantally located. So, they claimed that the horizontal eustachian tube is not a significant major etiological factor in the development of otitis media. However, some studies showed that eustachian tube dysfunction and mastoid pneumatization may play a key role in the adhesive otitis media in adults, serous otitis media, or cholesteatoma. Plain and Fuschs, in their study in adults, showed that the aeration of the middle ear and mastoid and function of eustachian tube stated that the major factor on the development of serous otitis media in adults.[26] Likewise Sade stated that wide mastoid pneumatization provides good aeration of the middle ear.[27] In the literature, the horizontal angle of the plane of the eustachian tube is one of the first studies that reported study by Proctor.[16] Our study is the standard horizontal plane angle measurement according to Reid made previously been used in the two studies. One of these studies was made by Takasaki *et al*.[25] In our study, we have used as well as multiplanar reconstruction techniques. In their study, 27 patients were reported with otitis media and 25 healthy children without and 45 adult individuals without any ear disease. In our study, only adult individuals (including children under the age of adolescence) CT were used. By the age of 7 years the anatomical features of the eustachian tube become to the adult form as adults under the age of 7 individual studies were not included in BT.

Takasaki *et al*. detected the eustachian tube angles in Reid plane 27.3° ± 2° for the right ear, 27.3° ± 2.8° for the left ear in the normal adult population. These angles of the children were found significantly lower (for the right ear 20.4° ± 3.5°, for the left ear 21.2° ± 4.8° in the children with effusion and serous otitis media; the angles in the children with otitis media without effusion were 19.9° ± 3° right, left 20.0° ± 3.6°, $P < 0.01$). There was no significant difference when compared the angles of eustachian tube in the children of serous otitis media to healthy children ($P > 0.01$). In our study, the mean according to Reid plane was measured in intact adult 28.84° ± 3.97°. Here, the angle measurement according to Reid plane of the eustachian tube in normal individuals was seen to be close to his measure of Takasaki *et al*. In our study, the angle measurements of ears with cholesteatoma and COM without cholesteatoma were compared to angle measurements in adult patients with normal ears. The results showed significantly lower angles in the ears of cholesteatoma than the angles of normal ears. We found the angle in the patients with cholesteatoma and COM as 26.85° ± 4.04°. This value is actually very close to the values in normal individuals in the study by Takasaki *et al*. But there is significantly lower compared to that of the normal ear, the difference brings to mind the idea may be a factor in combination with other factors in the development of cholesteatoma in these patients. At the

same time, measurements in COM without cholesteatoma were significantly higher than those measured in the ear cholesteatoma. The average angle of the ear with COM without cholesteatoma in the Reid was 28.94° ± 4.06° in our study. This value is very close to measurements in normal ears.

We found the average value of tubotympanic angles 145.17° ± 6.36 in the patients with unilateral COM and cholesteatoma this value was 147.13° ± 6.38° for the healthy ear of the same patient. These values for the patients with unilateral COM without cholesteatoma were 144.58° ± 6.72° and 146.29° ± 5.82°, respectively.

But for the patients with bilateral disease, there was no difference between the tubotympanic angles of normal and control group.

Conclusion

COM is still a common problem in the world. We detected in our study that cholesteatoma correlated to the angle between eustachian tube and horizontal plane ($P = 0.0001$). Although cholesteatoma is a multifactorial disorder, this angle may be used as a prognostic factor for the development of cholesteatoma.

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Conflicts of interest
There are no conflicts of interest.

References

1. Seibert JW, Danner CJ. Eustachian tube function and the middle ear. Otolaryngol Clin North Am 2006;39:1221-35.
2. Cummings BJ, Fredrickson JM, Harker LA, Krause CJ, Richardson MA, Schuller DE, *et al.* Anatomy and Physiology of the Eustachian Tube. 3rd ed., Vol. 4. St. Louis: Mosby-Year Book, Inc.; 1998.
3. Fujii N, Inui Y, Katada K. Temporal bone anatomy: Correlation of multiplanar reconstruction sections and three-dimensional computed tomography images. Jpn J Radiol 2010;28:637-48.
4. Yoshida H, Kobayashi T, Takasaki K, Takahashi H, Ishimaru H, Morikawa M, *et al.* Imaging of the patulous eustachian tube: High-resolution CT evaluation with multiplanar reconstruction technique. Acta Otolaryngol 2004;124:918-23.
5. Cho ZH. 7.0 Tesla MRI Brain Atlas*: In Vivo* Atlas with Cryomacrotome Correlation. İntroduction 2; 2010.
6. Kretschmann HJ, Weinrich W. Neuroimaging and Clinical Neuroanatomy: Magnetic Resonance İmaging. Vol. 1. Stuttgart: Thieme; 2010. p. 4.
7. Diamant M. Otitis and pneumatization of the mastoid bone. Acta Otolaryngol 1940;40 Suppl (1-149):1.
8. Tumarkın A. On the nature and vicissitudes of the accessory air spaces of the middle ear. J Laryngol Otol 1957;71:65-99.
9. Unsal EE, Ensari S, Koç C. A rare and serious complication of chronic otitis media: Lateral sinus thrombosis. Auris Nasus Larynx 2003;30:279-82.
10. Todd NW, Martin WS. Relationship of eustachian tube bony landmarks and temporal bone pneumatization. Ann Otol Rhinol Laryngol 1988;97(3 Pt 1):277-80.
11. Todd NW. Cranial anatomy and otitis media: A cadaver study. Am J Otol 1998;19:558-64.
12. Bayramoglu I, Ardiç FN, Kara CO, Ozüer MZ, Katircioglu O, Topuz B. Importance of mastoid pneumatization on secretory otitis media. Int J Pediatr Otorhinolaryngol 1997;40:61-6.
13. Iino Y, Imamura Y, Hiraishi M, Yabe T, Suzuki J. Mastoid pneumatization in children with congenital cholesteatoma: An aspect of the formation of open-type and closed-type cholesteatoma. Laryngoscope 1998;108:1071-6.
14. Sadé J, Fuchs C. A comparison of mastoid pneumatization in adults and children with cholesteatoma. Eur Arch Otorhinolaryngol 1994;251:191-5.
15. Kemaloglu YK, Göksu N, Ozbilen S, Akyildiz N. Otitis media with effusion and craniofacial analysis-II: Mastoid-middle ear-eustachian tube system in children with secretory otitis media. Int J Pediatr Otorhinolaryngol 1995;32:69-76.
16. Proctor B. Embryology and anatomy of the eustachian tube. Arch Otolaryngol 1967;86:503-14.
17. Prades JM, Dumollard JM, Calloc'h F, Merzougui N, Veyret C, Martin C. Descriptive anatomy of the human auditory tube. Surg Radiol Anat 1998;20:335-40.
18. Schwalbe G. Lehrbuch der anatomie der Sinnesergare. Erlangen: Besold; 1887.
19. Graves GO, Edwards LF. The eustachian tube. A review of its descriptive, microscopic, topographic and clinical anatomy. Arch Otolaryngol 1944;39:359-97.
20. Sadler-Kimes D, Siegel MI, Todhunter JS. Age-related morphologic differences in the components of the eustachian tube/middle ear system. Ann Otol Rhinol Laryngol 1989;98:854-8.
21. O'Donoghue GM, Jackler RK, Jenkins WM, Schindler RA. Cochlear implantation in children: The problem of head growth. Otolaryngol Head Neck Surg 1986;94:78-81.
22. Bylander A, Tjernström O. Changes in eustachian tube function with age in children with normal ears. A longitudinal study. Acta Otolaryngol 1983;96:467-77.
23. Bylander A, Tjernström O, Ivarsson A. Pressure opening and closing functions of the eustachian tube by inflation and deflation in children and adults with normal ears. Acta Otolaryngol 1983;96:255-68.
24. Swarts JD, Rood SR. Preliminary analysis of the morphometry of the infant *Eustachian tube*. In: Aksoy S, Sayin I, Yazici ZM, Kayhan FT, Karahasanoglu A, Inci E, editors. Recent Advances in Otitis Media: Proceedings of the Fifth İnternational Symposium, May 20-4, 1991. Ft. Lauderdale, FL. Hamilton (ON): BC Decker Inc.; 1993. p. 111-3.
25. Takasaki K, Takahashi H, Miyamoto I, Yoshida H, Yamamoto-Fukuda T, Enatsu K, *et al.* Measurement of angle and length of the eustachian tube on computed tomography using the multiplanar reconstruction technique. Laryngoscope 2007;117:1251-4.
26. Sadé J, Fuchs C. Secretory otitis media in adults: II. The role of mastoid pneumatization as a prognostic factor. Ann Otol Rhinol Laryngol 1997;106:37-40.
27. Sadé J. The correlation of middle ear aeration with mastoid pneumatization. The mastoid as a pressure buffer. Eur Arch Otorhinolaryngol 1992;249:301-4.