SSR Institute of International Journal of Life Sciences
ISSN (O): 2581-8740 | ISSN (P): 2581-8732
Pillai *et al.*, 2026
doi: 10.21276/SSR-IIJLS.2026.12.3.18

Original Article

open access

Microbiological Profile of Chronic Rhinosinusitis in a Tertiary Care Centre in South India

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Received: 18 Jan 2026/ Revised: 20 Mar 2026/ Accepted: 26 Apr 2026

ABSTRACT

Background: Although the role of infection in the pathogenesis of CRS is debated, a significant percentage of bacterial and fungal isolates have been identified in most studies on CRS. Emerging antibiotic resistance is also a concern due to the empirical use of antibiotics. Apart from the local and orbital complications, CRS is associated with life-threatening complications like cavernous sinus thrombosis. So, timely diagnosis and prompt treatment are essential.

Methods: A cross-sectional study was conducted among 100 patients with clinically or radiologically diagnosed CRS. Bacterial and fungal isolates were identified. Antimicrobial susceptibility testing of the bacterial isolates was performed.

Result: The study's culture positivity was 63%. Among the bacterial isolates, Gram-negative isolates predominated. The predominant fungal isolates obtained in the study were *Aspergillus flavus* (37.5%) and *Aspergillus fumigatus* (16.6%). Among FRS cases, 27.8% had histopathological evidence of tissue invasion.

Conclusion: Infective aetiology with a gram-negative predominance was noted, emphasising the need for culture-directed therapy rather than empirical antibiotics. Except for invasive fungal sinusitis, there is little difference between sinusitis due to bacterial or fungal aetiology. So, the diagnosis of CRS should be based on clinical, microbiological, and histopathological correlation rather than on symptoms alone.

Key-words: Chronic rhinosinusitis, Fungal rhinosinusitis, Functional Endoscopic Sinus Surgery

INTRODUCTION

Rhinosinusitis is a group of disorders characterised by inflammation of the nasal mucosa and paranasal sinuses.[1] Based on the duration of illness, they can be classified into acute and chronic rhinosinusitis. A duration of less than 4 weeks is considered acute, and more than 12 weeks without complete resolution is considered chronic rhinosinusitis (CRS).[2] CRS is a spectrum of infectious and inflammatory processes characterised by any two of the following symptoms: nasal congestion, nasal discharge, facial pain, and hyposmia/anosmia [3].

How to cite this article
Pillai HS, Sreelatha S, Menon P. Microbiological Profile of Chronic Rhinosinusitis in a Tertiary Care Centre in South India. SSR Inst Int J Life Sci., 2026; 12(3): 9813-9819.

Access this article online
https://iijls.com/

CRS remains poorly understood from a pathogenic standpoint [4]. A diverse range of factors has been investigated, including infectious causes (bacterial, viral, or fungal), allergic mechanisms, anatomic abnormalities, and mucociliary dysfunction.[5] Most studies reported infections (26-44%) as the most common aetiology, followed by anatomical obstruction. [3]

The treatment of patients with CRS is a challenge.[6] Unlike acute rhinosinusitis, there is no definitive and consistent data on the infectious agents involved. The patients are often subjected to multiple courses of antibiotics and surgeries with little or no improvement in their condition. [7] Empirical use of antimicrobial therapy not based on culture reports is leading to an increasing incidence of drug resistance, making the management of

doi: 10.21276/SSR-IIJLS.2026.12.3.18

the condition more complex.[8] A deeper understanding is essential to move from an empirical decision-making process to more evidence-based or culture-directed therapy.[9]

Fungal infections of the paranasal sinuses were considered uncommon, affecting only immunocompromised individuals. Its incidence has shown a marked increase over the past decades, especially in tropical countries like India.[10] In most instances, Fungal Rhinosinusitis (FRS) requires aggressive management and needs to be distinguished from other aetiologies. Any delay in diagnosis can result in a high rate of morbidity as well as mortality. [5]

Lack of progress in the diagnosis and treatment of CRS is due to a paucity of knowledge regarding the microbiological and histopathological aspects of chronic sinus disease.[8] Maxillary sinus puncture was considered the gold standard for collecting samples for microbiological studies, but the procedure is painful and invasive, limiting its role. Later, noninvasive procedures, such as swabs collected from the middle meatus secretions under endoscopic view, were used. But the results were not very reliable, as there is a risk of contamination with normal nasal flora.[11] Functional endoscopic sinus surgery (FESS) is a minimally invasive surgical procedure.[12] The procedure allows direct visualisation and collection of samples from affected sinuses, with minimal discomfort to the patient and minimal contamination. The procedure also paves way for concurrent histopathological correlation by taking biopsy especially in suspected fungal etiology.

MATERIALS AND METHODS

Study Design, Setting- Hospital based cross sectional study was conducted at the Department of Microbiology, Govt Medical College, Thrissur. A total of 100 patients with clinically or radiologically diagnosed chronic rhinosinusitis who were posted for FESS in the Department of Otorhinolaryngology during the study period were included. Patients with acute rhinosinusitis were excluded from the study. The study was conducted for 1 year (December 2018-November 2019) after obtaining ethical clearance.

Sample Size- Sample size was calculated based on a similar study using the formula

$$n=Z\alpha^2 p(100-p)/d^2$$

where p is the prevalence (21%) and d=0.08 (Absolute precision). [10,13]

Specimen collection- The specimens, such as sinus aspirate or tissue from sinus mucosa, were collected during the endoscopic sinus surgery. Sinus aspirate specimens were transported in sterile leak-proof containers, and tissue specimens in sterile screw-cap containers with sterile normal saline.

Specimen processing- The type of samples received in the laboratory was noted, whether tissue or sinus aspirate, necrotic or non-necrotic or purulent.

Microscopic examination- Gram staining of the samples was performed to identify the probable pathogen. A portion of the sample was treated with 10% KOH to detect the presence of fungal elements. Width, septation and branching angulation of the fungal hyphae were noted. KOH positivity for fungal elements was communicated immediately to the ENT surgeon, especially in suspected Zygomycetes infection. [14,15]

Culture- Each sample received in the laboratory was subjected to both bacterial and fungal culture. For bacterial culture, tissue specimens were homogenised with a sterile mortar and pestle before inoculation. Aspirated pus or homogenised tissue samples were inoculated onto blood agar (BA), MacConkey agar (MA), Brain Heart Infusion Broth (BHIB) and incubated at 37°C. Absence of growth after 48 hours of incubation, with no growth in BHIB subcultures, was reported as sterile. Anaerobic culture methods were not performed due to a lack of facilities. For fungal culture, the samples were inoculated onto two Sabouraud's dextrose agar (SDA)-one without cycloheximide, the other with cycloheximide and incubated at room temperature. Homogenisation of the tissue samples was not done as these procedures could destroy the hyphae and reduce the viability of zygomycetes. SDA slopes were examined daily during the first week and twice a week thereafter. The slopes were kept for 4 weeks before being labelled negative for fungal growth.

Identification of bacterial isolates- Bacterial isolates were identified by their characteristic colony morphology and Gram staining from bacterial growth.

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Further identification of the isolates was performed using standard biochemical tests.

Antibiotic sensitivity testing was performed using the disc diffusion method according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Multidrug-resistant (MDR) gram-negative bacilli were screened for the presence of extended-spectrum β-lactamase (ESBL), AmpC and Carbapenemase.

Identification of fungal isolates- Filamentous fungi were identified based on growth rate, surface colour and texture, reverse pigmentation, and microscopic examination findings. Microscopic examination was performed using a tease-mount preparation of the growth in lactophenol-cotton blue (LPCB).[14,15] Histopathology correlation was done for tissue biopsy samples for which fungal isolation was obtained to look for evidence of tissue or vascular invasion.

Statistical Analysis- Data collected were entered into MS Excel. Quantitative variables were expressed as means, while qualitative variables were expressed as percentages. Statistical associations between risk factors and culture positivity were calculated using the chi-square test.

RESULTS

100 specimens from clinically or radiologically diagnosed cases of chronic rhinosinusitis, received from the department of ENT over a period of 1 year, were included in the study. Out of 100 samples processed, pure bacterial isolates were obtained from 39 samples, pure fungal isolates from 22 samples, and two samples yielded a mixed isolate of Klebsiella and Rhizopus (Table 1).

Table 1: Microbiological profile of CRS

Isolates	No of cases	Percentage
Bacteria	39	39
Fungus	22	22
Mixed isolates (Bacteria + fungal)	2	2
No bacterial or fungal pathogen	37	37
Total	100	100

Out of the bacterial isolates, the predominant isolate was *Klebsiella pneumoniae* (43.9%), closely followed by *Staphylococcus aureus* (36.6%). Mixed bacterial growth was obtained in 14.6% cases. Other bacterial isolates were *Streptococcus pyogenes* (2.4%), *Klebsiella aerogenes* (4.9%), *Serratia marcescens* (2.4%), *Pseudomonas aeruginosa* (12.2%) and *Acinetobacter baumanii* (2.4%) (Table 2).

Table 2: Total bacteriological profile (*Out of the total bacterial isolates)

Staphylococcus aureus	10	24.3
Streptococcus pyogenes	1	2.4
Klebsiella pneumoniae (including 2 isolated with Rhizopus)	15	36.6
Pseudomonas aeruginosa	5	12.2
Klebsiella aerogenes	2	4.9
Serratia marcescens	1	2.4
Acinetobacter baumanii	1	2.4
Mixed bacterial growth	6	14.6
Total	41	100

All Enterobacteriaceae isolates (*K. pneumoniae, K. aerogenes* and *S. marcescens*) showed 100% susceptibility to amikacin. 61% of *K. pneumoniae* isolates, 50% of *Enterobacter aerogenes*, and 50% of *S. marcescens* isolates were susceptible to oral antibiotics such as cotrimoxazole and quinolones.

Both *P. aeruginosa* and *Acinetobacter baumannii* isolates were 100% susceptible to amikacin, ceftazidime, imipenem, and piperacillin-tazobactam. 62.5% of the Pseudomonas isolates were susceptible to ciprofloxacin, but the Acinetobacter isolate was 100% resistant.

The resistance mechanisms identified among MDR gram-negative bacterial isolates in the study were extended-spectrum beta-lactamase (ESBL) and serine carbapenemase production in two *K. pneumoniae* isolates. All Staphylococcal isolates were methicillin-sensitive and 100% susceptible to linezolid. *The isolated Streptococcus pyogenes* strain was susceptible to commonly used oral antibiotics such as ampicillin and erythromycin. Among 24 fungal isolates *A. flavus* was isolated predominantly (37.5%), followed by *A. fumigatus* (16.6%). Among the 3 Rhizopus isolates, *K. pneumoniae* was co-isolated from two samples (Table 3).

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Table 3: Fungal Isolates

Fungal isolate	Number	Percentage
Aspergillus flavus	9	37.5
Aspergillus fumigatus	4	16.6
Aspergillus niger	2	8.3
Aspergillus terreus	1	4.17
Fusarium	2	8.3
Pencillium	3	12.5
Rhizopus	3	12.5
Total	24	100

Of the 24 fungal culture-positive samples, 20 were KOH-positive, and among the fungal culture-negative samples, 2 were KOH-positive. The kappa value of 0.83 showed almost perfect agreement between KOH and fungal culture positivity (Table 4).

Table 4: Comparison of microscopy with fungal culture

	Fungal culture		Kappa value
KOH	Positive	Negative	0.83
Positive	20	2	
Negative	0	2	
Total	20	4	

Histopathologically, 18 out of 22 tissue samples showed evidence of fungi. Of these, 13 were noninvasive (72%) and 5 were invasive (28%). Rhizopus, *A. fumigatus* and *A. flavus* were the isolates from the invasive cases. Diabetes mellitus and bronchial asthma were the most common comorbidities among the study population (Tables 5 and 6).

Table 5: Association between Diabetes Mellitus and Culture Positivity

DM	Fungal Culture				X^2 value	p-value
	Positive		Negative			
	n	%	n	%		
Yes	22	68.8	10	31.1	0.67	0.41
No	41	60.3	27	39.7		

Table 6: Association between bronchial asthma and fungal culture positivity

DM	Fungal Culture				X^2 value	p-value
	Positive		Negative			
	n	%	n	%		
Yes	4	66.7	2	33.3	6.37	0.01
No	20	21.3	74	78.7		

DISCUSSION

The study was conducted to identify the bacterial and fungal etiologic agents associated with CRS and to determine the antibiotic sensitivity pattern of the bacterial isolates. A total of 100 clinically or radiologically diagnosed cases of chronic rhinosinusitis were studied.

The culture positivity of the present study was 63%. The result was consistent with the studies by Surapaneni *et al.* [3] and Iseh *et al.* [16], which reported culture positivity rates of 44% and 67.1%, respectively. A study by Vipul *et al.* also showed a culture positivity rate of nearly 60% [7]. Negative cultures in 37% of the samples could be attributed to prior treatment with antimicrobial agents, viral or anaerobic etiology and non-infectious etiologies of CRS.

A total of 47 bacterial isolates and 24 fungal isolates were obtained in the present study. *K. pneumoniae* (43.9%), *S. aureus* (36.6%), *P. aeruginosa* (17%), *K. aerogenes* (4.3%), *A. baumanii* (2.13%), *S. marcescens* (2.13%), *S. pyogenes* (2.13%) and Coagulase-negative Staphylococci *(Staphylococcus saprophyticus)* (2.13%) were the bacterial isolates in the study.

A predominance of gram-negative bacteria was observed in the study. The study by Mantovani *et al*. also reported a predominance of gram-negative bacteria (58.6%) [5]. Kim *et al.* noted a significant increase in gram-negative isolates.[17]. The shift in trend from gram-positive to gram-negative isolates may be due to selection pressure from commonly used antibiotics that primarily target gram-positive isolates. This emphasises the need for antimicrobial therapy based on culture results.

K. pneumoniae (43.9%) was the predominant isolate in the study. Several virulence factors, such as fimbriae, capsule, lipopolysaccharide (LPS), and siderophores, help them evade host immune defence mechanisms. Moreover, the ability to form biofilms enhances virulence and confers resistance to antimicrobial agents.

doi: 10.21276/SSR-IIJLS.2026.12.3.18

Staphylococci and Pseudomonas are also associated with biofilm formation in patients with CRS. Resistance to oral antibiotics such as cotrimoxazole and ciprofloxacin was observed in 38.9% of the isolates in the present study.

Non-fermenter isolates obtained in the study were *P. aeruginosa* and Acinetobacter baumannii. *A. baumannii* was isolated from a patient with a history of CRS for 3 years, requiring hospitalization and multiple courses of antibiotics. Pseudomonas species were commonly isolated from patients with diabetes mellitus, other immunosuppression, a history of sinus surgeries, or who had received multiple courses of antibiotics. Pseudomonas, a common contaminant of tap water, can contribute to sinus infections when nasal irrigation is performed with unsterile fluids. In the present study, *P. aeruginosa* was isolated from 8 patients, of whom 3 had a history of diabetes mellitus.

No resistance to ceftazidime was observed among the *P. aeruginosa* isolates in the present study. A study by Vipula *et al.* had also reported 100% susceptibility to ceftazidime among the Pseudomonas isolates.[7] *A. baumannii* isolate obtained in the present study was resistant to oral antibiotics, ciprofloxacin and cotrimoxazole.

The predominant gram-positive isolate in the study was *S. aureus* (36.6%), of which 80% were penicillin-resistant. No methicillin-resistant Staphylococcal isolates were identified in the present study. This finding was contrary to the expectation in the current scenario. The decreased isolation of MRSA could be due to the strict hospital infection control practices. In the study by Brook *et al.*, the MRSA rate was 60% [8], compared with the study by Kim *et al.*, where the MRSA prevalence was only 0.9%.[17]. *S. pyogenes* was isolated from 1 patient. Streptococcal isolates are mainly implicated in patients with acute rhinosinusitis, but can be associated with acute exacerbations in patients with CRS. In the present study, isolation of ESBL, Carbapenemase, or AmpC-producing organisms was very low, accounting for only 6.4% of the total bacterial isolates.

Fungal aetiology was once thought to be uncommon among cases of chronic rhinosinusitis.[10] Presently, it is estimated that about 5-10% of patients with CRS actually have fungus as an etiological agent. The present study had a fungal culture positivity of 24%. The result was comparable to those of the studies by Prateek *et al.* [10], Udayasri *et al.* [13], and Shivani *et al.* [1]. In the present study, Aspergillus species accounted for 66.7% of the total fungal isolates, of which *A. flavus* (37.5%) was the most predominant, followed by *A. fumigatus* (16.7%). Most studies on fungal rhinosinusitis have also identified *A. flavus* as the predominant isolate, followed by *A. fumigatus* [13]. Penicillium species were isolated from 3 patients, of whom 2 had a history of bronchial asthma and 1 had a history of DM. *Talaromyces marneffei (Pencillium marneffei)* was isolated from one patient with a history of pulmonary tuberculosis along with bronchial asthma. There were 2 Fusarium isolates in the study. Fusarium species can manifest as both invasive and noninvasive FRS. [18] A case of chronic invasive FRS by Fusarium species was reported by Danielle et al in 2008 in an immunocompromised patient.[19] Rhizopus species were isolated from 3 patients. Studies by Shivani *et al.* [1], Udayasri *et al.* [13] and Prateek *et al.* [10] had also reported Rhizopus isolates in patients with CRS. MDR Klebsiella isolates were concurrently isolated with 2 of the Rhizopus isolates. Defects in the mucociliary mechanism or breaches in mucosal integrity due to underlying bacterial rhinosinusitis may have aided fungal spores in reaching the sinuses. The multidrug-resistant nature of the co-isolate might have contributed to the chronicity of the disease. A study by Kim *et al.* [20] reported sinonasal balls with mixed bacterial and fungal aetiology in patients with CRS. He observed a decreased expression of S100A7 and S100A8/A9 proteins in CRS patients with mixed balls compared to those with fungal balls.

There was almost perfect agreement between KOH and fungal culture positivity. Of the 24 fungal culture-positive samples, 20 were KOH-positive. Two patients with KOH smear positivity but culture-negative were on antifungals before sample collection.

Isolation with tissue samples was 22 (91.7%), compared to 2 (8.3%) in the case of sinus aspirate. Out of these 22 tissue samples, 18 were positive on histopathological examination. Negative reports in 3 cases may be due to a lack of fungal hyphae in the portion of the tissue sent for histopathology. Categorization of FRS based on histopathology has both prognostic and management implications.[10] In this study, 72% of the fungal isolates showed no evidence of any tissue or vascular invasion. One case of *A. flavus* was diagnosed as chronic granulomatous disease. A study by Kaur *et al*. in 2013-2014 also showed *A. flavus* as the most common isolate from chronic granulomatous FRS. [21] 3 cases of Rhizopus

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and 1 case of *A. fumigatus* were diagnosed with chronic invasive FRS in the study, characterised by dense accumulation of hyphae involving adjacent tissues, with occasional invasion of blood vessels. One patient from whom Rhizopus was isolated had third cranial nerve palsy along with orbital cellulitis. The patients with chronic invasive disease invariably had a history of diabetes mellitus.

Patients with chronic invasive cases were started on Amphotericin B based on KOH findings. One case showed intracranial extension, requiring neurosurgical intervention followed by maxillectomy and antifungal therapy. Non-invasive cases were managed symptomatically without antifungals. Early categorisation and prompt treatment are essential, as clinical differentiation of FRS from other CRS etiologies is difficult unless complications arise.

Diabetes mellitus and bronchial asthma were the two main comorbidities identified in the present study. However, no statistically significant association between DM and culture positivity was observed in the present study.

A bidirectional relationship exists between CRS and Bronchial asthma. Compared to patients who do not have asthma, patients with asthma and CRS have poor outcomes, less improvement in quality of life (QoL) and a higher rate of revision surgery after endoscopic surgery. In the global allergy and asthma network survey conducted in Europe, the median asthma prevalence was 8.6% and ranged from 5.2% to 16.8% across centres. [22] In a study by Chapurin *et al.* [23] in 2017 on comorbidities associated with CRS patients, the prevalence of bronchial asthma was 4.4%, and in a study on FRS by Shivani *et al*., it was 4.64%.[1] The low prevalence may be due to underdiagnosis of the condition. In the present study, 66.7% of the patients with bronchial asthma presented with non-invasive FRS and was found to be statistically significant.

LIMITATIONS

The microbiological profile of CRS patients posted for FESS was studied. Antifungal susceptibility testing of the fungal isolates was not performed due to a lack of facilities. Anaerobic bacterial agents could not be studied.

CONCLUSIONS

Chronic rhinosinusitis is a multifactorial disease, with infection playing a major role, as indicated by culture positivity of 63% in the present study. The diagnosis depends mainly on the isolation of the pathogen. Though diabetes mellitus was identified as a major comorbidity in patients with CRS, no statistically significant association were noted between diabetes mellitus and culture positivity. Resistance to commonly used oral agents and a shift in trend to gram-negative isolates were noted, which could contribute to treatment failure in patients with CRS. So, the choice of antibiotics should optimally be based on culture and antibiotic susceptibility testing of the isolates. Bronchial asthma was noted as a statistically significant risk factor in patients with fungal rhinosinusitis. Management of fungal rhinosinusitis requires isolation of the fungi and histopathological characterisation to decide on the treatment and the antifungal agent to be used. Demonstration of fungal elements by KOH examination helps initiate antifungal therapy early. Early identification and prompt treatment of invasive fungal sinusitis can lead to a good clinical outcome.

CONTRIBUTION OF AUTHORS

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