

ORIGINAL ARTICLE

Eustachian Tube Dysfunction and Hearing Abnormalities among Patients with Chronic Rhinosinusitis

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ABSTRACT

Background: Eustachian tube dysfunction (ETD) may occur in patients with chronic rhinosinusitis (CRS) because persistent sinonasal inflammation can impair Eustachian tube ventilation and middle-ear pressure regulation. Hearing abnormalities may accompany this dysfunction, particularly when conductive mechanisms are involved. **Aim of the study:** To determine the occurrence of ETD and hearing abnormalities among patients with CRS and to characterize their associated clinical and audiological findings. **Methods & Materials:** This cross-sectional analytical study included 80 adults with CRS selected by purposive sampling. Participants underwent clinical and nasal endoscopic assessment, tympanometry, Eustachian Tube Dysfunction Questionnaire-7 (ETDQ-7), and pure-tone audiometry. ETD was defined using tympanometric findings and an ETDQ-7 score ≥ 2.1 . Associations between clinical characteristics, ETD, and hearing abnormalities were analyzed using appropriate statistical tests, with $p < 0.05$ considered statistically significant. **Result:** The mean age was 39.2 ± 11.6 years, and 57.5% of participants were male. ETD was identified in 27 (33.75%) participants, including unilateral ETD in 16 (20.0%) and bilateral ETD in 11 (13.75%). Hearing abnormalities were present in 23 (28.75%), including conductive hearing loss in 14 (17.5%), sensorineural hearing loss in 6 (7.5%), and mixed hearing loss in 3 (3.75%). ETD was significantly associated with CRS duration, nasal polyps, bilateral CRS, and inferior turbinate hypertrophy ($p = 0.021$, $p = 0.008$, $p = 0.032$, and $p = 0.046$, respectively). Hearing abnormalities were significantly more frequent among participants with ETD than those without ETD (55.56% vs. 15.01%, $p < 0.001$). Conductive hearing loss (44.44% vs. 3.77%), air-bone gap ≥ 10 dB (51.85% vs. 9.43%), and mean PTA (29.4 ± 10.8 vs. 21.8 ± 7.2 dB) were also significantly higher among participants with ETD (all $p < 0.001$). **Conclusion:** ETD was common among patients with CRS and was significantly associated with longer disease duration and selected sinonasal findings. ETD was also strongly associated with hearing abnormalities, particularly conductive hearing loss and increased PTA thresholds. Routine assessment of Eustachian tube function and hearing may therefore be valuable in CRS patients with persistent, bilateral, or extensive sinonasal disease.

Keywords: Chronic rhinosinusitis; Eustachian tube dysfunction; Hearing loss; Tympanometry; Pure-tone audiometry.

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INTRODUCTION

Eustachian tube dysfunction (ETD) is a condition in which the Eustachian tube fails to adequately regulate middle-ear pressure, protect the middle ear from nasopharyngeal influences, or clear middle-ear secretions, potentially producing ear fullness, pressure, tinnitus and hearing disturbance. Chronic rhinosinusitis (CRS), a persistent inflammatory disorder of the nose and paranasal sinuses, may contribute to ET dysfunction through mucosal inflammation and impaired ventilation of the Eustachian tube [1,2]. Worldwide, CRS has an estimated pooled prevalence of 8.71%, while clinically significant ETD symptoms occur in approximately 47.2% of patients with CRS [3,4]. In Bangladesh, a nationally representative survey reported disabling hearing impairment in 9.6% of the population, although a

contemporary population-based prevalence estimate specifically for ETD among patients with CRS remains unavailable [5]. The Eustachian tube normally opens intermittently during swallowing, yawning and other activities, allowing pressure equalization between the middle ear and atmosphere while providing protection from nasopharyngeal sound and secretions. In CRS, persistent nasal and nasopharyngeal inflammation may interfere with this process and produce functional or anatomical Eustachian tube impairment [6]. Inflammatory oedema around the Eustachian tube opening may further restrict ventilation and impair middle-ear pressure regulation [7]. Objective assessment using tympanometry, together with clinical or endoscopic evaluation, can therefore help identify middle-ear and Eustachian tube abnormalities that may not be apparent from

nasal symptoms alone [8]. ETD associated with CRS may have important consequences because impaired middle-ear ventilation can lead to negative middle-ear pressure, conductive hearing abnormalities, ear discomfort and reduced quality of life [9]. Otologic symptoms such as aural fullness, hearing loss, otalgia and tinnitus are relatively common among patients with CRS [10]. Conversely, improvement of sinonasal inflammation may improve Eustachian tube-related symptoms; systematic reviews have reported significant reductions in ETD symptom scores following endoscopic sinus surgery. Identifying ETD in CRS may have practical advantages for comprehensive diagnosis, treatment planning and follow-up. Early recognition may also help clinicians distinguish ear-related symptoms caused by sinonasal disease from independent middle-ear disorders [11,12]. However, existing research has several limitations. ETD prevalence varies considerably according to the diagnostic method used, and patient-reported questionnaires do not always correspond closely with objective findings [13]. Moreover, many studies have focused on symptoms rather than combining subjective assessment with tympanometry and hearing evaluation. Available evidence also includes predominantly observational studies, with limited long-term follow-up and relatively few controlled comparisons [11,12]. Evidence from South Asian populations, particularly Bangladesh, is also limited, restricting the applicability of international findings to local patients. Therefore, a current study is needed to clarify the burden and clinical characteristics of ETD and hearing abnormalities among Bangladeshi patients with CRS. The present study aimed to determine the occurrence of ETD and hearing abnormalities among CRS patients and to characterize their relevant clinical and audiological findings.

METHODS & MATERIALS

This cross-sectional analytical study was conducted among 80 patients with chronic rhinosinusitis (CRS) attending at the Department of ENT and Head-Neck Surgery, Kurmitola Multicare Specialized Hospital, Dhaka, Bangladesh from January 2024 to December 2025. A total of 80 eligible patients diagnosed with CRS were included using purposive sampling.

Inclusion Criteria

- Patients aged ≥ 18 years.
- Patients diagnosed with chronic rhinosinusitis based on relevant clinical and endoscopic findings.
- Patients attending the study department during the study period.
- Patients who underwent clinical, endoscopic, tympanometric, and audiological assessment.
- Patients willing to participate in the study.

Exclusion Criteria

- Patients with conditions other than CRS that could independently affect Eustachian tube function or hearing.
- Patients with pre-existing significant hearing impairment unrelated to CRS.
- Patients with previous major otological surgery or known chronic middle-ear disease.
- Patients unable to complete the required clinical, endoscopic, tympanometric, or audiological assessments.

- Patients unwilling to participate in the study.

Data Collection

Eligible patients with CRS were evaluated through detailed history taking and clinical examination. Demographic information including age and gender was recorded. Clinical characteristics of CRS included duration of disease, nasal obstruction, nasal discharge, facial pain or pressure, headache, postnasal discharge, and reduced sense of smell. CRS phenotype was categorized as CRS without nasal polyps or CRS with nasal polyps. Nasal endoscopic examination was performed to document mucosal edema, purulent discharge, nasal polyps, inferior turbinate hypertrophy, deviated nasal septum, middle meatal edema, and bilateral sinonasal involvement. The Lund-Kennedy endoscopic score was recorded as an indicator of endoscopic disease severity.

Eustachian tube function was assessed using tympanometry and the Eustachian Tube Dysfunction Questionnaire-7 (ETDQ-7). Tympanometric peak pressure, static compliance, and tympanogram type were recorded. Tympanograms were categorized as Type A, Type B, or Type C. Patients were categorized as having normal Eustachian tube function or ETD. ETD was further classified as unilateral or bilateral. An ETDQ-7 score ≥ 2.1 was considered indicative of Eustachian tube dysfunction.

Audiological assessment was performed to evaluate hearing status. Pure-tone audiometry (PTA) was used to determine hearing thresholds in both ears, and the mean PTA was recorded. Hearing status was categorized as normal hearing or hearing abnormality. Hearing loss was further classified as conductive, sensorineural, or mixed according to audiological findings. The severity of hearing loss was categorized as mild, moderate, or moderately severe. Air-bone gap ≥ 10 dB was also recorded, along with speech discrimination score.

Statistical Analysis

Data were entered, processed, and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequency and percentage. The Chi-square test or Fisher's exact test was used to assess associations between categorical variables, including selected clinical characteristics and ETD, and between ETD and hearing abnormalities. Continuous variables such as PTA and ETDQ-7 scores were compared between patients with and without ETD using an appropriate independent-samples statistical test based on data distribution. A p-value < 0.05 was considered statistically significant.

RESULTS

The study included 80 patients with chronic rhinosinusitis (CRS), with a mean age of 39.2 ± 11.6 years. The largest proportion of participants were aged 30–39 years (33.75%), followed by 40–49 years (27.50%), ≥ 50 years (21.25%), and 18–29 years (17.50%). Males comprised 57.50% of the participants. Regarding disease duration, 38.75% had CRS for 3–5 years, 31.25% for > 5 years, and 30.00% for < 3 years, with a mean duration of 4.7 ± 2.8 years. Nasal obstruction was the most frequent clinical symptom (83.75%), followed by nasal discharge (76.25%), headache (70.00%), reduced sense of smell (67.50%), facial pain or pressure (65.00%), and postnasal discharge (58.75%) (Table I).

Table I: Sociodemographic and Clinical Characteristics of the Study Participants (n=80)

Variables	Frequency (n)	Percentage (%)
Age group (years)		
18–29	14	17.50
30–39	27	33.75
40–49	22	27.50
≥50	17	21.25
Mean ± SD	39.2 ± 11.6	
Gender		
Male	46	57.50
Female	34	42.50
Duration of CRS (years)		
<3 years	24	30.00
3–5 years	31	38.75
>5 years	25	31.25
Mean ± SD	4.7 ± 2.8	
Nasal obstruction	67	83.75
Nasal discharge	61	76.25
Facial pain/pressure	52	65.00
Headache	56	70.00
Postnasal discharge	47	58.75
Reduced sense of smell	54	67.50

CRS without nasal polyps was present in 61.25% of participants, while 38.75% had CRS with nasal polyps. On endoscopic examination, mucosal edema was observed in 77.50%, middle meatal edema in 72.50%, bilateral sinonasal involvement in 73.75%, inferior turbinate hypertrophy in

62.50%, purulent discharge in 53.75%, deviated nasal septum in 47.50%, and nasal polyps in 38.75%. The mean Lund–Kennedy endoscopic score was 4.0 ± 1.7 (Table II).

Table II: Clinical and Endoscopic Characteristics of Chronic Rhinosinusitis (n=80)

Findings	Frequency (n)	Percentage (%)
CRS phenotype		
CRS without nasal polyps	49	61.25
CRS with nasal polyps	31	38.75
Mucosal edema	62	77.50
Purulent discharge	43	53.75
Nasal polyps	31	38.75
Inferior turbinate hypertrophy	50	62.50
Deviated nasal septum	38	47.50
Middle meatal edema	58	72.50
Bilateral sinonasal involvement	59	73.75
Lund–Kennedy endoscopic score, Mean ± SD	4.0 ± 1.7	

Tympanometric assessment showed a mean peak pressure of -56.8 ± 41.5 daPa and mean static compliance of 0.63 ± 0.25 mL. Type A tympanograms were found in 65.00%, Type C in 26.25%, and Type B in 8.75%. Normal Eustachian tube function was present in 66.25%, whereas ETD was identified

in 33.75%; unilateral and bilateral ETD were present in 20.00% and 13.75%, respectively. The mean ETDQ-7 score was 2.6 ± 1.0 , and 36.25% had an ETDQ-7 score ≥ 2.1 (Table III).

Table III: Tympanometric and Eustachian Tube Function Findings (n=80)

Parameters	Frequency (n)	Percentage (%)
Tympanometric peak pressure (daPa), Mean ± SD	-56.8 ± 41.5	
Static compliance (mL), Mean ± SD	0.63 ± 0.25	
Tympanogram type		
Type A	52	65.00
Type B	7	8.75
Type C	21	26.25
Eustachian tube function		
Normal ET function	53	66.25
Eustachian tube dysfunction	27	33.75
Unilateral ETD	16	20.00
Bilateral ETD	11	13.75
ETDQ-7 score, Mean ± SD	2.6 ± 1.0	
ETDQ-7 ≥ 2.1	29	36.25

The mean PTA was 24.1±9.3 dB in the right ear and 24.8±9.7 dB in the left ear. Normal hearing was found in 71.25% of participants, while 28.75% had a hearing abnormality. Conductive hearing loss was present in 17.50%, sensorineural hearing loss in 7.50%, and mixed hearing loss in 3.75%.

Regarding severity, mild hearing loss was observed in 21.25%, moderate hearing loss in 6.25%, and moderately severe hearing loss in 1.25% (Table IV).

Table IV: Hearing Abnormalities among Study Participants (n=80)

Audiological Findings	Frequency (n)	Percentage (%)
PTA right ear (dB), Mean ± SD	24.1 ± 9.3	
PTA left ear (dB), Mean ± SD	24.8 ± 9.7	
Hearing status		
Normal hearing	57	71.25
Any hearing abnormality	23	28.75
Conductive hearing loss	14	17.50
Sensorineural hearing loss	6	7.50
Mixed hearing loss	3	3.75
Severity of hearing loss		
Mild	17	21.25
Moderate	5	6.25
Moderately severe	1	1.25
Air-bone gap ≥10 dB	19	23.75
Speech discrimination score, Mean ± SD	96.5 ± 3.8	

Among participants with ETD, 21.95% of those aged <40 years and 46.15% of those aged ≥40 years had ETD, (p=0.286). ETD was present in 36.96% of males and 29.41% of females. ETD was significantly more frequent among participants with nasal polyps than those without nasal polyps (51.61% vs. 22.45%,

p=0.008). Bilateral CRS was also significantly associated with ETD, with ETD present in 38.98% of those with bilateral disease compared with 19.05% without bilateral involvement (p=0.032) (Table V).

Table V: Association of Clinical Characteristics with Eustachian Tube Dysfunction (n=80)

Variables	ETD n = 27 n (%)	No ETD n = 53 n (%)	p-value
Age			
<40 years	9 (21.95)	32 (78.05)	0.286
≥40 years	18 (46.15)	21 (53.8)	
Gender			
Male	17 (36.96)	29 (63.0)	0.538
Female	10 (29.41)	24 (70.6)	
CRS duration			
<3 years	5 (20.83)	19 (79.2)	0.021
3–5 years	9 (29.03)	22 (71.0)	
>5 years	13 (52.00)	12 (48.0)	
Nasal polyps			
Present	16 (51.61)	15 (48.4)	0.008
Absent	11 (22.45)	38 (77.6)	
Bilateral CRS			
Present	23 (38.98)	36 (61.0)	0.032
Absent	4 (19.05)	17 (81.0)	
Inferior turbinate hypertrophy			
Present	21 (42.00)	29 (58.0)	0.046
Absent	6 (20.00)	24 (80.0)	

Hearing abnormalities were significantly more frequent among participants with ETD than those without ETD (55.56% vs. 15.01%, p<0.001). Normal hearing was present in 44.44% of participants with ETD compared with 84.91% of those without ETD (p<0.001). Conductive hearing loss occurred in 44.44% of participants with ETD compared with 3.77% without ETD (p<0.001). Sensorineural hearing loss was observed in 3.70% and 9.43%, respectively (p=0.398), while

mixed hearing loss occurred in 7.41% and 1.89%, respectively (p=0.218). An air-bone gap ≥10 dB was significantly more frequent among participants with ETD (51.85% vs. 9.43%, p<0.001). The mean ETDQ-7 score was also significantly higher among participants with ETD (3.5±0.8 vs. 2.1±0.6, p<0.001) (Table VI).

Table VI: Association between Eustachian Tube Dysfunction and Hearing Abnormalities (n=80)

Hearing Findings	ETD n = 27 n (%)	No ETD n = 53 n (%)	p-value
Normal hearing	12 (44.44)	45 (84.91)	<0.001
Any hearing abnormality	15 (55.56)	8 (15.01)	<0.001
Conductive hearing loss	12 (44.44)	2 (3.77)	<0.001
Sensorineural hearing loss	1 (3.70)	5 (9.43)	0.398
Mixed hearing loss	2 (7.41)	1 (1.89)	0.218
Air-bone gap ≥ 10 dB	14 (51.85)	5 (9.43)	<0.001
PTA (dB), Mean $\pm$ SD	29.4 $\pm$ 10.8	21.8 $\pm$ 7.2	<0.001
ETDQ-7 score, Mean $\pm$ SD	3.5 $\pm$ 0.8	2.1 $\pm$ 0.6	<0.001

DISCUSSION

Eustachian tube dysfunction refers to impaired ventilation and pressure regulation of the middle ear due to inadequate Eustachian tube function, while hearing abnormalities refer to impairment in the ability to detect or perceive sound [14]. The present study evaluated Eustachian tube dysfunction (ETD) and hearing abnormalities among 80 patients with chronic rhinosinusitis (CRS). The mean age was 39.2 ± 11.6 years, with the largest proportion aged 30–39 years (33.75%), and males constituted 57.50% of participants. The mean duration of CRS was 4.7 ± 2.8 years. Nasal obstruction (83.75%) and nasal discharge (76.25%) were the most frequent symptoms, followed by headache (70.00%), reduced sense of smell (67.50%), facial pain/pressure (65.00%), and postnasal discharge (58.75%). Similar adult CRS populations have been described in previous studies investigating ETD, although age and sex distributions varied between cohorts. In a study of 101 CRS patients, Tangbumruntham et al. reported that 48.5% had clinically significant ETD symptoms based on ETDQ-7, supporting the frequent coexistence of otologic symptoms with CRS [4]. Endoscopic assessment showed CRS without nasal polyps in 61.25% and CRS with nasal polyps in 38.75%. Mucosal edema (77.50%), middle meatal edema (72.50%), inferior turbinate hypertrophy (62.50%), and bilateral sinonasal involvement (73.75%) were common, with a mean Lund-Kennedy score of 4.0 ± 1.7 . These findings indicate substantial sinonasal inflammatory burden. Previous research has similarly demonstrated a relationship between CRS severity and ETD symptoms. A study of 82 patients undergoing surgery for CRS found clinically significant ETD symptoms in 47.6% and reported correlation between ETDQ-7 and overall sinonasal disease severity [12]. In the present study, Type A tympanograms were found in 65.00% of participants, whereas Type C and Type B patterns occurred in 26.25% and 8.75%, respectively. ETD was identified in 33.75%, including unilateral dysfunction in 20.00% and bilateral dysfunction in 13.75%. The mean ETDQ-7 score was 2.6 ± 1.0 , and 36.25% had a score ≥ 2.1 . The prevalence of ETD was lower than that reported in several earlier CRS studies. A systematic review and meta-analysis involving 1,336 CRS patients estimated that approximately 47.2% had ETDQ-7 scores consistent with ETD. The lower prevalence in the present study may partly reflect differences in diagnostic criteria, population characteristics, and the use of objective tympanometric assessment alongside symptom-based evaluation [2]. Hearing assessment showed mean PTA values of 24.1 ± 9.3 dB in the right ear and 24.8 ± 9.7 dB in the left ear. Overall, 28.75% had a hearing abnormality, with conductive hearing loss being the most frequent type (17.50%), followed by sensorineural (7.50%) and mixed hearing loss (3.75%). An air-bone gap ≥ 10 dB was present in 23.75%. These findings are consistent with the physiological consequences of impaired Eustachian tube ventilation, which primarily affects

middle-ear pressure and sound transmission. Recent research in CRS with nasal polyps reported higher rates of tympanometric abnormalities and conductive hearing loss in patients with type-2 inflammatory disease, further supporting the association between sinonasal inflammation, ET dysfunction, and middle-ear abnormalities [15]. A significant association was observed between CRS duration and ETD. Dysfunction increased from 20.83% among participants with CRS for <3 years to 52.00% among those with disease duration >5 years ($p=0.021$). This suggests that prolonged sinonasal inflammation may increase the likelihood of Eustachian tube impairment. Nasal polyps were also significantly associated with ETD, occurring in 51.61% of participants with polyps compared with 22.45% without polyps ($p=0.008$). This agrees with recent findings showing increased middle-ear and conductive hearing abnormalities among patients with CRS with nasal polyps, particularly in association with type-2 inflammation. However, the systematic review by Chen et al. found no significant difference in ETDQ-7 scores according to polyp status, indicating that this relationship may vary according to disease phenotype and assessment method [2]. Bilateral CRS was significantly associated with ETD, with dysfunction occurring in 38.98% of participants with bilateral disease compared with 19.05% without bilateral involvement ($p=0.032$). Inferior turbinate hypertrophy was similarly associated with ETD (42.00% vs. 20.00%, $p=0.046$). These findings support a relationship between greater sinonasal involvement and impaired Eustachian tube function. Nevertheless, recent prospective research has suggested that inflammatory mechanisms may be more important than mechanical nasal obstruction alone in determining Eustachian tube patency. Age and gender were not significantly associated with ETD, suggesting that CRS-related clinical characteristics were more important determinants within this population [16]. The strongest finding was the significant association between ETD and hearing abnormalities. Any hearing abnormality occurred in 55.56% of participants with ETD compared with 15.01% without ETD ($p<0.001$). Conductive hearing loss was particularly frequent among participants with ETD (44.44% vs. 3.77%, $p<0.001$), as was an air-bone gap ≥ 10 dB (51.85% vs. 9.43%, $p<0.001$). Mean PTA was also significantly higher in the ETD group (29.4 ± 10.8 dB vs. 21.8 ± 7.2 dB, $p<0.001$). In contrast, sensorineural and mixed hearing loss were not significantly associated with ETD. These findings are consistent with previous studies demonstrating that CRS-associated ETD is principally related to middle-ear ventilation abnormalities and conductive hearing impairment [7]. The ETDQ-7 score was significantly higher among participants with ETD than those without ETD (3.5 ± 0.8 vs. 2.1 ± 0.6 , $p<0.001$). Previous studies have also demonstrated an association between ETDQ-7 scores and sinonasal symptom severity, while systematic reviews have shown that ETD

symptoms frequently improve following treatment of CRS. Overall, the present findings support the clinical importance of assessing Eustachian tube function and hearing in patients with CRS, particularly those with prolonged disease, nasal polyps, bilateral involvement, or inferior turbinate hypertrophy [2,12].

LIMITATIONS

This study has several limitations. Its cross-sectional design prevents determination of temporal or causal relationships between chronic rhinosinusitis, Eustachian tube dysfunction, and hearing abnormalities. The relatively small sample size of 80 participants may limit statistical power and generalizability. Purposive sampling from a single clinical setting may have introduced selection bias and may not represent the broader Bangladeshi CRS population. ETD assessment relied on tympanometry and ETDQ-7, which may not capture all functional abnormalities. Longitudinal assessment was not performed to evaluate changes following CRS treatment.

CONCLUSION

Eustachian tube dysfunction was a frequent finding among patients with chronic rhinosinusitis and was associated with clinically relevant hearing abnormalities. ETD was identified in 33.75% of participants, while hearing abnormalities were present in 28.75%. Nasal polyps, bilateral CRS, inferior turbinate hypertrophy, and longer CRS duration were significantly associated with ETD. Patients with ETD had substantially higher rates of hearing abnormalities, conductive hearing loss, air–bone gaps, and higher mean PTA thresholds than those without ETD. These findings support the importance of incorporating Eustachian tube and hearing assessment into the clinical evaluation of patients with CRS, particularly in those with persistent or extensive sinonasal disease.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

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