ORIGINAL ARTICLE

Journal of Otorhinolaryngology and Facial Plastic Surgery 2022;8(1):1-6.
https://doi.org/10.22037/orlfps.v8i1.41625

Evaluation of Tubotympanic Angle of Eustachian Tube and its Relationship with Eustachian Tube Function in Patients with Chronic Middle Ear Infection

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Article Info

Article Note:
Received: November, 2022
Accepted: November, 2022
Publish Online: December, 2022

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Keywords:
Otitis media;
Eustachian tube angle;
Temporal bone CT scan.

Abstract

Background: Chronic otitis media is characterized by the accumulation of fluid in the middle ear and behind the tympanic membrane without signs of acute infection. The association between a middle ear infection and anatomical and physiological disorders of the Eustachian tube has been reported in several studies and its malfunction is one of the main causes of middle ear infection.

Aim: We aim to find the relation between tubotympanic angle of theEustachian tube and chronic otitis media.

Methods: In this study, 100 patients with chronic unilateral middle ear infections were included. To determine the tubotympanic angle of the Eustachian tube, a temporal bone CT scan was used in the radiology department of Loghman Hospital. Eustachian tube angle and ear function were recorded.

Results: Among the 100 patients in the study, 42 were men and 58 were women. The mean age of patients in the study was 39.64±12.64 years. The angle was 3.79 ± 34.27 in the healthy ear and 2.43 ± 31.06 in the diseased ear, which showed a statistically significant difference between the two groups.

Conclusion: Eustachian tube angles in adults may play an important role in the cause of chronic otitis media. In this study, it was found that the horizontalization of the Eustachian tube is associated with chronic otitis media. Besides, determining the angle of the Eustachian tube can help determine the susceptibility to otitis media.

Conflicts of Interest: The Authors declare no conflicts of interest.
Please cite this article as: Khosravi Farsani P, Abbasi Z, Eftekharian A, Davoodi F, Bazgir N. Evaluation of Tubotympanic Angle of Eustachian Tube and its Relationship with Eustachian Tube Function in Patients with Chronic Middle Ear Infection. J Otorhinolaryngol Facial Plast Surg 2022;8(1):1-6. https://doi.org/10.22037/orlfps.v8i1.41625

Introduction

Otitis media (OM) or inflammation of the middle ear is a broad concept consisting of chronic suppurative OM, acute OM, recurrent acute OM, chronic OM with effusion, and OM with effusion (1). The annual incidence of OM is relatively high, with an incidence of 10.8 per 100 people each year, worldwide. This rate is the highest in young children aged less than four (2). If left untreated, OM can lead to various serious complications including suppurative complications (acute mastoiditis, meningitis, and brain abscess), conductive and probable sensorineural hearing loss, and other intracranial complications (2, 3). It is estimated that 21000 people die of OM complications globally each year. Thus, prompt diagnosis and treatment prevent the mentioned complications (2). The cause of OM is multifactorial, comprising endogenous and exogenous factors. Among endogenous factors, the eustachian tube function seems to be very important (4). The angle between the eustachian tube and the

Journal of Otorhinolaryngology and Facial Plastic Surgery 2022;8(1):1-6.
https://doi.org/10.22037/orlfps.v8i1.41625

horizontal plane is about 45 degrees in adults, and 10 degrees in infants and young children (5). the length of the eustachian tube is more in adults compared to infants, ranging from 30 to 40 millimeters (5, 6). The tubotympanic angle is an auditory tube angle between the line extending from the tympanic hole and the center of the longitudinal axis which is drawn from the center of the bony part of the external acoustic meatus (7).

In this survey, we aim to evaluate the tubotympanic angle in 100 patients with OM without cholesteatoma who were admitted to the Loghman-Hakim hospital otolaryngology departments from September 2022 to January 2023. Furthermore, we assess the correlation of tubotympanic angle, eustachian tube function, and audiometric evaluations.

Methods

Study design

A case-control study was conducted on patients with chronic OM without cholesteatoma. We include patients with unilateral chronic OM without cholesteatoma aged between 18 to 60 who visited Loghman Hakim Hospital in Tehran, Iran for a two-year period. All included patients were a candidate for tympanomasteidectomy.

The exclusion criteria consisted of bilateral OM, presence of cholesteatoma, allergic or chronic sinusitis, polyposis, patients with congenital otological anomalies, and patients with congenital hearing loss. We also excluded patients with unstandardized temporal computed tomography (CT) scans.

The ethics committee of Shahid Beheshti University of Medical Sciences approved this survey. The study protocol was following the Declaration of Helsinki. All the included patients were informed about the purpose of the study, and written consent was obtained.

Case definition, data collection laboratory, and imaging studies

The diagnosis of OM without cholesteatoma was confirmed by physical examination and CT scan. Demographic data of patients were recorded. All the included patients underwent a thorough audiometry. The tubotympanic angle is the angle between the longitudinal line that passes through the center of the external ear canal and the line that passes through from the tympanic opening of the eustachian tube. The tubotympanic angle was assessed in all patients by performing a CT scan of the temporal bone.

The eustachian tube function of healthy ears and involved ears were evaluated separately by a modified inflation deflation test.

Test in ears with perforated tympanic membranes

Inflation test

Initially, the probe is sealed inside the external ear canal, then positive pressure is applied until the increase in positive pressure causes the opening of the Eustachian tube (opening pressure).

This device is turned off spontaneously and lets the applied positive pressure discharge until the opening of the eustachian tube is closed (closing pressure). Then we ask the patient to swallow several times. The swallowing allows the positive pressure created to be actively discharged until no further positive pressure is discharged swallowing. The remaining pressure is called residual pressure.

Deflation test

In the next step, by applying a pressure of 20 dapa, we closed the opening of the Eustachian tube (closing pressure). Then the device is turned off and the patient is asked to swallow several times and actively discharge the applied negative pressure. When no more pressure is discharged by swallowing, the remaining pressure is called residual pressure.

Valsalva test

The pressure pump is turned off and the probe is completely sealed in the ear canal. Then we ask the patient to pressure the middle ear through the pharynx area while the nose and mouth are closed. The measured pressure by the device is a positive pressure, which we call pressure opening. The patient is asked not to do

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anything, so the applied pressure is deflated spontaneously, the remaining pressure in this phase is called the closing pressure. Again, we ask the patient to swallow several times, the remained pressure is called residual pressure.

Tests in ears with intact temporal membranes

First, the probe is sealed inside the external ear canal, then routine tympanometry is performed for the patient and the pressure is recorded. If the pressure is less than -100, which means C type, or if it is more than 50, it means +A type, it is an indication of eustachian tube malfunction. As a result, no further test is needed to be performed. Moreover, if the pressure is between 100dapa and 50dapa, that is An type of tympanometry. complementary tests are performed for An type of tympanic membrane.

Inflation test

Two-hundred dapa pressure is applied, then the patient is asked to swallow several times. In this case, the middle ear pressure changes to the negative. Subsequently, the tympanogram was drawn again

Deflation test

Minus two-hundred dapa pressure was applied and the patient was asked to swallow several times, then the middle ear pressure changes direction to the positive. Afterward, we draw the tympanogram.

Valsalva test

Patients are inquired to pressure their middle ears through their throats, while their mouths and noses are closed. Then the pressure pump is turned off. Then the tympanogram is drawn. the patient is asked to swallow several times and actively discharge the applied pressure. Once more, the tympanogram is recorded. the difference between the remaining pressure with the basal tympanogram is residual pressure.

Toynbee test

The patient is inquired to swallow several times with his mouth and nose closed. Then we draw the tympanogram, in which the middle ear pressure changes to the negative

Tubotympanic angle

An expert radiologist measured the tubotympanic angle via Toshiba 16-slice computed tomography (CT) scan.

Statistical analysis

The statistical analysis was conducted using SPSS version 22. Chi-square, and T-tests, were conducted to assess the association between nominal and quantitative variables. A P-value less than 0.05 was considered to be statistically significant. To omit the effect of the confounding variables we used a logistic regression model.

Results

One-hundred consecutive patients were included in our study. Fifty-eight patients were men and 42 patients were females.The mean age of included individuals was 39.64±12.64 years. Based on the laterality of ear involvement, patients were divided into two groups. One group with the left ear involvement, and the other with right ear involvement. Fifty patients had left ear involvement. The distribution of gender considering the laterality of ear involvement is listed in Table 1. No significant difference in gender distribution was observed between the two groups.

Table 1 The distribution of gender regarding ear involvement laterality

Laterality of ear involvement	Gender	
	Female	Male
Left	28	22
Right	30	20

The tubotympanic angle was determined in all cases. The details of measured angles are demonstrated in Table 2.

After conducting T-test, it was revealed that the difference between affected and unaffected ears in patients with left ear OM, and right ear OM was significant (0.001 and 0.000, respectively). The tubotympanic angle was more obtuse in affected ears. After performing the eustachian

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tube function test, 22 right ears and 32 left ears had dysfunction. The means tubotympanic angle of the right ear with normal and abnormal eustachian tube function were 143±2.54 and 145.4±1.8, respectively. The difference in this angle between ears with normal and abnormal eustachian tube function was statistically significant (P-value=0.04).

Table 2 The Tubotympanic angle means of affected and unaffected ears in two groups.

Laterality of ear involvement	Tubotympanic angle	
	Tubotympanic angle of the right ear	Tubotympanic angle of left ear
Right ear involvement	145.87±2.8	149±2.67
Left ear involvement	148.91±2.15	145.5±4.61

The mean of the tubotympanic angle of left ears with normal eustachian tube function was 147.58±1, while this value in left ears with the abnormal function was 149.6±1.9. In accordance, the difference between these two means was also significant (P-value=0.003). Showing that the tubotympanic angle is more in ears with abnormal eustachian tube function.

Twenty-two patients had abnormal audiometry, and 78 patients had normal functions in audiometric evaluations. The mean tubotympanic angle of patients with normal and abnormal audiometry was 145±6.04 and 142.98±4.4, respectively. After conducting an independent t-test, it was revealed that there was no statistically significant difference.

Patients with normal audiometric evaluations were classified into two groups. Patients with otitis media and healthy patients. the mean tubotympanic angle of the two groups are listed in Table 3.

Table 3. The mean tubotympanic angle of patients with normal audiometric evaluations

Normal audiometric evaluations	Tubotympanic angle
Patients without otitis media	142.98±4.4
Patients with otitis media	148.58±3.2

As it is illustrated in Table 3, patients with OM and normal audiometric evaluations had more obtuse tubotympanic angles.

Discussion

The eustachian tube is a hollow tunnel in bone connecting the nasopharynx to the middle ears. It has two parts, two third is made up of the fibrocartilaginous tissue, and the rest of bone (8). It controls middle ear pressure, helps drain middle ear secretions, and protects eardrums. It also promotes secretions and protects the ear against noise dangers (9, 10).

Eustachian tube dysfunctions lead to cartilage malformations, chronic OM, chronic OM with effusion, cholesteatoma, and tympanic membrane perforations (11). One newly discovered variable associated with chronic OM is tubotympanic angle. It is defined as the angle between the longitudinal axis of the tympanic orifice and the longitudinal axis of the center of the external ear bony part in the axial plane (12). We conducted a case-control study on 100 patients with OM without cholesteatoma who were admitted to the Loghman-Hakim hospital otolaryngology department. The means of tubotympanic angle of healthy and affected ears were compared. We also evaluate the correlation of tubotympanic angle, audiometric evaluations, and eustachian tube function. To our knowledge, this is the first study that assessed the relation of tubotympanic angle, eustachian tube function, and audiometric evaluations.

After conducting statistical tests, it was revealed that ears with OM had a more obtuse

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Tubotympanic angle. In addition, ears with abnormal eustachian function have a significantly more obtuse angle. While ears with abnormal audiometric had no significant difference in Tubotympanic angle. In 2016, 210 patients with OM and cholesteatoma, 70 patients with OM and without cholesteatoma, and 70 normal controls were evaluated. Despite our findings, they found that the tubotympanic angle is not significantly different in patients from normal controls (13). Eibol et al. conducted a study on 210 patients. They found that patients with COM had a narrower auditory tube and wider tubotympanic angle. They concluded that a higher tubotympanic angle is a risk factor for developing COM (14). The results of Vivek et al.'s study confirmed the results of the previous study (15). Nemade et al. compared 92 ears with COM and 108 normal ears. The mean tubotympanic angle in ears with COM was 148.12±3.43. Meanwhile, in normal ears, this value was 145.14±4.34 (7). these means were nearly as same as the measured tubotympanic angle we measured in our cases. Following the two mentioned studies (7), the recent survey also concluded that the tubotympanic angle in COM patients was significantly more obtuse.

Eustachian tube angle is another variable, recently considered as a possible predisposing factor for OM. Takasaki et al. evaluated 54 ears with OME, 50 normal children's ears, and 90 normal ears of adults. They showed that the eustachian tube angle is more horizontal in patients with OME (16). Dinc et al confirmed the same results. They conducted a case-control study on 125 patients and confirmed revealed that the eustachian tube angle is more horizontal in diseased ears. They also found that the eustachian tube angle is wider in male patients (17).

This study was conducted as a single-center survey. A multi-center study with more patients is required to have more precise results.

Conclusion

In summary, we found that the tubotympanic angle is more obtuse in patients with OM. Furthermore, ears with eustachian tube dysfunction have higher tubotympanic angles. No statistically significant difference in tubotympanic angle was observed between ears with normal and abnormal audiometric evaluations.

Acknowledgments

Not declared.

Conflicts of Interest

The authors declare no conflicts of interest.

Financial Support

The authors declare there is no funding support for this study.

Ethics

this study was ethically approved by the ethical committee of Shahid Beheshti University of Medical Sciences (date of approval: 23/3/2022). Written informed consents were obtained from all included patients. IR.SBMU.MSP.REC.1399.128

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References

1. Gaddey HL, Wright MT, Nelson TN. Otitis Media: Rapid Evidence Review. Am Fam Physician. 2019 Sep;100(6):350–6.

2. Monasta L, Ronfani L, Marchetti F, Montico M, Brumatti L, Bavcar A, et al. Burden of Disease Caused by Otitis Media: Systematic Review and Global Estimates. PLoS One [Internet]. 2012 Apr 30 [cited 2022 Apr 15];7(4):e36226. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0036226

3. Verhoeff M, Van Der Veen EL, Rovers MM, Sanders EAM, Schilder AGM. Chronic suppurative

Journal of Otorhinolaryngology and Facial Plastic Surgery 2022;8(1):1-6.
https://doi.org/10.22037/orlfps.v8i1.41625

otitis media: a review. Int J Pediatr Otorhinolaryngol [Internet]. 2006 Jan [cited 2023 Jan 31];70(1):1–12. Available from: https://pubmed.ncbi.nlm.nih.gov/16198004/

4. Bylander-Groth A, Stenström C. Eustachian tube function and otitis media in children. Ear Nose Throat J [Internet]. 1998 [cited 2023 Jan 31];77(9). Available from: https://pubmed.ncbi.nlm.nih.gov/9787519/

5. Proctor B. Embryology and anatomy of the eustachian tube. Arch Otolaryngol [Internet]. 1967 [cited 2023 Jan 31];86(5):503–14. Available from: https://pubmed.ncbi.nlm.nih.gov/4952840/

6. Isaacson B. Anatomy and Surgical Approach of the Ear and Temporal Bone. Head Neck Pathol [Internet]. 2018 Sep 1 [cited 2023 Jan 31];12(3):321–7. Available from: https://pubmed.ncbi.nlm.nih.gov/30069845/

7. Nemade SV, Shinde KJ, Rangankar VP, Bhole P. Evaluation and significance of Eustachian tube angles and pretympanic diameter in HRCT temporal bone of patients with chronic otitis media. World J Otorhinolaryngol - head neck Surg [Internet]. 2018 Dec [cited 2023 Jan 31];4(4):240–5. Available from: https://pubmed.ncbi.nlm.nih.gov/30564785/

8. GRAVES GO, EDWARDS LF. THE EUSTACHIAN TUBE: A REVIEW OF ITS DESCRIPTIVE, MICROSCOPIC, TOPOGRAPHIC AND CLINICAL ANATOMY. Arch Otolaryngol [Internet]. 1944 May 1 [cited 2023 Feb 2];39(5):359–97. Available from: https://jamanetwork.com/journals/jamaotolaryngology/fullarticle/575435

9. Yang L, Gong PG, Zheng MF, Zhao XD, Liu YY, Peng H. [Eustachian tube and its dysfunction related diseases' occurence and treatments]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi [Internet]. 2016 Jun 20 [cited 2023 Feb 2];30(12):1001–5. Available from: https://pubmed.ncbi.nlm.nih.gov/29771075/

10. Bluestone CD, Doyle WJ. Anatomy and physiology of eustachian tube and middle ear related to otitis media. J Allergy Clin Immunol [Internet]. 1988 [cited 2023 Feb 2];81(5 Pt 2):997–1003. Available from: https://pubmed.ncbi.nlm.nih.gov/3286738/

11. Bal R, Deshmukh P. Management of Eustachian Tube Dysfunction: A Review. Cureus [Internet]. 2022 Nov 13 [cited 2023 Feb 2];14(11). Available from: https://pubmed.ncbi.nlm.nih.gov/36523693/

12. Aksoy S, Sayin I, Yazici ZM, Kayhan FT, Karahasanoglu A, Hocaoglu E, et al. The evaluation of the angles of Eustachian tubes in the patients with chronic otitis media on the temporal computerized tomography. Niger J Clin Pract [Internet]. 2016 May 1 [cited 2023 Feb 2];19(3):318–22. Available from: https://pubmed.ncbi.nlm.nih.gov/27022791/

13. El-Anwar MW, Eldib DB, Nofal AAF, Khazbak AO. Eustachian Tube: Computed Tomography Analysis. J Craniofac Surg [Internet]. 2020 Sep 1 [cited 2023 Feb 2];31(6):1763–5. Available from: https://pubmed.ncbi.nlm.nih.gov/32694471/

14. Elibol E, Baran H. Evaluation of the relationship of chronic otitis media with the Körner's septum, auditory tube angle, and tubotympanic angle. Surg Radiol Anat [Internet]. 2021 Jul 1 [cited 2023 Feb 2];43(7):1179–86. Available from: https://pubmed.ncbi.nlm.nih.gov/33386931/

15. Vivek S, Menon UK, Sandya CJ, Polson AM. Study of the Reliability of High Resolution CT Scan Evaluation of Eustachian Tube as Predictor of Predisposition for Chronic Otitis Media. Indian J Otolaryngol Head Neck Surg [Internet]. 2022 Aug 1 [cited 2023 Feb 2];74(Suppl 1):332–8. Available from: https://pubmed.ncbi.nlm.nih.gov/36032929/

16. 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 [Internet]. 2007 Jul [cited 2023 Feb 2];117(7):1251–4. Available from: https://pubmed.ncbi.nlm.nih.gov/17603324/

17. Dinç AE, Damar M, Uıur 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 [Internet]. 2015 Sep 1 [cited 2023 Feb 2];125(9):2187–92. Available from: https://pubmed.ncbi.nlm.nih.gov/25778737/