Journal of Medical Bacteriology

Investigation of Concha Bullosa in CT Scan: A Comparative Study Between Patients with Allergic Fungal Rhinosinusitis and Non-Fungal Rhinosinusitis with Polyposis with Culture of Secretions

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ARTICLE INFO

Article type:
Research Article

Article history:

Received	09	Jun	2025
Revised	25	Jun	2025
Accepted	13	Jul	2025
Published	23	Aug	2025

Keywords:
Concha bullosa, Fungal allergic rhinosinusitis, Non-fungal rhinosinusitis, Polyposis, Radiological report.

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ABSTRACT

Background: Understanding the radiographic and anatomical distinctions in patients with allergic fungal rhinosinusitis (AFRS) is crucial for effective treatment and recurrence prevention. Current study aimed to investigate the presence of Concha bullosa in CT scans of patients with AFRS compared to patients with non-fungal rhinosinusitis with polyposis (NFRP), alongside the culture of the secretions.

Methods: This cross-sectional study involved 86 patients with an average age of 40.91 ± 13.45 years, all suffering from nasal polyps and undergoing endoscopic sinus surgery at the Amir Alam Hospital. Participants were divided into two groups; AFRS group (n=43), and NFRP group (n=43). CT scans of the paranasal sinuses were conducted for all patients. Additionally, assessments were made for fungal cultures from Concha bullosa secretions, sinus secretions, and polyp tissue.

Results: The average age of patients in the AFRS group was significantly lower than that of the NFRP group (37.3 years vs. 44.5 years, P=0.012). The incidence of Concha bullosa with secretion was higher than the ones without secretion. Notably, the AFRS group exhibited a significantly greater prevalence of Concha bullosa with secretion compared to the NFRP group (44.2% vs. 18.6%, P=0.034). In terms of fungal cultures, Aspergillus was the only positive finding in the AFRS group (13.5%, n=5) and in the NFRP group (6.1%, n=2). The species Aspergillus flavus (4.3%, n=3) was more frequently identified in fungal cultures from sinus secretions and polyp tissue among AFRS group.

Conclusion: Concha bullosa is more common in the AFRS group than in the NFRP group. It suggests a potential association between fungal colonization and disease recurrence. Also, Aspergillus, especially Aspergillus flavus, are frequently found in AFRS group, pointing to the role in the disease. The findings stress the need to consider Concha bullosa when treating AFRS to enhance outcomes and lower recurrence rates.

- ***Please cite this paper as:*** Irani S, Esmaeilzadeh Avval M, Arbabi L, Kazemi MA, Lotfi M. Investigation of Concha Bullosa in CT Scan: A Comparative Study Between Patients with Allergic Fungal Rhinosinusitis and Non-Fungal Rhinosinusitis with Polyposis with Culture of Secretions. *J Med Bacteriol.* 2025; **13** (3): pp.83-90. DOI: 10.18502/jmb.v13i3.19511

Introduction

Rhinitis is a type of inflammation in the nasal cavity that is categorized into various forms such as allergic, vasomotor, drug-induced, non-allergic eosinophilic, atrophic, and acute rhinitis (1). Chronic rhinosinusitis, with a prevalence of approximately 12 to 15 percent, is considered one of the most common chronic inflammatory diseases (2). The condition is associated with symptoms such as nasal congestion, sneezing, nasal discharge, itching of the nose and eyes, tearing, and frontal headache (3). The diagnostic criteria for rhinitis include the presence of these symptoms and the absence of anatomical nasal disorders, such as septal deviation or nasal tumors (3). During clinical examination, the nasal mucosa is often observed to be swollen and pale.

Chronic rhinosinusitis is divided into two groups: with and without polyps. Chronic rhinosinusitis is multifactorial, and its inflammatory changes can range from increased mucosal thickness to widespread polyposis. Nasal polyps are the most common nasal tumors, and there is still no specific standard treatment for them (4). Symptoms of the condition include nasal congestion, breathing difficulties, headaches, anosmia, rhinorrhea, and posterior nasal discharge. In advanced cases, chronic rhinosinusitis can lead to thinning or erosion of the sinus bones and deformity of the facial skeleton (5).

The exact cause of nasal polyposis is not fully understood, but environmental factors such as allergens and pathogenic factors play a role in its development. Recently, the role of fungi in the development of nasal polyposis has come to attention, but the present theory has not yet been conclusively confirmed (5). Fungal rhinosinusitis is classified based on histopathology into two types: invasive and non-invasive (6). Non-invasive forms include fungal balls and eosinophilic fungal rhinosinusitis, which are further sub-categorized into allergic and non-allergic types (7).

Allergic fungal rhinosinusitis (AFRS) is the most common type of fungal rhinosinusitis, and cases are on the rise (8). The disease often occurs in young individuals, particularly in warm and humid regions (8, 9). Studies have shown that the prevalence of the AFRS is high in patients with nasal polyposis in Iran, and these patients experience more recurrences compared to patients with non-fungal rhinosinusitis with polyposis (NFRP). The diagnosis of the AFRS is often based on imaging findings such as CT scan and MRI (9). In patients with AFRS , specific anatomical structures like the concha bulla and Haller cells are more frequently observed (10).

Previous studies have indicated that the concha bulla may serve as a site for the accumulation of mucin or fungal secretions and play a role in the development of the AFRS (3). Findings from Cody et al., demonstrated that the AFRS is more prevalent in areas with high levels of fungal spores. Additionally, results from a study by Makary and colleagues (2020) showed that anatomical changes in the sinuses, such as concha bulla and Haller cells, are more commonly observed in patients with the AFRS (11). The aim of current study is to examine and confirm the theory that certain anatomical changes in the sinuses, such as concha bullosa, may play a role in the occurrence of the AFRS. Given the high prevalence of treatment-resistant nasal polyps in ear, nose, and throat clinics, limited studies have been conducted. The present research is designed to compare the radiological and pathological evidence of the AFRS with the NFRP changes at Amiralam Hospital. The results of current study could play a significant role in better decision-making for the diagnosis and treatment of patients with the AFRS.

Materials and Methods

The present study was conducted as a cross-sectional study from 2022 September to 2023 September on patients with nasal polyps who underwent endoscopic sinus surgery at Amiralam

Hospital in Tehran. Sampling was conducted using a convenience sampling method, and medical records of the patients were also utilized. The sample size was determined based on the study by Rowan et al. (3), considering a random error of 5 percent, an 80 percent statistical power, to be 43 patients with allergic fungal rhinosinusitis (AFRS group) and 43 individuals in the group of patients with non-fungal rhinosinusitis with polyposis (NFRP group). The required sample size was calculated using STATA software. All patients were assessed after obtaining informed consent to participate in the study. Patients with immune deficiencies, cystic fibrosis, any type of malignancy, Kartagener syndrome, autoimmune diseases, or granulomatosis were excluded from the study. The data collection tool was a questionnaire. Demographic, clinical, radiological findings, and microbiological culture results were gathered from patients' records and recorded in a designed information form. The diagnosis of polyps was based on the history, which included nasal obstruction, rhinorrhea, posterior nasal drainage, nosebleeds, snoring, and clinical examination (anterior rhinoscopy, sinus endoscopy, and observing a polypoid mass of pale yellow or pink occupying the nasal cavity), which was determined by specialists in ear, nose, and throat.

In the present study, the diagnosis of the AFRS was based on the diagnostic criteria presented by Benet and Kuhn. According to these criteria, five diagnostic factors were considered: the presence of type-1 hypersensitivity based on the patient's history or positive skin test or serology; nasal polyposis; CRS confirmed by CT scan; observation of allergic mucin during surgery or in the histopathological examination of the affected sinus; demonstration of fungal elements in sinus samples through culture or histopathology; and the absence of evidence of fungal invasion in patients. Additionally, criteria such as a history of asthma, predominantly unilateral disease, radiographic evidence of bone erosion, positive fungal culture, presence of Charcot-Leyden crystals in polyp samples, nasal secretions, and eosinophilia in serum were considered to support the diagnosis.

Radiological Evaluation

CT scans without contrast of the paranasal sinuses were performed for all patients. Diagnostic features included space-occupying lesions with heterogeneous densities, deformity, thinning of the bony wall, or dilation and erosion of the sinus wall as reported by radiology specialists. Type I hypersensitivity reaction was considered positive based on the atopy history questionnaire (allergic rhinitis, asthma, dermatitis).

The patients' imaging was inspected by a radiologist specialized in head & neck Imaging. The criteria including the anterior and posterior table of the sinuses (frontal, anterior ethmoid, posterior ethmoid, sphenoid, and maxillary), borders of the orbit, concha bullosa, Onodi cells, Haller cell, Agger nasi cells, intersinus frontal cells were all gathered.

For microbial culture, samples were collected separately during endoscopic sinus surgery from the contents of the middle turbinate (if present) and sinus secretions. Sampling was conducted using surgical forceps directly, without contact cloth or sterile gauze pads. then, samples were placed in two separate containers. Part of the samples was evaluated for pathology in formalin after Periodic Acid-Schiff (PAS) staining, while the other part was collected for fungal microbiological studies and culture in a sterile normal saline container. The samples were transported to the Mycology Laboratory of the Faculty of Medicine at room temperature (immediately) or at 4 degrees in the refrigerator (for a maximum of 24 hours) and were cultured on a direct slide using 20% potassium hydroxide, as well as on dextrose agar for a period of 4 weeks. Based on the morphology of the colonies and direct slides, the fungal samples were identified. Data were analyzed using SPSS software version 22. Description of the data was

performed with mean ± standard deviation and frequency (percentage). Demographic, clinical, CT scan findings, and microbiological culture results were compared between two groups of patients with AFRS group and patients with NFRP group using the Chi-square test and Fisher's exact test. The relationship between CT scan findings and the age and gender of the patients was also examined using the Chi-square test and Fisher's exact test. The significance level in all tests was set at 0.05.

Results

In the present study, a total of 86 patients were examined in two groups: patients with the AFRS (AFRS group; n = 43 patients) and patients with NFRP (NFRP group; n = 43 patients) as shown in Table 1. The results indicated that the age of patients in the AFRS group was significantly lower than that of patients in the NFRP group (37.3 years vs. 44.5 years, P=0.012) (Table 1).

The results of the analysis of gender distribution and atopic history in AFRS group and NFRP group showed that there were no significant differences between groups in terms of gender distribution (P=0.186), and atopic history (P=0.604) (Table 1).

Table 2 displays the correlation between CT scan results with age and gender of patients. The findings of current study showed that there is no noteworthy association between the NFRP group's gender and age and different CT scan results (P>0.05) (Table 2 and Table 3).

The description of fungal growth findings from Concha bullosa secretions of 70 patients showed that 13.5% of patients in the AFRS group, and 6.1% of patients in the NFRP group had positive fungal growth. The results of current study indicated that there was no significant relationship between negative and positive fungal growth from the Concha bullosa secretions of patients in the AFRS group, and patients in the NFRP group (P=0.434) (Table 4).

The results show that fungal infections such as Aspergillus are more frequent in AFRS patients, while bacterial infections such as Pseudomonas and beta-hemolytic Streptococcus are often observed in patients with NFRP (Table 5).

Table 6 shows the difference in positive fungal growth in sinus secretions and polyp tissue categorized by patients in two groups. The results of positive fungal growth in sinus secretions and polyp tissue indicated that 14% of AFRS group had positive fungal growth, while all patients in the NFRP group had negative fungal growth. The findings of present study demonstrated a notable difference between the two groups regarding fungal growth in sinus secretions and polyp tissue (P=0.237) (Table 6).

Discussion

Allergic fungal rhinosinusitis (AFRS) is a distinct type of chronic rhinosinusitis characterized by a unique set of radiographic and pathophysiological findings (12). The precise pathophysiology of the AFRS has not been fully elucidated and tends to occur unilaterally. The recurrence rate in the AFRS is high and often requires revision endoscopic sinus surgery, with some studies reporting recurrence rates as high as 50% (12). Thorough examination and complete opening of concha bullosa during surgery for the AFRS is essential as it may harbor fungal residues (13). In precent study, the aim was to evaluate the prevalence of concha bullosa in patients with the AFRS and compare it with patients with the NFRP. We also examined the microbiological culture results in concha bullosa secretions and in the secretions of sinuses and polyp tissue in these two groups of patients. For the purpose, 86 patients with a mean age of 40.91 ± 13.45 years, of whom 60.5% were male, were equally divided into two groups for the study.

The results indicated no significant difference in the gender distribution of patients between the AFRS group and the NFRP group; however, analysis of patient age revealed a significant difference between the two groups, with the mean

Table 1. Description of demographic and clinical information among patients in the AFRS Group, and patients in the NFS group.

Variables		Total n=86	AFRS group n=43	NFS group n=43	P value
Age	≤41	55(64)	33(76.7)	22(51.2)	**0.013**
	41<	31(36)	10(23.3)	21(48.8)	
Gender	Male	52(60.5)	23(53.5)	29(67.4)	**0.186**
	Female	34(39.5)	20(46.5)	14(22.6)	
Atopy history	No	67(77.9)	32(74.4)	35(81.4)	**0.604**
	Yes	19(22.1)	11(25.6)	8(18.6)	

Table 2. The relationship between CT scan findings and the gender of patients in the AFRS group, and NFRP group.

Variables	Gender	AFRS group n=43	NFRP group n=43	P value
Cuncabulosa with secretion	Male	11 (57.9)	6 (75)	0.401
	Female	8 (42.1)	2 (25)	
Cuncabulosa without secretion	Male	0 (0)	0 (0)	-
	Female	1 (100)	1 (100)	
Anode	Male	3 (33.3)	9 (69.2)	0.192
	Female	6 (66.7)	4 (30.8)	
Bone erosion	Male	3 (50)	7 (87.5)	0.245
	Female	3 (50)	1 (12.5)	
Haller	Male	2 (66.7)	4 (66.7)	1
	Female	1 (33.3)	2 (33.3)	
None	Male	4 (80)	3 (42.9)	0.293
	Female	1 (20)	4 (57.1)	

Table 3. The relationship between CT scan findings and the age of AFRS group, and NFRP Group.

Variables	Age	AFRS group n=43	NFRP group n=43	P value
bulosa with Cunca secretion	41≥	17 (89.5)	7 (87.5)	0.882
	>41	2 (10.5)	1 (12.5)	
bulosa without Cunca secretion	41≥	1 (100)	1 (100)	-
	>41	0 (0)	0 (0)	
Anodic	41≥	6 (66.7)	4 (30.8)	0.192
	>41	3 (33.3)	9 (69.2)	
Bone erosion	41≥	3 (50)	2 (25)	0.580
	>41	3 (50)	6 (75)	
Haller	41≥	3 (100)	3 (50)	0.464
	>41	0 (0)	3 (50)	
None	41≥	3 (60)	5 (71.4)	1
	41≥	17 (89.5)	2 (28.6)	

Table 4. Description of the fungal culture from Conchal secretion in patients in the AFRS group and patients in the NFRP group according to the culture results.

Fungal culture	Total n=86	AFRS group n=43	NFRP group n=43	P value
Negative	41(95.3)	38 (88)	79 (91)	0.237
Positive	2(4.7)	5 (12)	7 (9)	

Table 5. Description of the culture findings from the sinus secretions and polyp tissue in AFRS group and NFRP group.

Microorganism	Total 86 = n	AFRS group 43 = n	NFRP Group 43 = n
Negative	33 (76.7)	(72)31	64 (74.3)
Pseudomonas	0 (0)	2 (4.6)	2 (2.3)
Escherichia coli	2 (4.6)	0 (0)	2 (2.3)
Klebsiella	3 (6.9)	0 (0)	3 (3.4)
Staphylococcus aureus	2 (4.6)	0 (0)	2 (2.3)
Beta-hemolytic Streptococcus non-A	0 (0)	2 (4.6)	1 (1.1)
Haemophilus influenzae	1 (2.3)	0 (0)	1 (1.1)
Enterobacter	0 (0)	1 (2.3)	1 (1.1)
Aspergillus flavus	0 (0)	3 (6.9)	3 (3.4)
Aspergillus niger	0 (0)	2 (4.6)	2 (2.3)
Schizosaccharomyces pombe	0 (0)	1 (2.3)	1 (1.1)

Table 6. Comparison of fungal culture from sinus secretions and polyp tissue in patients with the AFRS, and the NFRP.

Fungal culture	Total n=86	AFRS group n=43	NFRP group n=43	P value
Negative	80(93)	37 (86)	43 (100)	0.026
Positive	6(6.9)	6 (14)	0 (0)	

age of patients in the AFRS group being significantly lower than that in the NFRP group (37.3 years versus 44.7 years, P=0.012). Similar to the current study findings, Rowan et al., also stated that the AFRS typically occurs in younger patients (3).

Also, the present study showed that concha bullosa with secretion has a higher prevalence compared to Concha bullosa without secretion. Additionally, concha bullosa was more common in the AFRS group compared to the NFRP group, but the difference was not significant.

The relatively larger size of the Concha bullosa, in comparison to the middle turbinate, may contribute to the narrowing of the bony complex and subsequently lead to obstructive sinus CRS.

The Concha bullosa may facilitate the accumulation of allergic mucus, which can help increase sinus surgeries (5). The Concha bullosa can create conditions for the growth of fungi, and when combined with obstructive effects from other sinus anatomies, it can lead to the AFRS (11).

Similar to the findings of the study, other researchers have also reported a high prevalence of Concha bullosa in patients with the AFRS. A study recently conducted by Makary et al., on 155 patients with the AFRS showed that Concha bullosa is present in about 40% of the patients (1). In the study by Rowan et al., the prevalence of Concha bullosa in patients with the AFRS was reported to be 42.9%, which was significantly higher compared to individuals with Chronic rhinosinusitis with nasal polyps (18.6%) or Chronic rhinosinusitis without nasal polyps (14.3%)(3).

In present study, the secretions of Concha bullosa and sinus secretions, as well as polyps' tissue were cultured in the fungal media. In the secretions from Concha bullosa, the fungus Aspergillus was reported, which was found in 12% of patients with the AFRS and 4.3% of patients with the NFRP. In the cultivation of sinus secretions in the group with the AFRS, Aspergillus flavus (6.9%, 3 cases) was noted, while in the cultivation of sinus secretions in the patients with non-fungal rhinosinusitis with polyposis, Escherichia coli (4.6%, 2 cases), Klebsiella (6.9%, 3 cases), and Haemophilus influenzae (2.3%, 1 case) were the most common. Fungal colonization in the nasal and paranasal sinuses is a common finding. Aspergillus species are the main etiological agents in fungal rhinosinusitis. Singh et al., examining 76 clinically suspected cases of fungal rhinosinusitis, it was reported that the AFRS is the most common type and it was found that Aspergillus flavus is the most frequent fungus causing fungal rhinosinusitis (5).

The finding indicates that concha bullosa can create conditions conducive to the growth of fungi, and when combined with the obstructive effects resulting from other sinus anatomies, it can lead to the development of the AFRS (11). If the normally air-filled concha bullosa is filled with fungal particles or allergic mucus, and the site is not detected during sinus surgery, also the untreated disease site can result in the spread of the disease with localized tissue inflammation and cause narrowing of the middle meatus, thereby blocking access to most sinuses in local treatments, hence facilitating disease progression (10). The current study showed that the prevalence of concha bullosa in patients with the AFRS is higher compared to patients with the NFRP, although the difference was not statistically significant. Aspergillus species are the main etiological factors in patients with the ARFS. Conversely, the results of fungal growth of the sinus secretions observed that the fungal growth in the AFRS group was notably greater than that NFRP group.

Conclusion

Concha bullosa is more common in the AFRS group than in the NFRP group. It suggests a link between Concha bullosa, fungal colonization, and disease recurrence. Also, Aspergillus, especially Aspergillus flavus, are frequently found in AFRS group, pointing to the role in the disease. The findings stress the need to consider Concha bullosa when treating AFRS to enhance outcomes and lower recurrence rates.

Acknowledgements

The authors of the article express their sincere gratitude to the operating room staff, departments, and laboratory of Amir Alam Hospital who assisted us in conducting current project.

Funding Information

The present study was conducted concurrently with the residency thesis of Dr. Ismailzadeh at the

Ear, Nose, and Throat Research Center of Amir Alam Hospital under the supervision of Tehran University of Medical Sciences.

Ethics approval and consent to participate

The article is the result of a residency thesis with ethical code IR.TUMS.AMIRALAM.REC .1400.045 from the Ethics Committee of Tehran University. To comply with ethical research standards, the research process and the role of subjects were explained clearly. Assurance was also provided regarding the protection of the collected data.

Conflict of interest

The authors declare that there are no conflicts of interest in the current study.

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