**Research**

# Comparison between Eustachian tube angle and length in chronic otitis media and contralateral ear

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## ABSTRACT

**Background:** Chronic suppurative otitis media (CSOM) is still a significant public health problem, especially in developing countries. Eustachian tube dysfunction is one of the factors that influence the occurrence of CSOM. The pathogenesis of acute and chronic otitis media is initiated by negative pressure in the middle ear. One theory of the development of CSOM is the continuum theory. The Eustachian tube as one of the factors that influence the occurrence of CSOM has been proven from various studies comparing CSOM patients and the average population; and comparing CSOM with cholesteatoma and without cholesteatoma.With the advanced technology, CTscan helps assessing pathological conditions in the ear as a diagnostic tool and evaluation modality. CTscan imaging with a multiplanar reconstruction technique can provide a clear image of the anatomical shape of the Eustachian tube. **Objective:** To determine the relationship between the angle and length of the Eustachian tube in the ear with CSOM and the contralateral ear's angle and length. **Method:** An analytic study with a cross-sectional design involving 30 samples of CSOM cases with the contralateral ear by measuring the angle and length of the Eustachian tube using the multiplanar HRCT temporal reconstruction technique. **Result:** Statistical analysis with paired t-test showed that the Eustachian tube angle was significantly more horizontal in the CSOM ear than the contralateral ear ($p<0.05$). Eustachian tube length was shorter in CSOM than contralateral ($p<0.05$). **Conclusion:** The angle of the Eustachian tube in the CSOM ear is smaller (more horizontal) and shorter than the contralateral ear.

**Keywords:** chronic suppurative otitis media, contralateral ear, Eustachian tube, temporal HRCT scan

## *ABSTRAK*

***Latar belakang:*** *Otitis media supuratif kronis (OMSK) saat ini masih menjadi masalah besar kesehatan masyarakat, terutama di negara-negara berkembang. Disfungsi tuba Eustachius adalah salah satu faktor yang berpengaruh dalam terjadinya OMSK. Patogenesis terjadinya otitis media akut dan kronis diawali oleh tekanan negatif di telinga tengah. Salah satu teori terjadinya OMSK adalah teori* continuum. *Tuba Eustachius sebagai salah satu faktor yang mempengaruhi terjadinya OMSK, sudah terbukti dari hasil berbagai penelitian yang membandingkan penderita OMSK dengan populasi normal, serta OMSK dengan dan tanpa kolesteatoma. Dengan berkembangnya teknologi, pencitraan* CT scan *berperan penting dalam menilai kondisi patologi di telinga, baik sebagai alat diagnostik maupun sebagai media evaluasi. Pencitraan CT scan dengan teknik rekonstruksi multiplanar dapat memberikan gambaran yang jelas kondisi anatomi tuba Eustachius. Tujuan: Mengetahui kesesuaian hubungan sudut dan panjang tuba Eustachius pada telinga yang mengalami OMSK dengan sudut dan panjang tuba telinga kontralateral. Metode: Penelitian analitik dengan pendekatan potong lintang yang melibatkan 30 sampel pasien OMSK dengan telinga kontralateral. Pengukuran sudut dan panjang tuba Eustachius menggunakan teknik rekonstruksi multiplanar HRCT scan temporal. Hasil: Analisis statistik dengan uji t berpasangan menunjukkan sudut tuba Eustachius secara signifikan lebih horisontal pada*

*telinga dengan OMSK dibandingkan kontralateral (p<0,05). Panjang tuba Eustachius lebih pendek pada OMSK dibandingkan kontralateral (p<0,05).* ***Kesimpulan:*** *Sudut tuba Eustachius telinga OMSK lebih kecil (horisontal) dan pendek dibandingkan telinga kontralateral.*

***Kata kunci:*** *otitis media supuratif kronis, telinga kontralateral, Tuba Eustachius, HRCT scan temporal*

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## INTRODUCTION

Chronic suppurative otitis media (CSOM) is still a significant public health problem, especially in developing countries. In 2004, WHO found that 65-330 million people had CSOM, where >90% of cases were within Southeast Asia, the West Pacific, and Africa. The high incidence was related to low socioeconomic factors, poor nutrition, and poor health education. Hearing loss was one of the complications that were related to the increased health burden on a country.[1,2]

Eustachian tube dysfunction is one of the conditions that could causes CSOM, mainly through the negative pressure of the middle ears, which is the primary pathogenesis of both acute and chronic otitis media. Continuum theory is one of the theories which explain that otitis media is caused by a dynamic and continuous inflammation process preceded by Eustachian tube obstruction.[3,4]

Eustachian tube has different length and angles in children and adults. It is shorter and more horizontal in children, making the nasopharynx infection easier to spread into the middle ear. Previous studies stated that the Eustachian tube angle was significantly more horizontal in CSOM with cholesteatoma.[5]

Direct examination of Eustachian tube is complex. With the advances in technology, CT scan is able to constitute as both diagnostic and evaluation modalities. CT scan imaging with multiplanar reconstruction technique can clearly visualize Eustachian tube's condition anatomically.[5–7] A study in Indonesia found a significant difference between healthy ear group, CSOM with cholesteatoma, and CSOM without cholesteatoma; using contralateral ear as comparison.[7] However, there were limited studies comparing the CSOM and the contralateral ear. The primary aim of this study was to find the difference between the angle and length of Eustachian tube in the CSOM ear with contralateral ear using temporal High Resolution CT scan (HRCT scan).

## METHOD

This was an analytical study with cross-sectional design describing the angle and length of Eustachian tube. Our research was conducted in the Department of Otorhinolaryngology Head and Neck Surgery Faculty of Medicine Brawijaya University, and Radiology Department of RSUD dr. Saiful Anwar Malang from February 2022 to April 2022, after receiving an ethical clearance. The sample of our research was all chronic suppurative otitis media (CSOM) patients who came to the ORLHNS clinic of RSUD dr. Saiful Anwar Malang between December 2018 to December 2021, who met the inclusion and exclusion criteria.

Inclusion criteria including CSOM in one or both ears with a better condition of contralateral ear based on history taking, physical examination and temporal HRCT scan results. Ear condition was measured

based on the presence of cholesteatoma, duration of otorrhea, perforation type of tympanic membrane, and audiometry findings. Patients aged more than 20 years old were included. Patients with a history of prior surgical mastoidectomy in one or both ears were excluded from this study. There were 30 samples in this research.

The independent variable of this study was the angle and length of Eustachian tube, while the dependent variable was the ear with CSOM and contralateral ear. Data were collected from secondary data source i.e. medical records of RSUD dr. Saiful Anwar Malang. The tools used in the study were data collection forms, digital data of temporal HRCT scan of CSOM patients on solid discs, and a Digital Imaging and Communications in Medicine (DICOM) viewer program with multiplanar reconstruction techniques.

The measurement of the Eustachian tube angle and length based on the measurement conducted by Takasaki et al.[6], based on Reid's standard plane. The angle of the Eustachian tube was measured by drawing a line from the tympanic orifice to pharyngeal orifice of the Eustachian tube. The Eustachian tube angle is created from the angle of tympanic to pharyngeal orifice and the Reid's standard plane. The length between the two orifices of Eustachian tube measured as the length of Eustachian tube.[6,8]

The distribution of data on the angle and length of the Eustachian tube were analyzed using the Shapiro-Wilk test. Should p-value $<0.05$, then the data was not normally distributed, conversely should p-value $\geq 0.05$, then the data was normally distributed. The difference in the mean angle and length of the Eustachian tube between the CSOM ear and the contralateral ear was analyzed by *paired T-test* for the normally distributed data; whereas, if at least one of the data was not normally distributed, Wilcoxon test was used.

## RESULT

There were total 30 patients eligible in our study. Demographic characteristic showed a predominance of female with 23 subjects (76.7%). The age range was within 20–68 years old, which mostly in the age range of 41–50 years, as many as 13 subjects (43.3%), while the least group was the 31–40 years group with 2 subjects (6.7%). Clinical characteristics in this research consisted of ipsilateral ear with CSOM, duration of otorrhea, CSOM types with or without cholesteatoma, and complications of CSOM. There were 22 cases of unilateral CSOM (73.3%), and 8 cases of bilateral CSOM (26.7%) with a better condition of contralateral ear. It was found that the left ear was more prone to CSOM (56.7%) compared to the right ear (43.3%). The incidence of CSOM with cholesteatoma was higher (60%) than without cholesteatoma (40%).

The chief complaint of CSOM patients was discharge from the ear (otorrhea). The frequency of the disease duration was found to be the highest in the <1 year group, namely 10 cases (33.3%) and 1-5 years as many as 10 cases (33.3%). Groups 6-10 years and >10 years each found in 5 cases (16.7%). There were 8 cases of bilateral CSOM, in which the contralateral ear also experienced complaints of otorrhea mostly being found in the 6-10 years age group (37.5%), and lowest in the 1-5 years group (12.5%). The most common complication was mastoiditis, with a total of 25 cases (83.3%). In 8 cases of CSOM bilateral, 37.5% of these subjects had mastoiditis.

The result of the measurement of the Eustachian tube angle in CSOM ears showed an average of 29.62°, with the narrowest angle of 21.3° and the widest angle of 39.3° with mean ± SD (standard deviation) of 29.62 ± 5.34; while, the angle of the Eustachian tube of the contralateral ear showed an average of 32.53°, with the narrowest angle of 24.9° and the widest angle being 43.2°, with a mean ± SD of 30.48±4.31.

The length of the Eustachian tube in CSOM ears showed an average of 30.48 mm, with the shortest length being 20 mm and the longest length being 39.3 mm; mean±SD of 30.48±4.31; whereas the length of the Eustachian tube in contralateral ears showed an average of 32.17 mm, with the shortest length being 22.2 mm and the longest length being 39.2 mm; mean±SD of 32.17±3.71.

According to the Shapiro-Wilks normality test, data on the angle and length of the Eustachian tube CSOM and the contralateral ear all have a normal distribution ($p>0.05$), therefore to determine the relationship between the Eustachian tube of the CSOM and the contralateral ear can be done with paired T-test. (Table 1). The result of the analysis showed that there was a statistically significant difference between the angle of the two groups ($p<0.05$) (Table 2).

The results of the analysis with paired T-test also found a statistically significant difference between the length of the two groups ($p<0.05$) (Table 3).

**Table 1. Normality test of the length and angle data of the Eustachian tube in CSOM and contralateral ears.**

| Variable | p-value |
|---|---|
| CSOM angle | 0.062 |
| CLE angle | 0.612 |
| CSOM length | 0.940 |
| CLE length | 0.500 |

**Table 2. Paired T-test results between the Eustachian tube angle of the CSOM and the contralateral ear.**

| | Angle | | p-value |
|---|---|---|---|
| | CSOM | CLE | |
| x̄±SD | 29.62 ± 3.71 | 32.53±5.34 | 0.000 (<0.05) |
| Med (Min-Max) | 28.40(22.2–39.2) | 32.65 (24.9–43.2) | |

**Table 3. Paired T-test results between the Eustachian tube length of the CSOM and the contralateral ear**

| | Length | | p-value |
|---|---|---|---|
| | CSOM | CLE | |
| x̄±SD | 30.48±4.31 | 32.17±3.71 | 0.001 (<0.05) |
| Med (Min-Max) | 30.30(20.0–39.3) | 31.90 (22.2–39.2) | |

## DISCUSSION

Our study's result showed a predominance of females with 23 subjects (76.7%). This finding was not in accord with a previous study by Mahdiani et al.[9] in RSUP Dr. Hasan Sadikin Bandung, which showed an insignificant difference between gender, with 53% male and 46.3% female. A similar study also showed a predominance of CSOM patients within the 36-45 age group (28%). Narendra et al.[10] conducted a study in RSUP Sanglah Denpasar, and found that the subject proportion of males and females was similar (50% each) and mostly in the 31-40 years age group (32%). A case report by Artono et al.[11] (2020) found that complicated cases of CSOM in RSUD Dr. Soetomo Surabaya were more common in male subjects (88%) in 2017 and 68% in 2018. Majority was found in the age group of 11-25 years, in a total of 44.44% in 2017 and 50% in 2018, followed by the age group of 26-45 years old (33.33%

in 2017 and 31.25% in 2018). A study conducted in RSUD Dr. Saiful Anwar Malang by Wahyudiono et al.[12], comparing Middle Ear Risk Index (MERI) scores in CSOM patients with intracranial and extracranial complications revealed a similar proportion between male (47.5%) and female (52.5%). This discrepancy might be explained due to data variation based on inclusion and exclusion criteria. Therefore, our data did not represent the proper proportion according to gender and age group of the CSOM population in RSUD Dr. Saiful Anwar Malang.

In this study, the mean angle of the Eustachian tube in the CSOM ear group was 29.62°; with the narrowest angle at 21.3° and the widest one 39.3°. Whereas the mean angle of the Eustachian tube in the contralateral ear group (CLE) was 32.53°; with the narrowest angle being 24.9° and the widest was 43.2°. A paired T-test showed a significant difference between the CSOM group with CLE ($p<0.005$).

Until now, the measurement of the Eustachian tube angle in the CSOM ear compared to the contralateral ear has rarely been studied. A study in Japan by Takasaki et al.[6] of normal adults revealed no significant difference between the angle of the right (27.3°±2.7) and left Eustachian tube (27.3°±2.8). He also measured the angle of the pediatric group with OME, which showed a result of 20.4°±3.5, and the normal pediatric group with 21.2° ± 4.8, which statistically did not show a significant result. Measurement by Nemade et al.[8] showed a significant difference in angle of Eustachian tube, which was narrower in CSOM group as 25.41°±2.57 compared to standard group 27.56°±3.62 ($p<0.05$). In RSUD Dr. Zainoel Abidin Banda Aceh, Ridwan et al.[13] found that the average angle of Eustachian tube in normal population was 28.23°±2.46, safe-type CSOM was 29.12°±2.72, and unsafe-type of CSOM was 26.95°±4.19, with p-value >0.005. Therefore it was not significant. Dinc et al.[14], conducted a study in Turkey, with a result of significantly wider angle of standard group (124 subjects) with 23.6°±2.4 compared to the CSOM group (126 subjects) with 22.9°±2.8 ($p<0.05$), however it was not significant for the comparison between affected ear (22.7°±2.8) and contralateral ear (23.4°±2.6) ($p>0,05$). Masita et al.[7] also conducted a similar study in RSUD H. Adam Malik Medan, with a result of a significant difference between the average angle of Eustachian tube in standard group 33.61°±3.83, CSOM without cholesteatoma 32.82°±3.82, and CSOM with cholesteatoma 27.74°±4.44 ($p<0.001$). Aksoy et al.[5] found a narrower angle of Eustachian tube in CSOM ear compared to normal ear.

In adults, the Eustachian tube has an angle of 45° from the horizontal line, compared to 10° in children. The Eustachian tube are still developing and the angle is altered to become more oblique until the age of 20, and at last it can be divided into 3 major parts: *osseous*, junctional, and cartilaginous parts.[6,15,16] Dinc et al.[14] proposed that a narrower (horizontal) angle caused a tubal dysfunction, which led to retraction pouch that subsequently became the early formation of cholesteatoma.

This study revealed the mean length of the Eustachian tube in the CSOM group was 30.48 mm, with the shorter being 20 mm and the longest being 39.3 mm. In comparison, the mean length of the Eustachian tube in the contralateral group was 32.17 mm, with the shorter being 22.2 mm and the longest being 39.2 mm. The length comparison was analyzed with paired T-test due to its normal distribution. This study revealed a significant difference between the length of the Eustachian tube in the CSOM group and the contralateral ear ($p<0.05$). In a study by Dinc et al.[14], the length of the CSOM group is significantly shorter compared to normal group ($p=0.03$). However there was no significant difference between the length of CSOM and contralateral ear ($p=0.710$). Takasaki et al.[6] measured the length of the

Eustachian tube in children and adults, each with and without OME. The length of the right ear in adults was 42.5±2.8 mm and 42.9±2.9 mm for the left ear. The length of the right ear in children with OME was 37.2±3.0 mm and 37.6±3.2 mm on the left ear, while in healthy children was 37.5±3.3 mm and 38.0±3.2 mm on the left ear. Ridwan et al.[13] showed a significant difference between the Eustachian tube length of the normal ear (35.39±2.00 mm), safe type CSOM (33.58±2.39 mm), and unsafe type CSOM (29.53±2.81 mm). From these studies, the measurement method was done by measuring the distance from the tympanic orifice to the pharyngeal orifice of the Eustachian tube.

The length of the Eustachian tube varies between individuals, with a range of 30-40 mm. The development of the Eustachian tube in childhood plays a vital role in the pathomechanism of middle ear infections. Otitis media is more common in children. Bluestone et al.[15] explained that one of the influencing factors is an anatomical factor of the tube, where in children, the tubes are more horizontal and shorter, making them prone to dysfunction.

This study proved a statistically significant difference ($p<0.05$) in the angle and length of the Eustachian tube between the CSOM and contralateral ear. Thus, the hypothesis in this study was accepted.

Further research is needed on the anatomy of the Eustachian tube, including the diameter, tubo-tympanic angle, length of the osseous part, cartilaginous part, and the volume of the lumen between the ear with CSOM and the contralateral ear. In addition, further research is also needed to look for the relationship between the angle and length of the Eustachian tube anatomy by examining the Eustachian tube function (Eustachian tube ETF) between the ear with CSOM and contralateral ear.

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