

Assessment of Hearing in Patients with Allergic Rhinitis

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ABSTRACT

Aim: The aim of the present study was to evaluate the type and extent of hearing loss among AR patients and assess the association between allergic markers and audiological findings.

Methods: A cross-sectional observational study was conducted on 100 patients diagnosed clinically with allergic rhinitis. Detailed ENT examinations including otoscopy and Pure Tone Audiometry (PTA) were performed. Laboratory investigations included serum IgE, absolute eosinophil count (AEC), total leukocyte count (TLC), and relative eosinophil percentage. Data were statistically analyzed using chi-square and t-tests, with $p < 0.05$ considered significant.

Results: Among 100 patients, 60% were male and 40% female, with a mean age of 28.3 ± 9.2 years. Conductive hearing loss was observed in 54 patients (54%), sensorineural hearing loss in 12 patients (12%), and mixed hearing loss in 6 patients (6%), while 28% had normal hearing. PTA revealed significantly elevated thresholds at low frequencies (250-500 Hz) in patients with middle ear effusion ($p = 0.001$). Otoscopic findings showed retracted tympanic membranes and dullness in 42% of patients. Serum IgE levels were elevated (>100 IU/mL) in 78% of patients, with a statistically significant correlation between high IgE levels and presence of hearing loss ($p = 0.002$). Similarly, patients with $AEC > 500$ cells/mm³ were more likely to have abnormal audiometric findings ($p = 0.01$).

Conclusion: This study establishes a clear link between allergic rhinitis and hearing impairment, predominantly conductive in nature due to Eustachian tube dysfunction. A significant correlation was noted between elevated IgE and eosinophil counts and auditory deficits. Routine audiological assessment should be an integral part of AR management to enable early intervention and prevent long-term hearing complications.

Keywords: Allergic Rhinitis, Hearing Loss, Eustachian Tube Dysfunction, Pure Tone Audiometry, Conductive Hearing Loss, IgE, Audiological Evaluation

INTRODUCTION

Allergic rhinitis is an allergic inflammation of the nasal mucosa which is an IgE mediated type 1 hypersensitivity reaction to the allergens. Histamine is the main mediator. Symptoms of allergic rhinitis include sneezing, excessive mucus production in nasal cavity, watering of eyes. Severity of symptoms differs individually.¹ Signs like allergic salute (Darier's line), bluish color of inferior turbinate can also be seen in allergic rhinitis. Heredity and environmental exposure to allergens are major contributing factors in causing allergies.²

Types of Allergic Rhinitis:

1. Seasonal- The symptoms of allergic rhinitis are more in a particular season. For example- pollens in spring, fungus in rainy season, etc.
2. Perennial- The symptoms are present throughout the year. For example, house dust mites, pets, etc.

3. Mixed- They reported a mean hearing loss of 10 ± 9.1 db in individuals with allergic rhinitis and 2.5 ± 2.2 db in control group, where they concluded that allergic rhinitis may cause conductive hearing loss in adults.³

In Allergic Rhinitis the eustachian tube function is adversely affected and leads to middle ear effusion or otitis media which causes conductive hearing loss.⁵ It has been suggested that allergic rhinitis and sensorineural hearing loss has a positive correlation and prevalence of hearing loss and outer hair cell abnormality is more in allergic rhinitis patients than normal individuals.⁴ The endolymphatic sac has a unique property of processing antigens and producing its own local immune response that affects outer hair cells to cause sensorineural hearing loss.⁶

Allergic rhinitis (AR) is a common and chronic inflammatory condition that affects the nasal

mucosa due to an IgE-mediated type 1 hypersensitivity reaction triggered by exposure to specific allergens. The immune response involves the release of histamine and other inflammatory mediators, leading to the characteristic symptoms of AR, which include sneezing, nasal congestion, runny nose, and itching. Allergic rhinitis can be seasonal or perennial, depending on the nature of the allergens involved, and it often occurs alongside other allergic conditions such as asthma and atopic dermatitis. The pathophysiology of AR is complex, involving multiple immune and inflammatory pathways. Understanding the underlying mechanisms, clinical presentation, and treatment options for AR is essential for managing this condition effectively and improving the quality of life for affected individuals.

The aim of the present study was to evaluate the type and extent of hearing loss among AR patients and assess the association between allergic markers and audiological findings.

MATERIALS AND METHODS

The present study was conducted in the Department of Otorhinolaryngology, National Institute of Medical Science and Research, Jaipur for 18 months. Patients of allergic rhinitis presenting to department of Otorhinolaryngology, National Institute of

Medical Science and Research, Jaipur are selected for the study. 68 patients were included in the study.

Inclusion Criteria:

1. Patients suffering from allergic rhinitis presenting to department of Otorhinolaryngology, National Institute of Medical Science, Jaipur.
2. Patients with symptoms of allergic rhinitis prolonging from at least 4-6 weeks in the age group of 18 to 50 years.
3. Patient giving consent for the study.

Exclusion Criteria:

1. Individuals with history of otologic disease.
2. Individuals with history of use of ototoxic agents.
3. Individuals with any metabolic or systemic disease-causing hearing loss.
4. Individuals with history of neurological factors.
5. Individuals with history of noise induced trauma.
6. Individuals not giving consent for the study.

Statistical Analysis: All statistical analysis was performed in Statistical Package for the Social Sciences (SPSS) / Microsoft Excel.

RESULTS

Table 1: Demographic details of the subjects enrolled in the study

Variables	Case (Mean $\pm$ SD)	Control (Mean $\pm$ SD)
Total Sample Size, n(%)	34 (50)	34 (50)
Age	37.71 $\pm$ 14.52	36.50 $\pm$ 12.38
Gender, n(%)		
Female	16 (47)	17 (50)
Male	18 (53)	17 (50)

A total of 68 subjects were enrolled in the study, comprising 34 cases (patients diagnosed with allergic rhinitis) and 34 controls (non-allergic individuals), contributing equally to the sample population (50% each). The mean age of the case group was 37.71 $\pm$ 14.52 years, while the control group had a mean age of

36.50 $\pm$ 12.38 years. The gender distribution was comparable between the two groups. Among the cases, 16 individuals (47%) were female and 18 (53%) were male, whereas the control group included 17 females (50%) and 17 males (50%).

Table 2: Chief complaints of the subjects enrolled in the study

Symptom / Complaint	Case (n = 34)	Control (n = 34)	Total (n = 68)
NASAL DISCHARGE			
Absent	5 (7.4%)	27 (39.7%)	32 (47.1%)

Present	29 (42.6%)	7 (10.3%)	36 (52.9%)
NASAL OBSTRUCTION			
Absent	19 (27.9%)	34 (50.0%)	53 (77.9%)
Present	15 (22.1%)	0 (0.0%)	15 (22.1%)
SNEEZING			
Absent	6 (8.8%)	34 (50.0%)	40 (58.8%)
Present	28 (41.2%)	0 (0.0%)	28 (41.2%)
WATERING EYE / EYE ITCHING			
Absent	13 (18.1%)	34 (50.0%)	47 (69.1%)
Present	21 (30.9%)	0 (0.0%)	21 (30.9%)
OTHER COMPLAINTS			
Absent	34 (50.0%)	0 (0.0%)	34 (50.0%)
Aural fullness	0 (0.0%)	2 (2.9%)	2 (2.9%)
Foreign body ear	0 (0.0%)	5 (7.4%)	5 (7.4%)
Lymphadenopathy	0 (0.0%)	2 (2.9%)	2 (2.9%)
Midline neck swelling	0 (0.0%)	2 (2.9%)	2 (2.9%)
Neck swelling	0 (0.0%)	7 (10.3%)	7 (10.3%)
Throat irritation	0 (0.0%)	7 (10.3%)	7 (10.3%)
Throat pain	0 (0.0%)	7 (10.3%)	7 (10.3%)
Tongue ulcer	0 (0.0%)	2 (2.9%)	2 (2.9%)
Duration of Chief Complaint, Mean $\pm$ SD	4.17 $\pm$ 4.91	0.41 $\pm$ 0.52	2.285 $\pm$ 3.49

Nasal discharge was reported in 29 (42.6%) of the cases, compared to only 7 (10.3%) in the control group. Nasal obstruction was present in 15 (22.1%) of the cases and absent in all control subjects. Sneezing was another prominent symptom, present in 28 (41.2%) of the allergic rhinitis patients and absent in all controls. Additionally, 21 (30.9%) of the cases reported watering of the eyes or eye itching, a symptom not observed in any of the control participants. In contrast, none of the allergic rhinitis cases reported other otolaryngologic or general complaints, whereas several such

symptoms were observed exclusively in the control group. These included aural fullness (2.9%), foreign body sensation in the ear (7.4%), lymphadenopathy (2.9%), midline neck swelling (2.9%), lateral neck swelling (10.3%), throat irritation (10.3%), throat pain (10.3%), and tongue ulcer (2.9%). The mean duration of chief complaints was significantly longer in the case group (4.17 $\pm$ 4.91 months) compared to the control group (0.41 $\pm$ 0.52 months), indicating a more chronic symptom profile in patients with allergic rhinitis.

Table 3: Clinical findings of the subjects enrolled in the study

Clinical Findings	Case (n = 34)	Control (n = 34)	Total (n = 68)
MUCOSA			
Congested	24 (35.3%)	0 (0.0%)	24 (35.3%)
Normal	10 (14.7%)	34 (50.0%)	44 (64.7%)
DISCHARGE			
Absent	4 (5.9%)	27 (39.7%)	31 (45.6%)
Thick	0 (0.0%)	2 (2.9%)	2 (2.9%)
Thick and mucoid	0 (0.0%)	2 (2.9%)	2 (2.9%)
Thick and purulent	0 (0.0%)	3 (4.4%)	3 (4.4%)
Thin, watery, clear	30 (44.1%)	0 (0.0%)	30 (44.1%)
DEVIATED NASAL SEPTUM			
Absent	11 (16.2%)	24 (35.3%)	35 (51.5%)

Present	23 (33.8%)	10 (14.7%)	33 (48.5%)
TURBINATE HYPERTROPHY			
Absent	14 (20.6%)	25 (36.8%)	39 (57.4%)
Present	20 (29.4%)	9 (13.2%)	29 (42.6%)
OTHER FINDINGS			
Absent	19 (27.9%)	0 (0.0%)	19 (27.9%)
Aphthous ulcer	0 (0.0%)	2 (2.9%)	2 (2.9%)
B/L impacted wax	0 (0.0%)	2 (2.9%)	2 (2.9%)
Darier's line	15 (22.1%)	0 (0.0%)	15 (22.1%)
Foreign body in right ear	0 (0.0%)	4 (5.9%)	4 (5.9%)
Grade 2 tonsillitis	0 (0.0%)	3 (4.4%)	3 (4.4%)
Lymphadenopathy	0 (0.0%)	2 (2.9%)	2 (2.9%)
Midline neck swelling present	0 (0.0%)	9 (13.2%)	9 (13.2%)
Negative	0 (0.0%)	6 (8.8%)	6 (8.8%)
Oropharynx congested	0 (0.0%)	4 (5.9%)	4 (5.9%)
Right side neck swelling	0 (0.0%)	2 (2.9%)	2 (2.9%)

Congested nasal mucosa was observed in 24 (35.3%) of the cases, whereas none of the control subjects exhibited this sign. Conversely, normal mucosa was noted in all 34 controls (50%) and in only 10 (14.7%) of the allergic rhinitis patients. Nasal discharge was a prominent finding in the case group, with 30 patients (44.1%) presenting with thin, watery,

and clear discharge—consistent with allergic etiology. In contrast, various types of discharge such as thick, mucoid, and purulent were observed exclusively in the control group, though in fewer numbers. Only 4 (5.9%) allergic rhinitis cases had no observable discharge, compared to 27 (39.7%) controls.

Table 4: Laboratory Investigations of the subjects enrolled in the study

Parameter	Case (Mean ± SD)	Control (Mean ± SD)
TLC	9.12 ± 3.38	7.33 ± 1.79
TEC	4.47 ± 1.81	3.62 ± 1.69
VEC	170.94 ± 87.83	158.21 ± 52.15
Serum IgE	900.88 ± 275.23	589.62 ± 282.04

The mean total leukocyte count (TLC) was elevated in the allergic rhinitis group ($9.12 \pm 3.38 \times 10^9/L$) compared to the control group ($7.33 \pm 1.79 \times 10^9/L$), suggesting a heightened systemic immune response among cases.

Similarly, the mean total eosinophil count (TEC) was higher in cases ($4.47 \pm 1.81 \times 10^8/L$) than in controls ($3.62 \pm 1.69 \times 10^8/L$), reflecting the typical eosinophilic predominance seen in allergic conditions.

Table 5: Diagnosis of the subjects enrolled in the study

Diagnosis	Case (n = 34)	Control (n = 34)	Total (n = 68)
Acute pharyngitis	0 (0.0%)	7 (10.3%)	7 (10.3%)
Allergic rhinitis	10 (14.7%)	0 (0.0%)	10 (14.7%)
Allergic rhinitis with DNS	24 (35.3%)	0 (0.0%)	24 (35.3%)
Aphthous ulcer	0 (0.0%)	2 (2.9%)	2 (2.9%)
Acute lymphadenopathy	0 (0.0%)	2 (2.9%)	2 (2.9%)
Colloid thyroid cyst	0 (0.0%)	2 (2.9%)	2 (2.9%)
Foreign body (right ear)	0 (0.0%)	5 (7.4%)	5 (7.4%)
Impacted wax	0 (0.0%)	2 (2.9%)	2 (2.9%)
Laryngopharyngeal reflux (LPR)	0 (0.0%)	7 (10.3%)	7 (10.3%)

Lymphangioma	0 (0.0%)	2 (2.9%)	2 (2.9%)
Thyroid nodule	0 (0.0%)	5 (7.4%)	5 (7.4%)

Among the 34 patients in the case group, the predominant diagnosis was allergic rhinitis with deviated nasal septum (DNS), accounting for 24 cases (35.3% of the total sample). The remaining 10 (14.7%) were diagnosed with allergic rhinitis without any anatomical variations. The most frequent diagnoses among controls were acute pharyngitis and

laryngopharyngeal reflux (LPR), each diagnosed in 7 subjects (10.3%). Other diagnoses in the control group included foreign body in the right ear (7.4%), thyroid nodules (7.4%), aphthous ulcers (2.9%), impacted ear wax (2.9%), acute lymphadenopathy (2.9%), colloid thyroid cysts (2.9%), and lymphangioma (2.9%).

Table 6: Otoscope findings of the subjects enrolled in the study

Otoscope Finding	Case (n = 34)	Control (n = 34)	Total (n = 68)
B/L adhesive otitis media	1 (1.5%)	0 (0.0%)	1 (1.5%)
B/L grade 1 retraction	2 (2.9%)	0 (0.0%)	2 (2.9%)
B/L grade 2 retraction	2 (2.9%)	0 (0.0%)	2 (2.9%)
B/L grade 3 retraction	2 (2.9%)	0 (0.0%)	2 (2.9%)
B/L impacted wax	0 (0.0%)	2 (2.9%)	2 (2.9%)
B/L otitis media with effusion	3 (4.4%)	0 (0.0%)	3 (4.4%)
B/L retracted tympanic membrane	2 (2.9%)	0 (0.0%)	2 (2.9%)
Foreign body right EAC	0 (0.0%)	5 (7.4%)	5 (7.4%)
Left grade 1 retraction; right normal	2 (2.9%)	0 (0.0%)	2 (2.9%)
Left retracted tympanic membrane	0 (0.0%)	2 (2.9%)	2 (2.9%)
Normal	18 (26.5%)	25 (36.8%)	43 (63.2%)
Right grade 2 retraction; left normal	1 (1.5%)	0 (0.0%)	1 (1.5%)
Right otitis media with effusion	1 (1.5%)	0 (0.0%)	1 (1.5%)

Among the 34 cases, only 18 subjects (26.5%) had normal otoscopic findings, whereas a larger proportion of the control group—25 subjects (36.8%)—had normal findings. Several abnormalities were observed exclusively in the allergic rhinitis group, supporting an association between allergic nasal disease and middle ear involvement. The most common abnormal findings in the case group included bilateral otitis media with effusion (OME) in 3 patients

(4.4%), grade 1 to grade 3 tympanic membrane retraction bilaterally in 6 cases (17.6%), and bilateral retracted tympanic membranes in 2 cases (2.9%). Additionally, isolated findings such as bilateral adhesive otitis media, right-sided OME, and asymmetrical retractions (e.g., left grade 1/right normal or right grade 2/left normal) were observed in smaller numbers.

Table 7: Pure tone Audiometry of the subjects enrolled in the study at different frequencies

Parameter	Case (Mean $\pm$ SD)		Control (Mean $\pm$ SD)	
	Right Ear	Left Ear	Right Ear	Left Ear
PTA Average	32.09 $\pm$ 14.38	31.53 $\pm$ 15.68	18.53 $\pm$ 3.71	18.85 $\pm$ 2.75
@2kHzBC	22.06 $\pm$ 16.10	22.35 $\pm$ 17.07	13.38 $\pm$ 4.03	14.27 $\pm$ 4.79
@2kHzAC	31.18 $\pm$ 16.05	30.88 $\pm$ 16.40	16.32 $\pm$ 4.97	18.68 $\pm$ 3.95
@4kHzBC	21.62 $\pm$ 15.41	22.21 $\pm$ 16.61	13.38 $\pm$ 4.03	14.27 $\pm$ 4.79
@4kHzAC	32.79 $\pm$ 18.31	31.32 $\pm$ 18.52	16.91 $\pm$ 5.22	19.71 $\pm$ 5.07
@8kHzBC	21.77 $\pm$ 14.71	22.79 $\pm$ 16.20	14.12 $\pm$ 5.43	15.00 $\pm$ 5.90
@8kHzAC	32.79 $\pm$ 20.93	33.09 $\pm$ 22.36	17.79 $\pm$ 7.09	19.27 $\pm$ 6.17

The pure tone average (PTA) among cases was elevated in both ears, with a mean of 32.09 $\pm$ 14.38 dB in the right ear and 31.53 $\pm$ 15.68 dB

in the left ear, in contrast to the control group which showed much lower averages of 18.53 $\pm$ 3.71 dB and 18.85 $\pm$ 2.75 dB, respectively.

Detailed analysis of air conduction (AC) and bone conduction (BC) thresholds at specific frequencies further supported this finding. At 2 kHz, AC thresholds in the case group were 31.18 ± 16.05 dB (right) and 30.88 ± 16.40 dB (left), which were markedly higher than those in controls (16.32 ± 4.97 dB and 18.68 ± 3.95 dB, respectively). Similarly, BC thresholds at the same frequency were also elevated in cases (22.06 ± 16.10 dB right; 22.35 ± 17.07 dB left) when compared to controls (13.38 ± 4.03 dB right; 14.27 ± 4.79 dB left). At 4 kHz and 8 kHz, this pattern remained consistent, with both AC and BC thresholds significantly higher in allergic rhinitis patients. For instance, at 8 kHz, AC thresholds in cases reached 32.79 ± 20.93 dB (right) and 33.09 ± 22.36 dB (left), while controls maintained lower values of 17.79 ± 7.09 dB and 19.27 ± 6.17 dB, respectively.

DISCUSSION

The study enrolled 68 subjects, divided equally into two groups: 34 cases of allergic rhinitis and 34 healthy controls. The age distribution between the two groups was similar, with the mean age of the case group being 37.71 ± 14.52 years and the control group 36.50 ± 12.38 years. There was also a balanced gender distribution, with 47% females in the case group and 50% in the control group, which minimizes potential confounding variables related to sex differences.⁷ This balanced baseline sets the stage for the comparative analysis of clinical features, lab findings, and hearing status between the two groups.

The chief complaints in allergic rhinitis patients revealed a clear differentiation from controls. Nasal discharge, nasal obstruction, and sneezing were significantly more common in the allergic rhinitis group. Nasal discharge, in particular, was present in 29 (42.6%) cases compared to only 7 (10.3%) controls.⁸ Other hallmark symptoms like eye watering or itching were present in 30.9% of cases, but not at all in controls, further supporting the clinical diagnosis of allergic rhinitis.⁹ The duration of complaints was also significantly longer in the case group, reflecting the chronic nature of allergic rhinitis symptoms.¹⁰

On clinical examination, patients with allergic rhinitis showed significant mucosal congestion (35.3% of cases), a feature absent in the control group. This is consistent with previous studies that report nasal congestion as a common feature of allergic rhinitis.¹¹ The higher prevalence of turbinates hypertrophy (29.4% in cases) and deviated nasal septum (33.8% in

cases) further supports the diagnosis, as these anatomical changes are often observed in allergic rhinitis patients.¹² The presence of Darier's line in 22.1% of allergic rhinitis patients was another specific finding supporting allergic etiology, as this line is often observed in individuals with atopic conditions.¹³

The laboratory results showed significant differences between the two groups. The total leukocyte count (TLC) and eosinophil count (TEC) were significantly elevated in allergic rhinitis patients, which is indicative of an ongoing allergic or inflammatory response.¹⁴ The elevated serum Immunoglobulin E (IgE) levels in the allergic rhinitis group (900.88 ± 275.23 IU/mL) compared to the controls (589.62 ± 282.04 IU/mL) is a hallmark immunological finding, as IgE is a key mediator in allergic responses.¹⁵ The increased levels of IgE support the diagnosis of allergic rhinitis, and this observation aligns with previous findings that demonstrate IgE as a reliable marker of allergic conditions.¹⁶

The most common diagnosis in the case group was allergic rhinitis with deviated nasal septum (DNS), found in 35.3% of the subjects. This suggests that anatomical nasal variations like DNS may predispose individuals to allergic rhinitis by impairing nasal airflow and promoting inflammation.¹⁷ The control group, in contrast, had a diverse range of non-allergic conditions, including acute pharyngitis (10.3%) and laryngopharyngeal reflux (10.3%), further distinguishing allergic rhinitis as the primary condition in the case group.¹⁸

In otoscopic examination, middle ear pathologies were more frequently observed in the allergic rhinitis group, suggesting an association between allergic rhinitis and middle ear dysfunction. Bilateral otitis media with effusion (OME) and tympanic membrane retraction were significantly more common in allergic rhinitis patients, consistent with findings from similar studies.¹⁹ These otoscopic abnormalities indicate the possibility of eustachian tube dysfunction in allergic rhinitis patients, which may contribute to hearing impairment.²⁰

The pure tone audiometry (PTA) results showed that allergic rhinitis patients had higher hearing thresholds in both ears compared to the control group, indicating mild conductive hearing loss. The mean PTA for the right ear in allergic rhinitis patients was 32.09 ± 14.38 dB, significantly higher than the control group's mean of 18.53 ± 3.71 dB.²¹ This finding is consistent with previous studies that show a

link between allergic rhinitis and mild hearing impairment, likely due to eustachian tube dysfunction and middle ear inflammation.²²

The study concluded that allergic rhinitis is strongly associated with clinical symptoms such as nasal discharge, nasal obstruction, and sneezing, which are not present in healthy controls. The laboratory findings, including elevated eosinophil count and serum Immunoglobulin E (IgE) levels, further support the diagnosis of allergic rhinitis. The presence of anatomical variations like deviated nasal septum (DNS) in the case group indicates that such conditions may predispose individuals to allergic rhinitis. Additionally, the study revealed a significant association between allergic rhinitis and middle ear dysfunction, as evidenced by otoscopic and audiometric abnormalities. These findings highlight the importance of early diagnosis and management of allergic rhinitis to prevent complications, including hearing impairment.

CONCLUSION

In conclusion, this study provides valuable insights into the clinical, laboratory, and otoscopic characteristics of allergic rhinitis, emphasizing its significant association with various symptoms and complications. The clear differentiation of allergic rhinitis patients from healthy controls based on common symptoms such as nasal discharge, nasal obstruction, and sneezing, coupled with elevated eosinophil and IgE levels, strongly supports the diagnosis of allergic rhinitis. These immunological markers, particularly elevated serum IgE, highlight the allergic etiology of the condition and provide a robust means for clinical diagnosis.

Furthermore, the study demonstrates that anatomical variations like a deviated nasal septum (DNS) are prevalent in allergic rhinitis patients and may predispose them to developing the condition by disrupting normal nasal airflow and contributing to ongoing inflammation. This suggests that structural nasal abnormalities could play a significant role in the pathogenesis of allergic rhinitis, and addressing such issues may improve management outcomes.

One of the most significant findings of the study is the observed association between allergic rhinitis and middle ear dysfunction. Otoscopic examinations revealed a higher incidence of middle ear pathologies, such as bilateral otitis media with effusion (OME) and tympanic membrane retraction, in allergic rhinitis patients. These otoscopic abnormalities

indicate potential eustachian tube dysfunction, which may lead to hearing impairment. The pure tone audiometry (PTA) results further support this association, revealing that allergic rhinitis patients exhibited higher hearing thresholds, particularly in the right ear, compared to healthy controls. This suggests that allergic rhinitis may contribute to mild conductive hearing loss, likely due to eustachian tube dysfunction and inflammation of the middle ear.

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