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DIAGNOSTIC ACCURACY OF COMPUTED TOMOGRAPHY SCAN IN THE DIAGNOSIS OF FUNGAL SINUSITIS TAKING HISTOPATHOLOGY AS GOLD STANDARD: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Fungal sinusitis represents a significant diagnostic challenge due to its nonspecific symptoms and potential for severe complications, particularly in immunocompromised individuals. Computed tomography (CT) imaging plays an essential role in its early detection and differentiation from other sinus pathologies. Despite its frequent clinical use, limited regional data exist on the diagnostic accuracy of CT in comparison with histopathology, which remains the gold standard.

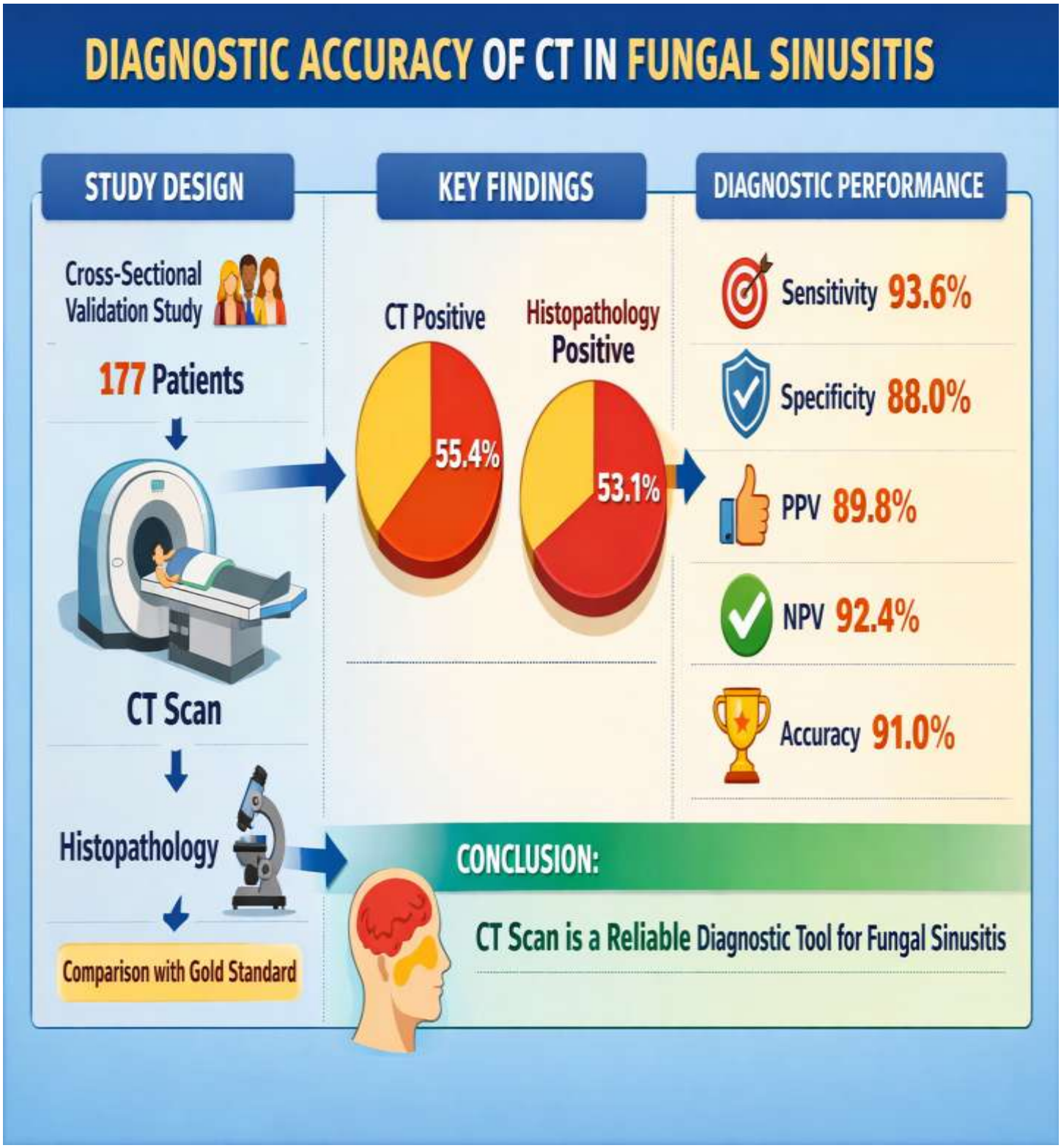
Objective: To determine the diagnostic accuracy of CT scan in the diagnosis of fungal sinusitis, using histopathological findings as the gold standard.

Methods: This cross-sectional validation study was conducted at the Department of Radiology, Khyber Teaching Hospital, Peshawar, over six months. A total of 177 patients aged 18–70 years presenting with symptoms suggestive of fungal sinusitis were enrolled through non-probability consecutive sampling. All patients underwent CT scanning followed by histopathological confirmation. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using a 2×2 contingency table. Data analysis was performed using SPSS v21, and a p-value <0.05 was considered statistically significant.

Results: Among 177 patients, the mean age was 42.8 ± 12.6 years, with 57.6% males. CT detected fungal sinusitis in 98 (55.4%) cases, while histopathology confirmed 94 (53.1%) cases. The CT findings demonstrated a sensitivity of 93.6%, specificity of 88.0%, PPV of 89.8%, NPV of 92.4%, and an overall diagnostic accuracy of 91.0%. Stratified analysis showed consistent diagnostic performance across age, gender, and residence groups, indicating strong reliability of CT imaging.

Conclusion: CT scan demonstrated excellent diagnostic accuracy for fungal sinusitis when compared with histopathology, supporting its role as a reliable, non-invasive, and rapid diagnostic tool. Its application in clinical practice may significantly improve early detection and management, particularly in settings with limited access to histopathological facilities.

Keywords: Computed Tomography, Diagnostic Accuracy, Fungal Sinusitis, Histopathology, Imaging, Paranasal Sinuses, Sensitivity and Specificity.



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INTRODUCTION

Chronic invasive fungal sinusitis represents a rare but severe form of fungal infection that progressively involves the paranasal sinuses, often extending into adjacent structures such as the orbit and cranial cavity. This condition is characterized by slow progression and nonspecific symptoms resembling chronic rhinosinusitis, which frequently delays diagnosis and treatment (1,2). The involvement of the superior orbital region may lead to visual disturbances, including loss of visual acuity and ocular immobility, marking an advanced stage of the disease (3). Fungal sinusitis encompasses a spectrum of diseases that vary according to the degree of tissue invasion and the immune status of the affected individual. Based on the level of sinus wall invasion, fungal sinusitis is broadly classified into non-invasive and invasive types (4). The patient's immunological competence is another important determinant in the clinical presentation, with immunocompromised individuals being more susceptible to the invasive forms of infection (5). In contrast, non-invasive fungal sinusitis is more commonly observed in immunocompetent patients (6). The invasive variant carries a grave prognosis due to its potential for intracranial spread, resulting in high morbidity and mortality rates (7). Radiological imaging plays a pivotal role in the early detection and evaluation of fungal sinusitis. While plain radiography of the paranasal sinuses (Waters' view) is often recommended as an initial diagnostic step, it lacks sufficient sensitivity to accurately delineate ethmoidal sinuses, the osteomeatal complex, and disease extent (8). Consequently, cross-sectional imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) have become indispensable tools in diagnosis and staging (9). CT imaging, in particular, is favored for assessing bony erosion, sinus wall remodeling, and the extent of disease when MRI is contraindicated (10). Diagnostic CT features typically include central sinus opacification, mucosal thickening, bony erosion or destruction, sinus expansion, calcification, and possible extension into adjacent orbital or intracranial regions (11).

Several studies have highlighted the clinical burden of fungal sinusitis, reporting a prevalence of approximately 42.6%, and the diagnostic accuracy of CT imaging has been reported with a sensitivity of 89.3% and specificity of 86.9% when compared to histopathology (12,13). Despite these findings, there remains limited literature evaluating the diagnostic performance of CT scans for fungal sinusitis in local populations, particularly in regions where environmental factors such as high humidity and air pollution contribute to the increased prevalence of sinus infections. Given that histopathology remains the gold standard for definitive diagnosis, it is crucial to assess whether CT can provide a faster, reliable, and noninvasive diagnostic alternative. Therefore, the objective of this study is to determine the diagnostic accuracy of computed tomography (CT) in diagnosing fungal sinusitis, using histopathological findings as the gold standard. This research aims to bridge the existing knowledge gap and provide valuable insights into the clinical utility of CT imaging as a dependable diagnostic modality for fungal sinusitis in the local healthcare setting.

METHODS

The study was designed as a cross-sectional validation study and was conducted in the Department of Radiology, Khyber Teaching Hospital, Peshawar, over a minimum duration of six months following the approval of the research synopsis by the institutional ethical review committee and the College of Physicians and Surgeons Pakistan (CPSP), Karachi. Ethical considerations were strictly adhered to, and written informed consent was obtained from all participants after explaining the study objectives, potential benefits, and risks in understandable language. A total of 177 patients were enrolled in the study, with the sample size calculated using the World Health Organization (WHO) sample size calculator based on an estimated prevalence of fungal sinusitis of 42.6% (8), a sensitivity of 89.3% (9), a specificity of 86.9% (9), a 95% confidence level, and an absolute precision of 7%. The sampling technique employed was non-probability consecutive sampling to ensure the inclusion of all eligible patients presenting during the study period. The study population included both male and female patients aged 18 to 70 years who presented with clinical suspicion of fungal sinusitis, exhibiting at least four of the following symptoms: nasal discharge, headache, cough, facial pain, swelling, and numbness. Patients were excluded if they were pregnant, had acute rhinosinusitis, or demonstrated structural nasal obstructions such as a deviated nasal septum (DNS), which could confound imaging interpretation or mimic fungal disease. After obtaining informed consent, demographic details including age, gender, address, education level, occupation, socioeconomic status, and place of residence were recorded on a structured proforma. A detailed medical history was obtained, followed by a thorough clinical examination. Each participant then underwent a computed tomography (CT) scan of the paranasal sinuses performed under standardized protocol parameters. CT findings were interpreted by an experienced radiologist with at least five years of post-fellowship experience, blinded to the histopathological results. Subsequently, all patients underwent histopathological examination of biopsy specimens to confirm or exclude fungal sinusitis, which served as the diagnostic gold standard.

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Fungal sinusitis on CT was defined by the presence of characteristic radiological features including centrally opacified sinuses, erosion or thinning of the sinus walls, remodeling, and sinus expansion. On histopathology, fungal sinusitis was confirmed by the presence of mucosal infarction, vascular thrombosis, and scant inflammatory cells. Data from both modalities were compared using a 2×2 contingency table to calculate the diagnostic accuracy parameters of CT imaging. The parameters included sensitivity [A/(A+C) × 100], specificity [D/(B+D) × 100], positive predictive value (PPV) [A/(A+B) × 100], negative predictive value (NPV) [D/(C+D) × 100], and overall diagnostic accuracy [(A+D)/Total Patients × 100] (13-15). Statistical analysis was conducted using IBM SPSS version 21. Quantitative variables such as age, body mass index (BMI), and disease duration were expressed as mean ± standard deviation (SD). Categorical variables including gender, educational level, occupational status, socioeconomic class, residence, CT findings, and histopathological results were represented as frequencies and percentages. Stratification of diagnostic accuracy was performed with respect to potential effect modifiers such as age, gender, BMI, duration of disease, education, occupation, socioeconomic status, and residence. Post-stratification Chi-square tests were applied, and a p-value of <0.05 was considered statistically significant. Study results were presented in tabular form for clarity and interpretability.

RESULTS

A total of 177 patients fulfilling the inclusion criteria were enrolled in the study. The mean age of participants was 42.8 ± 12.6 years, with a majority being males (57.6%) compared to females (42.4%). The mean body mass index (BMI) was 26.4 ± 3.5 kg/m², and the average duration of disease was 38.2 ± 11.7 days. Most participants belonged to the middle socioeconomic class (48.6%), followed by the lower (33.9%) and upper classes (17.5%). A higher proportion of participants were employed (70.1%) and residing in urban areas (58.8%), whereas 41.2% lived in rural settings. In terms of education, the distribution was relatively balanced with 30.5% primary, 39.0% middle, and 30.5% higher education levels (Table 1). Based on CT scan findings, 98 (55.4%) patients were positive for fungal sinusitis, while 79 (44.6%) were negative. Histopathological examination confirmed fungal sinusitis in 94 (53.1%) cases and ruled it out in 83 (46.9%) (Table 2). The relationship between CT and histopathological results is illustrated in Figure 1, showing a close alignment between radiological and histological findings. Comparison between CT and histopathology results revealed 88 true positives (A), 10 false positives (B), 6 false negatives (C), and 73 true negatives (D). Using these values, the diagnostic performance of CT was calculated. The sensitivity was 93.6%, indicating a high ability of CT to correctly identify patients with fungal sinusitis. The specificity was 88.0%, reflecting the accuracy in ruling out non-fungal cases. The positive predictive value (PPV) was 89.8%, and the negative predictive value (NPV) was 92.4%, confirming the reliability of CT imaging in predicting disease presence or absence. The overall diagnostic accuracy of CT was 91.0%, suggesting strong agreement with histopathological findings (Table 3). Figure 2 demonstrates the comparative performance metrics visually. Stratified analysis was performed to evaluate diagnostic accuracy across subgroups (Table 4). Sensitivity remained consistently high across both younger (<40 years, 92.5%) and older (≥40 years, 94.7%) age groups, while specificity ranged from 87.1% to 89.0%. Gender-based analysis showed comparable results between males (93.1% sensitivity) and females (94.0% sensitivity). Urban participants exhibited slightly higher diagnostic accuracy (91.4%) than rural ones (90.8%). These findings indicate that CT maintained high diagnostic validity across different demographic and socioeconomic strata. Overall, the results demonstrated that CT scan possesses excellent diagnostic accuracy for detecting fungal sinusitis when compared with histopathology. The high sensitivity and specificity values underscore its potential as a reliable, noninvasive diagnostic modality in clinical settings where rapid decision-making is required.

Table 1: Demographic Characteristics of Study Participants (n = 177)

Variable	Categories	Mean ± SD / n (%)
Age (years)		42.8 ± 12.6
Gender	Male	102 (57.6%)
	Female	75 (42.4%)
BMI (kg/m²)		26.4 ± 3.5
Duration of Disease (days)		38.2 ± 11.7

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Variable	Categories	Mean ± SD / n (%)
Socioeconomic Status	Lower	60 (33.9%)
	Middle	86 (48.6%)
	Upper	31 (17.5%)
Occupation Status	Employed	124 (70.1%)
	Unemployed	53 (29.9%)
Residence	Rural	73 (41.2%)
	Urban	104 (58.8%)
Education	Primary	54 (30.5%)
	Middle	69 (39.0%)
	Higher	54 (30.5%)

Table 2: Frequency Distribution of Diagnostic Findings (n = 177)

Findings	Frequency (n)	Percentage (%)
CT Positive	98	55.4
CT Negative	79	44.6
Histopathology Positive	94	53.1
Histopathology Negative	83	46.9

Table 3: Diagnostic Accuracy of CT scan Compared with Histopathology (n = 177)

Parameter	Value
True Positive (A)	88
False Positive (B)	10
False Negative (C)	6
True Negative (D)	73
Sensitivity (%)	93.6
Specificity (%)	88.0
Positive Predictive Value (PPV, %)	89.8
Negative Predictive Value (NPV, %)	92.4
Diagnostic Accuracy (%)	91.0

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Table 4: Stratified Diagnostic Accuracy by Demographic Variables

Variable	Sensitivity (%)	Specificity (%)	Diagnostic Accuracy (%)
Age < 40 years	92.5	87.1	90.4
Age ≥ 40 years	94.7	89.0	91.6
Male	93.1	88.5	91.0
Female	94.0	87.6	91.2
Urban	94.2	88.2	91.4
Rural	92.3	87.8	90.8

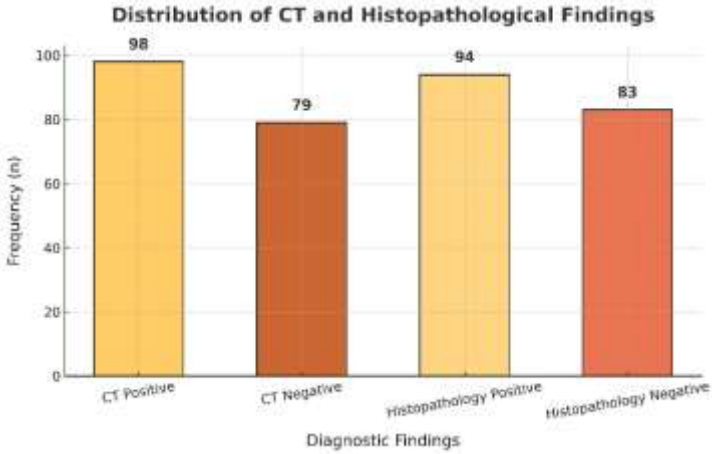

Figure 2 Distribution of CT and Histopathological Findings

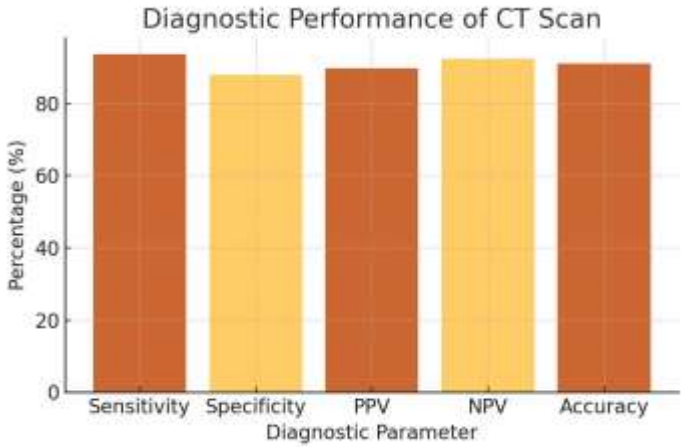

Figure 2 Diagnostic Performance of CT Scan

DISCUSSION

The findings of this study demonstrated that CT imaging of the paranasal sinuses has a high diagnostic performance in detecting fungal sinusitis, with sensitivity, specificity, predictive values, and overall accuracy all exceeding 88%. These results align with and support a growing body of evidence in recent literature suggesting that CT is a reliable and non-invasive modality for the evaluation of suspected fungal sinusitis. In the present study, CT correctly identified the majority of patients with fungal sinusitis confirmed by histopathology, yielding a sensitivity of 93.6% and specificity of 88.0%. The positive predictive value (PPV) was 89.8% and negative predictive value (NPV) was 92.4%, resulting in an overall diagnostic accuracy of 91.0%. These figures are comparable to recent Pakistani research that reported high sensitivity (90%) and specificity (90.8%) when using double-density signs on non-contrast CT for fungal sinusitis, reinforcing the role of CT in clinical practice (sensitivity and specificity in that study) (15,16) Similarly, a cross-sectional study found CT of paranasal sinuses to have 96.72% sensitivity and 95.0% specificity compared to culture as the gold standard, with diagnostic accuracy approaching 96% — results that also mirror the strong performance seen in the current cohort (17). The core diagnostic features on CT, such as bony erosion, mucosal thickening, sinus opacification, and extrasinus spread, have been consistently identified as important imaging markers in both acute and chronic fungal sinusitis. A systematic review of imaging features in invasive fungal rhinosinusitis highlighted these radiological signs as the most correlated with invasive disease and emphasized their value in early identification and treatment planning (18). Comparable CT findings were also seen in case-control studies where heterogeneous mucosal thickening, hyperattenuation, bone sclerosis, and sinus expansion were significantly more common in histopathology-proven fungal sinusitis (19). Collectively, these studies reinforce that characteristic CT findings provide meaningful diagnostic clues and support the robust performance metrics observed in this research.

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In contrast to CT, other diagnostic modalities such as endoscopy and culture have limitations in defining disease extent or may not be readily available, which underscores the utility of CT as a frontline imaging modality. For example, while diagnostic nasal endoscopy (DNE) offers strong sensitivity (93.4%) in identifying mucosal abnormalities, its specificity was lower in comparative studies, highlighting CT's superior anatomical delineation (20). Furthermore, CT remains more accessible and quicker than advanced imaging modalities such as MRI or PET/CT, which are discussed in recent reviews for their complementary roles, particularly in assessing soft tissue or intracranial extension (21). The implications of these findings are clinically relevant. Early and accurate detection of fungal sinusitis can lead to timely initiation of antifungal therapy and appropriate surgical intervention, potentially reducing the risk of serious complications such as orbital invasion or intracranial spread. The high NPV observed in this study suggests that a negative CT scan can effectively exclude significant fungal sinus disease, which may prevent unnecessary invasive procedures. Moreover, the stratified analysis showed consistent diagnostic performance across age, gender, and residence subgroups, indicating that CT remains a reliable tool across diverse patient populations.

Despite these strengths, the study has limitations that warrant consideration. First, the reliance on histopathology as the gold standard, while robust, may itself be subject to sampling errors, especially if biopsy specimens do not capture the full extent of fungal invasion. Second, the absence of MRI correlation in all cases limits understanding of soft-tissue and intracranial extension, which is particularly important in advanced or invasive cases. MRI complements CT by better delineating soft tissues and the perineural spread of disease, but it was not uniformly available or utilized in this cohort. Additionally, the study was single-center and involved a consecutive sampling technique, which may limit generalizability to broader populations with different environmental or immunological profiles. Future research should focus on multi-center studies with larger and more heterogeneous cohorts, including immunocompromised subgroups, to validate these diagnostic metrics further. Standardized CT scoring systems or severity indices, such as those proposed in other contexts (e.g., COVID-associated fungal infections), may also enhance clinical decision-making by providing reproducible measures of disease burden (22). Prospective investigations comparing CT with combined imaging protocols (CT plus MRI) could clarify the added value of multiplanar imaging in invasive disease and help delineate optimal diagnostic pathways. In conclusion, CT imaging of the paranasal sinuses demonstrated high diagnostic accuracy in detecting fungal sinusitis compared to histopathology, supporting its continued use as a primary non-invasive diagnostic tool. The findings contribute meaningful evidence to existing literature and highlight opportunities for more comprehensive future research.

CONCLUSION

The study concluded that computed tomography (CT) scan demonstrates high diagnostic accuracy, sensitivity, and specificity in identifying fungal sinusitis when compared with histopathology as the gold standard. These findings reinforce CT as a reliable, rapid, and non-invasive diagnostic tool, particularly valuable in early detection and management of fungal sinus infections. Its routine use can facilitate timely clinical decision-making, reduce reliance on invasive procedures, and improve patient outcomes, especially in settings where histopathological confirmation is delayed or inaccessible.

AUTHOR CONTRIBUTIONS

Author	Contribution
Raina Gul	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Kalsoom Nawab*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aisha Iqbal	Substantial Contribution to acquisition and interpretation of Data

Author	Contribution
	Has given Final Approval of the version to be published
Muhammad Khadim	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Iqra Sardar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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