



Diagnostic Accuracy of Computed Tomography in Diagnosing Fungal Sinusitis Keeping Histopathology as Gold Standard

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ARTICLE INFO

Keywords: Fungal Sinusitis, Histopathology, Paranasal Sinuses, Tomography X-Ray Computed.

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Declaration

Authors' Contribution

All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History

Received: 23-04-2025 Revised: 09-06-2025
Accepted: 17-06-2025 Published: 30-06-2025

ABSTRACT

Background: Fungal sinusitis is an infection of the paranasal sinuses caused by fungal organisms such as *Aspergillus* and *Mucor*. It can lead to serious complications if not diagnosed early. Clinical symptoms are often similar to other chronic sinus diseases, which makes early diagnosis difficult. **Objective:** To determine the diagnostic accuracy of computed tomography in diagnosing fungal sinusitis while keeping histopathology as the gold standard. **Study Design:** Cross sectional validation study. **Duration and Place of Study:** This research was conducted from 10 October 2023 to 10 April 2024 in the Department of Radiology, Liaquat University of Medical and Health Sciences, Jamshoro. **Methodology:** A total of 206 patients aged 25 to 80 years presenting with headache, nasal obstruction, or nasal discharge for two weeks or more were included. Computed tomography of the paranasal sinuses was performed using a 16 slice scanner with contrast administration. Data were analyzed using Statistical Package for the Social Sciences version 24. **Results:** The mean age of patients was 53.97 ± 16.33 years. Fungal sinusitis was detected in 64 patients (31.1%) on computed tomography and confirmed in 52 patients (25.2%) on histopathology. Sensitivity was 94.23%, specificity was 90.26%, positive predictive value was 76.56%, negative predictive value was 97.89%, and overall diagnostic accuracy was 91.26%. **Conclusion:** Computed tomography showed high diagnostic performance for detection of fungal sinusitis and can be considered a useful non invasive imaging method for early evaluation of patients with sinonasal symptoms.

INTRODUCTION

Fungal sinusitis refers to an infectious process involving the paranasal sinuses caused by fungi, with *Aspergillus* and *Mucor* being the most common causative agents.¹ It poses a major problem in otolaryngology due to the serious complications that may arise if it is not recognized in time.² It has been divided into invasive and non-invasive types depending on the extent of penetration of fungi into the tissues lining the sinuses.¹ Non-invasive forms comprise allergic fungal sinusitis and fungal balls, mostly occurring in immunocompetent patients, while invasive forms are seen in immunocompromised patients with diabetes mellitus or prolonged steroid therapy.³ The manifestations of fungal sinusitis consist of nasal obstruction, facial pain or pressure, nasal discharge, headache, and in some patients, decreased olfactory perception.⁴

Diagnosis of fungal sinusitis, however, poses a challenge, as the symptoms of this condition overlap with those of other forms of chronic sinusitis.⁵ The initial step in the evaluation of the patient involves taking a thorough history of the patient, followed by meticulous clinical examination of the nasal cavity.⁶ The use of nasal

endoscopy can help demonstrate the presence of edema, polyps, allergic mucin, or fungal material within the sinus ostia.⁷ However, the final diagnosis of the condition usually requires microbiological and histopathological confirmation of the presence of fungi, which may be obtained from the specimens of the sinus tissue.⁸

Computed tomography is viewed as a highly beneficial diagnostic technique in the evaluation of fungal sinusitis cases.⁹ The CT scan of the paranasal sinuses has been found to reveal detailed information regarding the anatomy of the sinuses, thickening of the mucosa, erosion of the bony walls, and areas of increased density that may be indicative of the presence of fungal debris.¹⁰ In many cases of fungal sinusitis, the CT scan has revealed the following features: heterogeneous opacification of the sinuses, areas of increased density that may be indicative of fungal debris, and erosion of the bony walls in the case of invasive forms of the condition.¹¹

Fungal sinusitis is recognized as an important cause of chronic sinus disease, especially in regions where there is a high degree of environmental fungal exposure and in the presence of predisposing factors such as diabetes mellitus. Early and accurate diagnostic determination is important

in preventing serious complications involving the orbit and intracranial structures. Although computed tomography is commonly used in the assessment of diseases involving the paranasal sinuses, its diagnostic accuracy for fungal sinusitis may vary in different settings. Limited local data are available regarding the efficacy of CT scanning in the diagnosis of fungal sinusitis in our region.

METHODOLOGY

A cross-sectional study was carried out in the Department of Radiology Liaquat University of Medical and Health Sciences Jamshoro. The study duration was from 10 October 2023 to 10 April 2024. Ethical permission was obtained before starting the research from the institutional review board. The calculated sample size was 206 patients. Sample size was estimated by using Dr. Lin Naing sensitivity and specificity calculator with sensitivity 96.19%,¹² specificity 93.33%,¹² anticipated frequency of fungal sinusitis 20.8%,¹³ margin of error 0.06 and confidence level 95%. Both male and female patients having age between 25 and 80 years were enrolled who were advised CT scan by treating physician due to complaints of headache, nasal obstruction or nasal discharge for period of two or more weeks. Patients who were previously diagnosed cases of fungal sinusitis, those presenting for follow up after treatment of fungal sinusitis and patients having known malignancy of nose or nasopharynx were not included in the study. After explaining the purpose of study, written informed consent was obtained from each participant before collection of data. Demographic information of each patient was recorded including age, gender, diabetes and hypertension status. Diabetes was taken as already diagnosed cases who were using oral hypoglycemic medicines for duration of 3 or more years. Hypertension was taken as patients already diagnosed and taking oral antihypertensive medicines for period of 3 or more years. Patients were evaluated for presenting symptoms including headache, nasal blockage and nasal discharge. Headache was considered when patient reported pain over frontal area of head of any severity which remained present for at least 2 weeks. Nasal obstruction was considered when patient complained inability to smell due to blocked nose for duration of 2 weeks or more. Nasal discharge was taken when discharge from either nostril of any color persisted for minimum 2 weeks.

Following clinical evaluation, the computed tomography (CT) scan of the paranasal sinuses was carried out. All the images were taken using a 16-slice CT scanner. The protocol began with non-contrast plain CT scans, followed by the administration of non-ionic contrast medium at the rate of 2 mL/kg of the patient's weight. Post-contrast images were taken about 60–70 seconds after the administration of the contrast medium. Images obtained from the CT scan were interpreted by a consultant radiologist with three years of experience in interpreting CT scans. Histopathological tests were then carried out on the tissues of the sinuses. The results were then recorded for comparison. CT images showing fungal sinusitis were characterized by the presence of soft tissue opacification in the frontal, maxillary, ethmoid, or sphenoid sinuses, with areas of high-density material within the sinuses. Histopathologically, the presence of

fungal sinusitis was confirmed by the presence of eosinophilic mucin with a characteristic red and blue gyriform pattern, the presence of Charcot-Leyden crystals, the presence of fungal hyphae, thickening of the mucosal lining with thickening of the basement membrane, and the presence of hyperplasia with the presence of inflammatory cells, particularly eosinophils.

All collected information was entered and analyzed using SPSS version 24. Continuous variables such as age and duration of symptoms were expressed as mean \pm standard deviation. Categorical variables including gender, diabetes, hypertension, presence of fungal sinusitis on CT scan and presence of fungal sinusitis on histopathology were presented as frequency and percentage. Diagnostic accuracy measures including sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy were determined through 2×2 contingency table using histopathology as gold standard.

RESULTS

The study included a total of 206 patients. The mean age of the patients were 53.97 ± 16.33 years, and the mean duration of symptoms were 5.14 ± 2.06 months. Among the study participants, 121 patients were male which accounts for 58.7% of total, while 85 patients were female which accounts for 41.3% of total. Regarding comorbid conditions, diabetes were present in 46 patients (22.3%) whereas 160 patients (77.7%) were not having diabetes. Similarly, hypertension were found in 52 patients (25.2%) and were absent in 154 patients (74.8%) (Table-I).

Table I
Patient Demographics

Demographics	Mean \pm SD
Age (years)	53.97 \pm 16.33
Duration of Symptoms (months)	5.14 \pm 2.06
Gender	
Male n (%)	121 (58.7%)
Female n (%)	85 (41.3%)
Diabetes	
Yes n (%)	46 (22.3%)
No n (%)	160 (77.7%)
Hypertension	
Yes n (%)	52 (25.2%)
No n (%)	154 (74.8%)

On the basis of overall diagnostic findings, CT scan were able to identified fungal sinusitis in 64 patients which is 31.1% of total cases, while it were absent in 142 patients (68.9%). On the other hand, histopathology were confirmed the presence of fungal sinusitis in 52 patients (25.2%), and were found absent in 154 patients (74.8%), with total of 206 patients being evaluated through both modalities (Table-II).

Table II
Overall Results of CT Scan and Histopathology in Diagnosis of Fungal Sinusitis

Fungal Sinusitis	CT Scan	Histopathology
Present	64 (31.1%)	52 (25.2%)
Absent	142 (68.9%)	154 (74.8%)
Total	206 (100%)	206 (100%)

When CT scan findings were compared against histopathology as a reference standard, CT scan were

showed positive results in 49 true positive cases and 3 false negative cases were also recorded (Table-III).

Table III

Comparison of CT Scan versus Histopathology in Diagnosis of Fungal Sinusitis

CT Scan	Histopathology		Total
	Present	Absent	
Present	49 (TP)	15 (FP)	64
Absent	3 (FN)	139 (TN)	142
Total	52	154	206

TP = True positive | FP = False positive | FN = False negative | TN = True negative

The diagnostic performance of CT scan in the detection of fungal sinusitis were evaluated through multiple parameters. The sensitivity were calculated as 94.23%, which indicating a high ability of CT scan to correctly identifies the positive cases. The specificity were found to be 90.26%, and the overall diagnostic accuracy were recorded as 91.26%. Furthermore, the positive predictive value (PPV) were 76.56% while the negative predictive value (NPV) were considerably high at 97.89%, which suggesting that a negative CT scan result were highly reliable in ruling out fungal sinusitis (Table-IV).

Table IV

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CT Scan in Diagnosis of Fungal Sinusitis

Diagnostic Parameter	Result
Sensitivity	94.23%
Specificity	90.26%
Diagnostic Accuracy	91.26%
PPV	76.56%
NPV	97.89%

DISCUSSION

In this study, it was found that the majority of patients were males, 121 (58.7%), compared to female patients, 85 (41.3%). This could be attributed to the fact that males are more exposed to outdoor environments and work in dusty areas, which increases the risk of infection by inhaling fungal spores. The average age of patients with fungal sinusitis was 53.97 ± 16.33 years. This indicates that middle-aged and elderly individuals are more likely to acquire this infection. This could be attributed to a weakening of the body's immunity as one ages. Among patients with fungal sinusitis, 46 (22.3%) had diabetes mellitus, and 52 (25.2%) patients had hypertension. Hypertension and diabetes mellitus are well known to cause an immunocompromised state. In diabetic patients, hyperglycemia impairs neutrophil function and limits the ability of immunologic cells to defend against infections by fungi. This increases susceptibility to invasive fungal infections. CT scan results showed that 64 patients out of 204 (31.1%) were diagnosed with fungal sinusitis, and histopathology results showed 52 patients out of 204 (25.2%). The sensitivity of CT scan results was 94.23%, specificity 90.26%, and diagnostic accuracy 91.26%. The high sensitivity of CT scan results can be attributed to CT scan's ability to clearly show bony erosions, soft tissue density, and hyperdensity in the sinuses, which are characteristics of fungal sinusitis. The negative predictive value of CT scan results was 97.89%. This indicates that if a patient is negative on a CT scan, it is highly reliable

because, without these characteristics, it is almost impossible for a patient to acquire fungal sinusitis.

The sensitivity of CT scan in current study were 94.23% and specificity were 90.26% with overall diagnostic accuracy of 91.26%. These findings were closely comparable to Lutfi *et al.*¹⁴ who were reported sensitivity of 93.6%, specificity of 77.7%, and diagnostic accuracy of 89.2% in 65 patients using culture as gold standard, which suggesting that CT scan perform consistently well across different reference standards. Similarly, Abbasi *et al.*¹⁵ were also reported comparable diagnostic accuracy of 90.2% with sensitivity of 95% and specificity of 73.5% against histopathology in 153 patients, which further supporting the reliability of CT scan in fungal sinusitis diagnosis. Bushra *et al.*¹⁶ were also found sensitivity of 94.67% which is very close to present study findings, however their specificity were relatively lower at 75% and diagnostic accuracy were 85.31%, this difference may be because of variation in patient selection criteria and disease severity among study populations.

The NPV of current study were recorded as 97.89% which were considerably high, indicating that negative CT scan result is very reliable for ruling out fungal sinusitis. This finding were in agreement with Iqbal *et al.*¹² who were reported NPV of 77.77% and Naz *et al.*¹⁸ who were found NPV of 71.4%, however both these values were lower than present study, which may be explained by difference in sample size and type of fungal sinusitis included in respective studies.¹⁷

The PPV in current study were 76.56%, which were comparatively lower than Aziz *et al.*¹⁹ who were reported PPV of 96.20% with very high diagnostic accuracy of 95.98% in a large sample of 323 patients. This difference can be attributed to larger sample size in study by Aziz *et al.*¹⁹ which generally tends to improve the precision of diagnostic estimates. On the other hand, Khalid *et al.*²⁰ were reported very low specificity of 15.8% and diagnostic accuracy of only 57.9%, which were considerably lower than present study findings. This major difference may be because Khalid *et al.*²⁰ were specifically studied allergic fungal sinusitis which is a distinct subtype with different radiological characteristics, making CT scan less specific in that particular group.

Among 206 patients in current study, 121 (58.7%) were male and 85 (41.3%) were female, which is consistent with gender distribution reported by Lutfi *et al.*¹⁴ Abbasi *et al.*¹⁵ Iqbal *et al.*¹² and Bushra *et al.*¹⁶ where male predominance were also observed. This consistent male predominance across studies can be explained by greater occupational and environmental exposure to fungal spores in male population. The mean age in present study were 53.97 ± 16.33 years which were relatively higher as compared to most other studies like Sarfraz *et al.*²¹ who were reported mean age of 31.6 ± 14.7 years and Naz *et al.*¹⁸ with mean age of 34.61 ± 10.94 years, this difference may reflects variation in referral patterns and geographic distribution of patient population.

The limitations of this study should be taken into consideration when interpreting the results. For instance, the fact that this is a single-center study might affect the overall ability of the results to represent a wider population. Also, the sample size was small in this study, which could affect the precision of diagnostic measures.

Finally, selection bias cannot be completely excluded in this study because the sample was taken from a single tertiary medical institution and might not represent a wider population. Moreover, long-term follow-up was not carried out in this study, and factors related to the stage of disease and immune status of the infected individuals were not taken into consideration, which could affect the overall diagnostic ability of CT scans.

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CONCLUSION

This study concludes that CT scan is a reliable and accurate diagnostic modality for diagnosing fungal sinusitis. When histopathology was used as a gold standard, CT scan showed high sensitivity, specificity, and diagnostic accuracy. CT scan also showed high negative predictive value, which indicates its effective use for ruling out fungal sinusitis.