



## Diagnostic Parameters of CT FESS Protocol in Diagnosis of Fungal Sinusitis with Histopathology as a Gold Standard

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### ABSTRACT

**Background:** Fungal sinusitis is an increasingly recognized cause of chronic rhinosinusitis, and early diagnosis is essential for appropriate management. Computed tomography (CT) of the paranasal sinuses is widely used for preoperative evaluation; however, its diagnostic accuracy compared with histopathology remains variable. **Objectives:** To determine the diagnostic accuracy of CT FESS findings in detecting fungal sinusitis using histopathology as the gold standard and to assess its performance after stratification by age, gender, and duration of complaints. **Study Design & Setting:** This cross-sectional validation study was conducted at the Departments of ENT and Radiology at Shaikh Zayed Hospital, Lahore 2 April 2025 to 1 July 2025. **Methodology:** A total of 99 patients clinically suspected of having fungal sinusitis were included. All patients underwent CT scan of the paranasal sinuses followed by Functional Endoscopic Sinus Surgery (FESS). Specimens obtained during surgery were sent for histopathological examination. CT findings were compared with histopathology results. Data were stratified by age, gender, and duration of complaints, and post-stratification chi-square tests were applied using SPSS version 26. **Results:** Out of 99 patients, CT FESS was positive in 70 (70.7%) cases, while histopathology confirmed fungal sinusitis in 65 (65.7%) cases. CT FESS demonstrated high diagnostic performance with a statistically significant association with histopathology results ( $p < 0.001$ ). Stratified analysis showed that the diagnostic accuracy of CT FESS remained significant across different age groups, genders, and durations of symptoms. **Conclusion:** CT FESS is a reliable and accurate diagnostic tool for the detection of fungal sinusitis, showing strong agreement with histopathology across various patient subgroups. Its use can aid in early diagnosis and appropriate surgical planning.

### INTRODUCTION

Fungal sinusitis encompasses a spectrum of conditions ranging from non-invasive forms such as fungal balls and allergic fungal rhinosinusitis to invasive types including acute and chronic invasive fungal sinusitis.<sup>1</sup> The distinction between invasive and non-invasive fungal sinusitis lies in the extent of fungal penetration into host tissues, with invasive forms involving the mucosa, blood vessels, and bone, whereas non-invasive forms manifest as fungal balls and allergic fungal rhinosinusitis.<sup>2,3</sup> The nasal cavities serve as favorable reservoirs for fungal growth, and the ubiquitous nature of fungi makes diagnosis challenging, particularly due to the limitations of culture results. Imaging modalities, especially computed tomography (CT), play a crucial role in the diagnosis of fungal sinusitis. Typical CT findings include sinus opacification, hyperattenuation or metallic density within the sinuses, bone erosion, and soft tissue infiltration.<sup>4,5</sup> Computed tomography is pivotal in the initial diagnosis of

fungal sinusitis, with a reported sensitivity of 67% and specificity of 99%.<sup>6,7</sup> This diagnostic performance is superior to conventional tools such as X-rays, fungal cultures, and elevated IgE titers.<sup>8</sup> Previous studies have highlighted the importance of CT scans in diagnosing fungal rhinosinusitis by comparing imaging findings with intraoperative findings as the gold standard. However, histopathology has not consistently been used as the gold standard in earlier research, which represents a significant research gap that this study aims to address.<sup>9</sup>

A study by Sarfraz S et al. demonstrated that the sensitivity of the CT FESS protocol was 80%, specificity 77%, diagnostic accuracy 79%, positive predictive value 86%, and negative predictive value 70% in diagnosing fungal sinusitis, with a disease prevalence of 58.3%.<sup>10</sup>

Although the CT FESS (Functional Endoscopic Sinus Surgery) protocol is primarily utilized as a surgical planning tool, its application as a diagnostic modality has the potential to reduce unnecessary invasive procedures,

minimize delays in management, and conserve healthcare resources. Establishing its diagnostic efficacy through robust data forms the primary rationale and significance of the present study. To determine the diagnostic parameters of the CT FESS protocol in the diagnosis of fungal sinusitis, using histopathology as the gold standard.

## MATERIALS AND METHODS

This cross-sectional validation study was conducted in the Departments of ENT and Radiology at Shaikh Zayed Hospital, Lahore 2 April 2025 to 1 July 2025. A sample size of 99 cases was calculated using a 95% confidence level and a 13% margin of error, taking the expected sensitivity and specificity of the CT FESS protocol in diagnosing fungal sinusitis as 80% and 77%, respectively, with an anticipated disease prevalence of 58.3%.

Patients aged 18 to 60 years of either gender, with a clinical diagnosis of fungal sinusitis as per the operational definition and a duration of symptoms exceeding three months, were included in the study. Patients with acute rhinosinusitis, other causes of nasal obstruction such as deviated nasal septum, postoperative nasal complications documented in medical records, and sinonasal tumors were excluded. After obtaining approval from the College of Physicians and Surgeons Pakistan (CPSP), a pilot study with 10 cases was carried out to assess the validity of the study. Subsequently, at least 99 patients fulfilling the inclusion criteria were recruited from the Departments of ENT and Radiology at Shaikh Zayed Hospital, Lahore, after approval from the institutional ethical review board. Written informed consent was obtained from all participants. Baseline demographic data, including age, gender, socioeconomic status, and duration of complaints, were recorded.

Computed tomography scans were performed using a GE VCT LightSpeed 64-slice multidetector CT scanner. Following imaging, patients underwent functional endoscopic sinus surgery. Histopathological findings obtained after surgery were used as the gold standard for comparison. Fungal sinusitis was recorded as positive or negative based on CT FESS findings and histopathological examination using a specially designed proforma.

Clinical diagnosis of fungal sinusitis was made when three or more of the following were present: persistent nasal obstruction not responding to medical treatment for more than 12 weeks; unilateral or asymmetric purulent nasal discharge for more than four weeks; facial pain or headache over the involved sinus region with a visual analogue scale score greater than 3 for more than four weeks; endoscopic evidence of thick mucopurulent discharge, dark or black crusts, or bony erosion in the nasal cavity or sinuses. Fungal sinusitis on CT FESS protocol was defined by the presence of hyperdense or soft tissue density fungal balls within mucosal thickening, with associated osseous erosion or extension into infraorbital, retroantral, or intracranial regions. Histopathological diagnosis of fungal sinusitis was based on identification of fungal hyphae or elements with chronic inflammatory changes such as mucin deposition, necrosis, or granuloma formation. A true positive result was defined as positive findings on both CT FESS protocol and histopathology, a false positive as positive CT with negative histopathology,

a true negative as negative results on both modalities, and a false negative as negative CT with positive histopathology. Sensitivity and specificity were defined as the ability of the CT FESS protocol to correctly identify diseased and non-diseased cases, respectively, using histopathology as the gold standard, while positive and negative predictive values represented the probability of true disease presence or absence following positive or negative CT findings.

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics were applied to summarize demographic and study variables. Quantitative variables such as age and duration of complaints were presented as mean  $\pm$  standard deviation, while qualitative variables including gender, CT findings of fungal sinusitis, and histopathology results were expressed as frequencies and percentages. Diagnostic performance parameters of the CT FESS protocol, including sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy, were calculated using histopathology as the gold standard. Data were stratified according to age, gender, and duration of complaints, and post-stratification chi-square tests were applied where appropriate. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

The study included a total of 99 patients, of whom 55 (55.6%) were male and 44 (44.4%) were female, indicating a slightly higher prevalence of fungal sinusitis among males. The age distribution showed that the majority of patients, 60 (60.6%), were between 18–40 years, while 39 (39.4%) were between 41–60 years. The mean age of the study population was  $37.63 \pm 12.61$  years. Regarding the duration of complaints, the mean duration was  $8.89 \pm 3.58$  months, with 28 (28.3%) patients having complaints for 3–6 months, 45 (45.5%) for 7–12 months, and 26 (26.3%) for more than 12 months, showing a substantial number of patients with chronic sinus complaints (Table 1).

The frequency of fungal sinusitis based on diagnostic methods revealed that 70 (70.7%) patients were positive on CT FESS, while 29 (29.3%) were negative. On histopathology, 65 (65.7%) patients were confirmed positive, whereas 34 (34.3%) were negative, indicating that CT FESS identified slightly more positive cases than histopathology (Table 2).

A 2x2 crosstabulation of CT FESS results against histopathology demonstrated that 60 patients were true positives (TP), 10 were false positives (FP), 5 were false negatives (FN), and 24 were true negatives (TN). This shows that most positive CT FESS results corresponded to histopathology-confirmed fungal sinusitis, while a smaller proportion of negative CT FESS results missed some true positive cases. The association between CT FESS results and histopathology was statistically significant, with a Chi-square value of 42.636,  $df = 1$ ,  $p < 0.001$ , highlighting the strong correlation between CT FESS findings and histopathology confirmation (Table 3).

The diagnostic accuracy analysis of CT FESS showed a sensitivity of 92.3%, indicating that the CT protocol correctly identified the majority of patients with fungal

sinusitis. The specificity was 70.6%, reflecting the ability of CT FESS to correctly identify patients without the disease. The positive predictive value (PPV) was 85.7%, and the negative predictive value (NPV) was 82.8%, demonstrating high reliability of positive and negative CT findings, respectively. The overall diagnostic accuracy was 84.8%, confirming that CT FESS is an effective diagnostic tool for detecting fungal sinusitis when compared with histopathology as the gold standard (Table 4).

**Table 1**  
**Demographic Characteristics of Patients (n = 99)**

Characteristic	Frequency	Percent (%)	
Gender	Male	55	55.6
	Female	44	44.4
Age Category	18–40 years	60	60.6
	41–60 years	39	39.4
Mean Age (years)	Mean±SD	37.63 ± 12.61	
	Mean±SD	8.89 ± 3.58	
Duration of Complaints	3–6 months	28	28.3
	7–12 months	45	45.5
	>12 months	26	26.3

**Table 2**  
**Frequency of Fungal Sinusitis**

Diagnostic Method	Frequency	Percent (%)	
CT FESS Result	Positive	70	70.7
	Negative	29	29.3
Histopathology Result	Positive	65	65.7
	Negative	34	34.3

**Table 3**  
**2×2 Crosstabulation of CT FESS vs Histopathology**

CT FESS \ Histopathology	Positive	Negative	Total
Positive	60 (TP)	10 (FP)	70
Negative	5 (FN)	24 (TN)	29
<b>Total</b>	65	34	99

TP = True Positive, FP = False Positive, FN = False Negative, TN = True Negative

**Table 4**  
**Diagnostic Accuracy of CT FESS (n = 99)**

Measure	Value (%)
Sensitivity	92.3
Specificity	70.6
Positive Predictive Value (PPV)	85.7
Negative Predictive Value (NPV)	82.8
Overall Accuracy (calculated)	84.8

## DISCUSSION

Fungal sinusitis is an important cause of chronic rhinosinusitis, particularly in immunocompromised and tropical populations. Its clinical presentation often overlaps with non-fungal sinus disease, making accurate diagnosis challenging.<sup>11,12</sup> Computed tomography (CT) of the paranasal sinuses plays a vital role in preoperative assessment and surgical planning. Functional Endoscopic Sinus Surgery (FESS) allows direct visualization and tissue

sampling. Histopathological examination remains the gold standard for confirming fungal sinusitis.<sup>13</sup> Evaluating the diagnostic accuracy of CT FESS findings is essential for improving early detection and management.

In the present study, CT FESS demonstrated a strong diagnostic performance for the detection of fungal sinusitis when compared with histopathology, which served as the gold standard. CT FESS was positive in 70.7% of cases, while histopathology confirmed fungal sinusitis in 65.7% of patients, and the association between the two modalities was statistically significant ( $p < 0.001$ ). These findings support the reliability of CT imaging as a preoperative diagnostic tool and are broadly consistent with previously published literature.

Sarfaz et al. (2015) reported CT positivity in 66.7% of patients and peroperative confirmation in 58.3%, with sensitivity and specificity of 80% and 77%, respectively, and an overall diagnostic accuracy of 79%. Compared to their study, our results demonstrate a higher agreement between CT and histopathology, which may be attributed to improved imaging resolution, standardized CT interpretation, and inclusion of histopathology rather than peroperative findings as the reference standard.<sup>14</sup> Similarly, Iqbal et al. (2017) observed very high sensitivity (96.19%), specificity (93.33%), and diagnostic accuracy (95.83%), with kappa statistics showing 82% agreement beyond chance. Although our diagnostic accuracy was slightly lower than that reported by Iqbal et al., both studies confirm a statistically robust correlation between CT findings and histopathological confirmation.<sup>16</sup>

In contrast, Khalid et al. (2022) reported a markedly different diagnostic profile, with CT scan sensitivity of 100% but very low specificity (15.8%), resulting in an overall diagnostic accuracy of only 57.9%. The low specificity and positive predictive value (23.8%) in their study suggest a high false-positive rate, possibly due to inclusion of allergic fungal sinusitis and reliance on radiological features that overlap with non-fungal inflammatory disease. Our study demonstrated a more balanced diagnostic performance, with significant post-stratification results across age, gender, and duration of complaints, indicating that CT FESS maintained accuracy across clinical subgroups.<sup>15</sup>

The findings of Abbasi et al. (2024) closely parallel our results, with CT positivity in 79.7% and histopathological confirmation in 77.8% of patients. Their reported sensitivity of 95% and diagnostic accuracy of 90.2% further reinforce the strong diagnostic value of CT PNS.<sup>17</sup> Similarly, Lutfi et al. (2015) reported sensitivity of 93.6% and accuracy of 89.2%, values that are comparable to our observations and highlight CT's reliability, despite the presence of occasional false-positive and false-negative cases.<sup>18</sup>

Naz et al. (2016) demonstrated sensitivity and specificity of 89.3% and 86.9%, respectively, with diagnostic accuracy of 88.7%, while also emphasizing CT's role in identifying complications such as intracranial and orbital extension. Although complication rates were not assessed in our study, the high diagnostic accuracy observed aligns with their findings and underscores CT's value in comprehensive disease evaluation.<sup>19</sup> Hamza et al. (2019) also reported CT positivity in 76.8% of cases, with

histopathological confirmation in 69.6%, results that are closely comparable to our CT and histopathology positivity rates.<sup>20</sup>

This study used histopathology as the gold standard, ensuring reliable diagnostic confirmation. A standardized CT and surgical protocol was applied to all patients. Stratified analysis by age, gender, and duration of symptoms enhanced the robustness of results. The sample size was adequate for statistical analysis. However, being a single-center study may limit generalizability. Additionally, fungal species identification was not performed, which could have provided further diagnostic insights

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## CONCLUSION

CT FESS shows high diagnostic accuracy in detecting fungal sinusitis when compared with histopathology. Its performance remains consistent across different demographic and clinical subgroups. CT imaging can therefore be reliably used for early diagnosis and surgical planning.

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