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Research Article

Fungal Diseases of the Paranasal Sinuses

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Abstract

Fungal rhinosinusitis comprises a heterogeneous group of diseases affecting the nasal cavity and paranasal sinuses, ranging from non-invasive colonization to rapidly progressive, life-threatening invasive infections. The clinical course and prognosis largely depend on the host immune status and the presence of tissue invasion, with invasive forms posing a high risk of orbital and intracranial complications. In recent years, the incidence of fungal rhinosinusitis has increased, likely due to improved diagnostic modalities, wider use of endoscopy, and a growing population of immunocompromised patients, including those with diabetes mellitus and post-COVID-19 conditions. This article provides a comprehensive review of fungal rhinosinusitis, focusing on current classification, epidemiology, pathophysiology, clinical manifestations, diagnostic strategies, and management principles. According to histopathological criteria, fungal rhinosinusitis is classified into non-invasive forms (saprophytic colonization, fungal ball, and allergic fungal rhinosinusitis) and invasive forms (acute invasive, chronic invasive, and granulomatous invasive fungal rhinosinusitis). Non-invasive disease typically affects immunocompetent individuals and is characterized by localized fungal accumulation or hypersensitivity reactions without tissue invasion, whereas invasive forms predominantly occur in immunocompromised patients and are associated with angioinvasion, tissue necrosis, and bone destruction. Diagnosis relies on a combination of clinical evaluation, endoscopic findings, radiologic imaging, and definitive histopathological confirmation. Computed tomography plays a key role in identifying hyperdense fungal material and bony changes, while magnetic resonance imaging is essential for assessing soft-tissue involvement and extrasinus extension. Management strategies vary according to disease type and include surgical intervention, systemic antifungal therapy, and correction of underlying predisposing factors. A clinical case of isolated sphenoid fungal rhinosinusitis with optic nerve compression is presented, illustrating the diagnostic challenges and therapeutic considerations. Successful treatment was achieved with endoscopic transnasal sphenoidotomy, followed by close postoperative surveillance. This case highlights the importance of early recognition, accurate diagnosis, and individualized management to prevent irreversible complications and ensure favorable outcomes.

Keywords

Paranasal Sinuses, Fungal Sinusitis, Fungal Involvement of the Paranasal Cavities, Endoscopic Surgery, Transnasal Sphenoidotomy

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1. Introduction

Fungal diseases of the nasal cavity and paranasal sinuses encompass a wide spectrum of disorders, ranging from benign colonization or non-invasive sinus disease to aggressive, tissue-invasive, life-threatening infections. Clinical manifestations depend on the risk of complications, in particular, orbital and intracranial complications are observed in invasive forms and may result in fatal outcomes.

In recent years, the increased detection of fungal sinus disease is likely related to advances in imaging techniques, wider use of endoscopy and biopsy and the growing prevalence of immunodeficiency states (e.g., diabetes mellitus, steroid therapy, post-COVID-19 status) [5, 11].

2. Classification of Fungal Rhinosinusitis [4]

According to the most widely accepted classification, fungal rhinosinusitis is divided into non-invasive and invasive forms, based on histopathological evidence of tissue invasion by fungal hyphae.

2.1. Non-invasive Forms

Localized colonization – saprophytic/fungal colonization or infestation of nasal secretions or crusts.

Fungal ball – a dense conglomeration of fungal hyphae (most commonly *Aspergillus*), usually confined to a single sinus, without tissue invasion [3].

Allergic fungal rhinosinusitis (AFRS) – a hypersensitivity reaction to fungal antigens, characterized by allergic (eosinophilic) thick mucus (mucin), often associated with nasal polyposis, without invasive growth.

2.2. Invasive Forms

Acute invasive fungal rhinosinusitis – a rapidly progressive disease (usually < 4 weeks) occurring in immunocompromised patients, associated with fungal angioinvasion, often resulting in necrosis, vascular thrombosis, and tissue destruction.

Chronic invasive fungal rhinosinusitis – develops slowly over months, mainly in patients with impaired immune function, and is characterized by invasion of soft tissues and bone.

Granulomatous (chronic) invasive fungal rhinosinusitis – a chronic, locally invasive disease often associated with specific geographic regions, characterized by granulomatous inflammation and bony involvement.

3. Epidemiology and Risk Factors

Recent retrospective studies (2019–2021) report that approximately 66% of fungal rhinosinusitis cases were invasive, while 34% were non-invasive [5].

The principal risk factor for invasive disease is immunodeficiency, most commonly seen in patients with uncontrolled diabetes mellitus, hematologic malignancies/neutropenia, immunosuppressive therapy, or comorbid conditions (e.g., COVID-19) [11].

Non-invasive forms (fungal ball, allergic fungal rhinosinusitis) more frequently affect immunocompetent individuals [12].

4. Pathophysiology

The distinction between non-invasive and invasive forms largely depends on the patient's immune status. Immunocompetent individuals typically develop fungal colonization or hypersensitivity reactions, whereas immunocompromised patients are at risk for fungal invasion, vascular thrombosis, tissue necrosis, and destruction of bone and soft tissues.

5. Clinical Manifestations

Fungal ball – usually unilateral, affecting a single sinus; symptoms include nasal obstruction, postnasal discharge, facial pressure or heaviness, and headache [3].

Allergic fungal rhinosinusitis – chronic nasal obstruction, nasal polyposis, thick eosinophil-rich mucus ("allergic mucin"), frequent recurrence despite previous surgery; commonly seen in patients with atopy, asthma, or allergic rhinitis.

Acute invasive fungal rhinosinusitis – rapid onset (days to weeks) with facial pain, fever, black necrotic nasal mucosa, periorbital edema, cranial nerve deficits, and vision loss, typically in immunocompromised patients [2].

Chronic invasive/granulomatous fungal rhinosinusitis – slower progression with facial swelling, proptosis (if orbital involvement is present), dull headache, and possible bony destruction. Symptoms may be subtle, and diagnosis is often delayed.

6. Diagnosis

Accurate diagnosis is based on a combination of:
clinical findings (immune status, risk factors),
endoscopic examination,
radiologic studies (CT, MRI),
and most importantly, histopathology and microbiology (culture / PCR) [12].

Computed tomography (CT) is the primary modality for detecting bony changes (erosion, dehiscence), hyperdense fungal accumulations (fungal ball), and sinus opacification.

Magnetic resonance imaging (MRI) is superior for assessing soft-tissue involvement, extrasinus extension (orbit, brain), vascular or periantral fat infiltration, and defining disease extent.

Radiologic signs such as the "black turbinate sign" may suggest invasive fungal sinusitis.

7. Histopathology and Microbiology

Definitive diagnosis of invasive fungal rhinosinusitis requires identification of fungal hyphae invading the mucosa, submucosa, blood vessels, or bone on biopsy specimens.

Such invasion must be absent in non-invasive fungal sinusitis [7].

8. Management / Treatment [2]

Non-invasive fungal rhinosinusitis (fungal ball): standard treatment is surgical removal via functional endoscopic sinus surgery (FESS) with adequate drainage. Systemic antifungal therapy is generally not required [8].

Allergic fungal rhinosinusitis: surgical removal of allergic mucin and polyps with sinus drainage, followed by postoperative corticosteroid therapy; immunotherapy may be considered in selected cases to reduce recurrence [4].

Invasive fungal rhinosinusitis, particularly acute invasive forms: urgent and aggressive early surgical debridement combined with systemic antifungal therapy.

Amphotericin B has historically been the standard agent, newer antifungals such as triazoles are increasingly used [8].

Chronic/granulomatous invasive forms: combined surgical and antifungal therapy tailored to the fungal species (e.g., triazoles for *Aspergillus*), along with management of underlying predisposing factors or immunosuppression [6].

Close follow-up is required in all forms. In invasive disease, multidisciplinary care (ENT, infectious disease specialist, and when necessary ophthalmology/neurosurgery) improves outcomes.

A 2025 retrospective study (2019–2021) showed that two-thirds of patients with fungal rhinosinusitis had invasive disease, many with diabetes mellitus and a history of COVID-19, highlighting the role of immunodeficiency and post-viral states [5].

Recent case series (2025) suggest that isavuconazole may be effective in invasive sinusitis caused by both *Mucorales* and *Aspergillus*, potentially with better tolerability than amphotericin B [9].

A 2020 CT-based analysis helped differentiate acute invasive fungal sinusitis caused by *Mucor* versus *Aspergillus* based on sinus involvement patterns and laterality [1].

Non-invasive fungal sinusitis remains relevant even among immunocompetent individuals, with recent reports describing fungal sinusitis in otherwise "healthy" patients, emphasizing the need for awareness beyond classic risk groups [10].

9. Clinical Case

In March 2025, a 46-year-old male from Armenia presented to Astghik Medical Center with severe headaches, acute pain in the left periorbital region, and sudden deterioration of vision in the left eye. He had been evaluated by a neurosurgeon and an ophthalmologist; no primary ophthalmologic pathology was identified.

Brain CT revealed a hyperdense lesion (105 HU) in the left sphenoid sinus, suggestive of fungal etiology, with destructive changes of the inferior, posterior, and superior sinus walls.

In March 2025, an endoscopic transnasal sphenoidotomy was performed at Astghik Medical Center by an otorhinolaryngologist and a neurosurgeon. A transnasal approach through the left nasal cavity was used. Under endoscopic visualization, after exposure of the left sphenoid sinus, the anterior wall and intersinus septum were removed.

Caseous pathological material (fungal debris) was identified, removed, and sent for histopathological examination. Thickened inflammatory mucosa was partially excised. A bony defect of the posterior sinus wall was observed without dural injury. Considering the high risk of cerebrospinal fluid leak and optic nerve injury, most of the thickened damaged mucosa was preserved.

The left optic nerve region became visible, with destruction of the bony walls of the optic canal due to inflammation. Fungal material embedded within the edematous mucosa was removed; it had been compressing the optic nerve from both superior and inferior aspects.

The procedure was performed under 0 °and 70 °endoscopic guidance.

PAS staining of the specimen revealed PAS-positive fungal flora. No systemic antifungal therapy was prescribed postoperatively.

Approximately two months after surgery, the patient reported frontal headaches. CT of the paranasal sinuses showed preserved aeration; mucosal thickening was noted in the right frontal sinus and catarrhal mucosal thickening in the sphenoid sinus, without evidence of fungal disease. Prophylactic anti-edematous and antifungal therapy was prescribed (fluconazole 150 mg, three tablets for 3 days).

Following treatment, the patient was asymptomatic. Follow-up CT performed seven months later revealed no pathological findings.

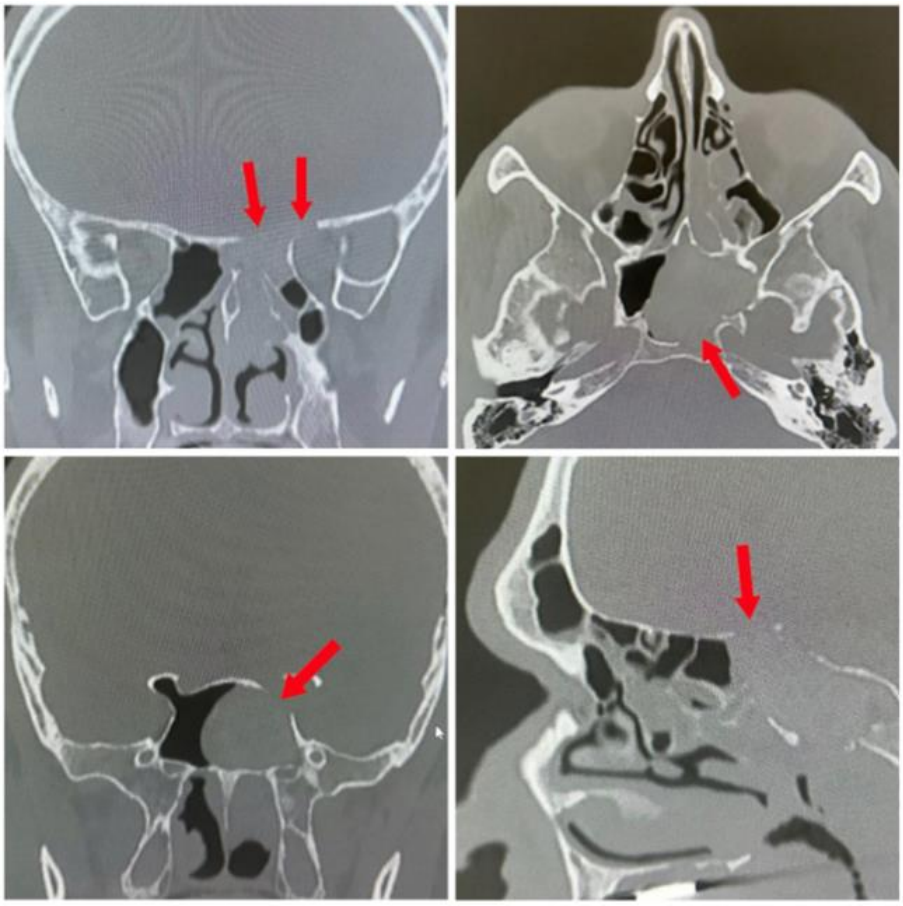

Figure 1. *CT sections demonstrate pathological contents within the sphenoid sinus and posterior ethmoid air cells. Arrows indicate defects of the superior and posterior walls of the sphenoid sinus.*

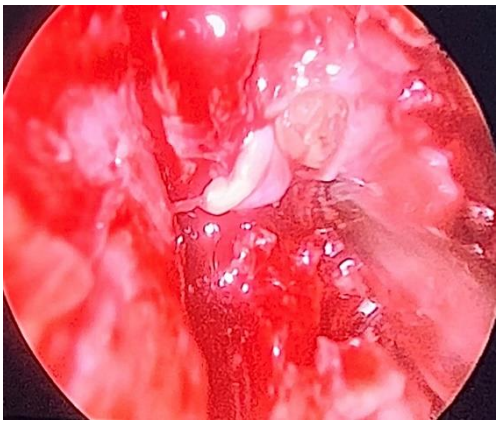

Figure 2. *Natural ostium of the left sphenoid sinus.*

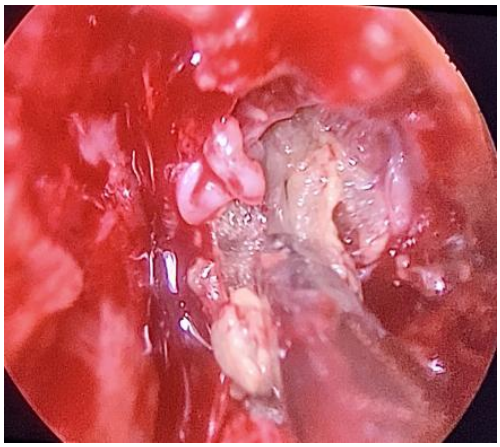

Figure 3. *Enlarged natural ostium with removal of fungal material from the sphenoid sinus.*

Figure 4. *Removal of fungal pathological material.*

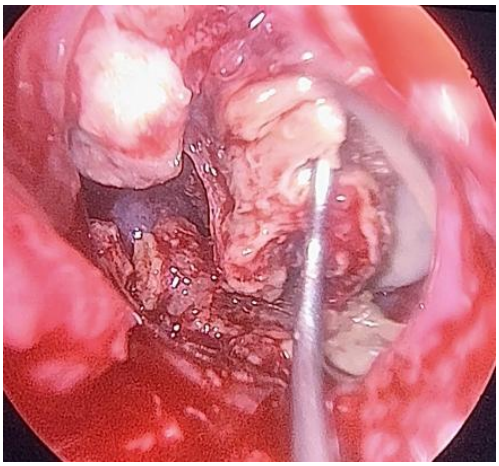

Figure 5. *Removal of fungal pathological material.*

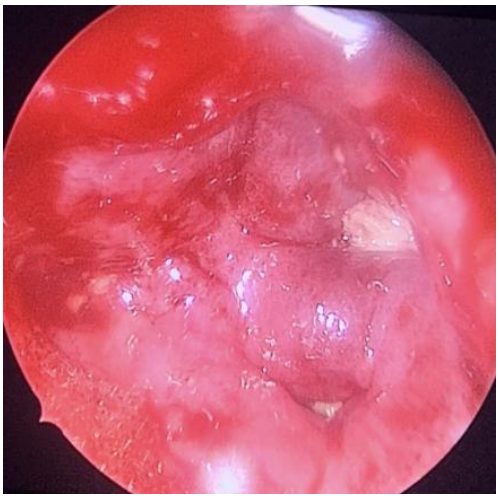

Figure 6. *Fungal involvement beneath edematous mucosa causing compression of the optic nerve.*

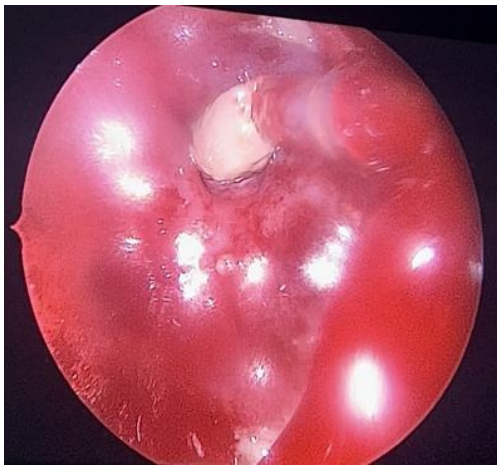

Figure 7. *Removal of fungal involvement with relief of optic nerve compression.*

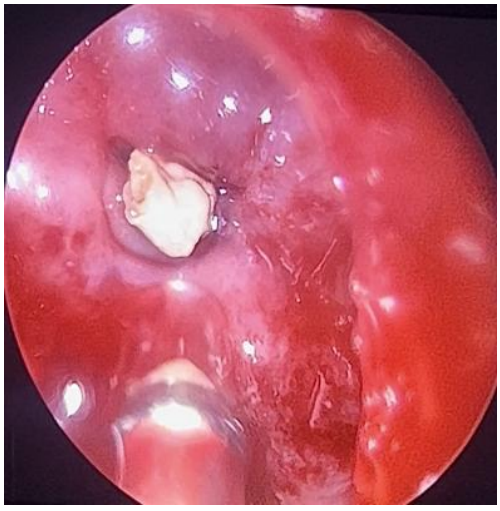

Figure 8. *After removal of the fungus shown in Figure 7, another portion of fungal material was found beneath the mucosa.*

Figure 9. *Cleansed sphenoid sinus cavity.*

Figure 10. *Fungal pathological material removed from the left spend sinus.*

Figure 11. *Intraoperative image.*

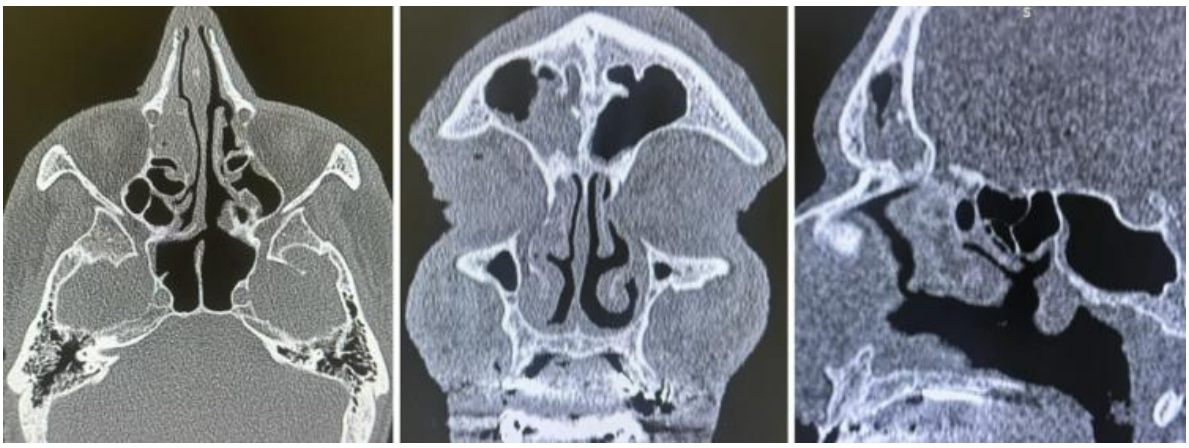

Figure 12. *Follow-up imaging two months after treatment demonstrates preserved aeration of the sphenoid sinus and decreased aeration of the right frontal sinus.*

10. Conclusion

Fungal rhinosinusitis represents a broad spectrum of disease ranging from non-invasive colonization to life-threatening invasive infection. Prompt recognition and early diagnosis are vital in fungal rhinosinusitis, as delays in management may result in aggressive local invasion, bony erosion, and permanent neurological or visual deficits. High clinical suspicion, combined with detailed radiologic evaluation and histopathological confirmation, is critical for accurate diagnosis. Endoscopic sinus surgery remains an effective and safe therapeutic approach, allowing adequate disease clearance while minimizing the risk of neurovascular complications. Close postoperative surveillance is essential to ensure long-term disease control.

Abbreviations

AFRS	Allergic Fungal Rhinosinusitis
CT	Computed Tomography
MRI	Magnetic Resonance Imaging
PCR	Polimerase Chain Reaction
FESS	Functional Endoscopic Sinus Surgery
ENT	Ear Nose Throat
PAS	Periodic acid-Schiff

Author Contributions

Arsen Koshtoyan: Methodology, Supervision, Validation, Vizualization

Vilen Azizyan: Methodology, Supervision, Validation, Vizualization

Lyusi Petrosyan: Conceprualization, Investigation, Resources, Writing – original draft, Writing – review &

editing

Yuri Ghukasyan: Data curation, Project administration, Resources

Avetis Kirakosyan: Methodology, Supervision, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

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