Original Research Article

Diagnostic Accuracy of Computed Tomography in the Diagnosis of Fungal Sinusitis Keeping Histopathology as A Gold Standard

Bushra*, Nasreen Aman

Department of Diagnostic Radiology, Lady Reading Hospital, Peshawar, Pakistan
*Corresponding author`s email address: drbushra15@gmail.com

Abstract: *Fungal sinusitis is an increasingly recognized cause of chronic sinonasal disease, particularly in immunocompromised and diabetic patients. Early and accurate diagnosis is essential for appropriate surgical and medical management. Computed tomography (CT) of the paranasal sinuses is widely used for initial evaluation; however, its diagnostic performance must be validated against histopathology, which remains the gold standard.* **Objective:** *To determine the diagnostic accuracy of computed tomography (CT) in diagnosing fungal sinusitis, using histopathological findings as the gold standard.* **Methods:** *This cross-sectional validation study included 143 patients aged 18–65 years presenting with clinical suspicion of fungal sinusitis. Patients with sinonasal tumors, antrochoanal polyps, and pregnant or lactating women were excluded from the Radiology Department, Lady Reading Hospital, Peshawar. The study duration was from 25-10-2024 to 25-04-2025. All participants underwent CT scanning of the paranasal sinuses followed by surgical intervention and histopathological examination. Diagnostic accuracy parameters, including sensitivity, specificity, and overall accuracy, were calculated using a 2×2 contingency table. Data analysis was performed using SPSS version 25.* **Results:** *The mean age of the patients was 42.75 + 14.689 years, there were 93 (65%) male patients. CT scan showed fungal sinusitis positive in 88 patients (61.5%), while histopathology in 75 patients (52.4%). Diagnostic accuracy of CT scan for fungal sinusitis was 85.31%, with sensitivity 94.67% and specificity 75%, respectively.* **Conclusion:** *Computed tomography is an effective and reliable imaging modality for diagnosing fungal sinusitis, demonstrating high sensitivity and good diagnostic accuracy compared with histopathology. CT scanning is a valuable noninvasive diagnostic tool for early detection and preoperative assessment of fungal sinusitis.*

Keywords: Computed Tomography, Fungal Sinusitis, Diagnostic Accuracy, Histopathology, Sensitivity, Specificity

Introduction

Fungal sinusitis encompasses a range of invasive and non-invasive fungal diseases involving the paranasal sinuses. Such infections may present with diverse clinical features, thus making early and precise diagnosis essential for effective management. Among available diagnostic tools, CT has become particularly valuable for its high-resolution images that reveal both anatomical details and disease-related variations within the sinus cavities. Regardless of this, histopathological examination remains the definitive approach for confirmation (1-4). A CT scan is routinely used to evaluate sinonasal disorders and plays a central role in identifying fungal sinusitis. The CT findings include increased sinus density, sinus opacification, and erosion of adjacent bony structures. Such imaging features help clinicians differentiate between invasive and non-invasive disease, which is critical for guiding appropriate treatment (5-7).

Histopathology provides direct evidence of fungal infection through tissue sampling. Biopsy enables identification of fungal species and assessment of tissue invasion, allowing distinction between mere fungal colonization and actual infection, a distinction that imaging alone cannot consistently determine. Tissue sampling, however, requires an invasive procedure that may not be appropriate for all patients, particularly those with medical contraindications. Radiological signs, including the hyperdense sinus contents and complete sinus opacification, strongly suggest the fungal involvement. CT imaging is thus functional not only for diagnosis but also for determining disease severity and type (7-9). Studies have shown that fungal sinusitis accounts for about 26% of sinus disease cases, and CT scanning has demonstrated high diagnostic performance, with reported sensitivities of 89.3% and specificities of 86.9% in recognizing fungal sinusitis (10, 11).

Fungal sinusitis shows a distinct density that is readily apparent on imaging. Cross-sectional imaging, such as CT, is essential for diagnosing this condition. As no such study has been conducted locally on this topic, the purpose of this study is to determine the diagnostic accuracy of CT in diagnosing fungal sinusitis, with histopathology as the gold standard. The results of this study will assist in understanding the diagnostic accuracy of CT in fungal sinusitis, when considered in conjunction with histopathology, which is vital in the management of patients with suspected fungal sinusitis. The findings of this research will elucidate the effectiveness of CT scans in evaluating their capacity to serve as a more convenient diagnostic alternative to histology.

Methodology

This cross-sectional validation study was conducted in the Radiology Department, Lady Reading Hospital, Peshawar. The study duration was from 25-10-2024 to 25-04-2025. Ethical approval was obtained from the hospital's IRB. The sample size was determined by using the WHO sample size calculator, keeping the following assumptions, frequency of fungal sinusitis (26%), (10) sensitivity of CT in the detection of fungal sinusitis (89.3%), (11) specificity of CT in the detection of fungal sinusitis (86.9%), (11) absolute precision of (10%) and a confidence level of (95%). The determined sample size was 143.

Non-probability consecutive sampling was used to select participants. The inclusion criteria were age between 18 and 65 years, both male and female genders, and suspected patients with fungal sinusitis who had all of the following features: reduced sense of smell, nasal or sinus inflammation, and nasal congestion or a runny nose. Exclusion criteria included patients with sinonasal tumours, antrochoanal polyps, and pregnant or lactating women.

The research work was started after obtaining informed written consent from all the patients, after communicating the study objective and assuring them that there was no risk involved. Demographic details such

as age, gender, address, socioeconomic status, occupation status, and residence area were recorded. Medical history was taken, and a physical examination was performed. In the radiology department, a CT scan was performed, and the findings were recorded. The findings were considered positive based on opacification and expansion of multiple paranasal sinuses, with centrally hyperdense content. After surgical intervention in these patients, histopathological evaluation was performed, and the findings were recorded. Findings were considered if the mucosa showed infarction, vascular thrombosis, and typically scant inflammatory cells. Both findings (CT and histopathological) were compared and recorded under the supervision of a consultant with at least 5 years of post-fellowship experience. The observations regarding patients were recorded on a pre-designed pro forma.

The analysis of collected data was performed using IBM SPSS v.25. Mean and standard deviation were calculated for numerical variables, such as age and disease duration. Frequencies and percentages were calculated for categorical variables, including gender, CT scan findings, histopathology findings, socioeconomic status, occupation status, and residence area. A 2x2 contingency table was used to determine the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of a CT scan in diagnosing fungal sinusitis, with histopathology as the gold standard. Effect modifiers like age, gender, disease duration, socioeconomic status, occupation status, and residence area were addressed through stratification. Post-stratification, a Chi-square test was used at the 5% significance level. Results were presented in tables.

Results

The study enrolled 143 patients. The mean age was 42.75 + 14.689 years. The mean duration of disease was 2.90 ± 1.433 months.
Regarding gender distribution, 93 patients (65%) were male and 50 (35%) were female (Table 1).

Computed tomography (CT) findings indicated positive fungal sinusitis in 88 (61.5%) cases, with 55 scans (38.5%) reported as negative. Histopathological examination indicated fungal sinusitis in 75 patients (52.4%) and was negative in 68 cases (47.6%). The diagnostic accuracy of CT scan was 85.31%, with sensitivity 94.67%, specificity 75%, positive predictive value was 80.68%, and the negative predictive value was 92.73% (Table 3). Table presents stratification of diagnostic accuracy of CT with demographics.

Table 1: Demographic profile of the patients

Demographic		n	%
Gender	Male	93	65.0
	Female	50	35.0
Age distribution (Years)	18 to 35	52	36.4
	36 to 50	37	25.9
	> 50	54	37.8
Socioeconomic status	Lower class	26	18.2
	Middle class	101	70.6
	Upper class	16	11.2
Residence area	Rural	63	44.1
	Urban	80	55.9
Occupation status	Employed	63	44.1
	Unemployed	80	55.9
Education status	Uneducated	57	39.9
	Educated	86	60.1

Table 2: CT & histopathology findings

CT & histopathology findings		n	%
CT finding of fungal sinusitis	Positive	88	61.5%
	Negative	55	38.5%
Histopathology of fungal sinusitis	Positive	75	52.4%
	Negative	68	47.6%

Table 3: Diagnostic accuracy of CT in the diagnosis of fungal sinusitis

		Histopathology of fungal sinusitis		Total	Diagnostic accuracy (85.31%)
		Positive	Negative		
CT finding of fungal sinusitis	Positive	(TP) 71	(FP) 17	88	Sensitivity: 94.67%
		49.7%	11.9%	61.6%	Specificity: 75%
	Negative	(FN) 4	(TN) 51	55	PPV: 80.68%
		2.8%	35.7%	38.5%	NPV: 92.73%
Total		75	68	143	143
		52.5%	47.6%	100%	100.%

Table 4: Stratification of diagnostic accuracy of CT with demographic parameters

Parameter	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy	P value
Age (Years)						
18 to 35	96.30%	60%	72.22%	93.8%	78.15%	0.0001
36 to 50	91.30%	78.6%	87.50%	84.62%	84.95%	0.0001
> 50	96%	86.21%	85.71%	96.2%	91.10%	0.0001
Gender						
Male	97.9%	73.91%	79.31%	97.14%	85.905%	0.0001
Female	89.3%	77.3%	83.33%	85%	83.3%	0.0001
SES						
Lower class	100%	54.55%	75%	100%	77.27%	0.02
Middle class	92.2%	82.00%	83.93%	91.11%	87.1%	0.0001
Upper class	100%	57.1%	75%	100%	78.55%	0.01
Education status						
Un-educated	96.8%	73.1%	81.1%	95%	84.95%	0.0001
Educated	93.2%	76.2%	80.4	91.4%	84.7%	0.0001
Occupation status						
Employed	93.8%	80.6%	83.33%	92.6%	87.2%	0.0001

Unemployed	95.3%	70.3%	78.8%	92.9%	82.8%	0.0001
Residence						
Rural	97.30%	76.9%	85.71%	95.2%	87.1%	0.0001
Urban	92.1%	73.8%	76.1%	91.2%	82.95%	0.0001
Duration of disease (Months)						
1 to 3	93.6%	78%	83%	91.4%	85.8%	0.0001
> 3	96.4%	70.4%	77.1%	95.00%	83.4%	0.0001

Discussion

The role of computed tomography (CT) in the diagnosis of fungal sinusitis has been consistently studies in the literature, highlighting its value while also acknowledging certain diagnostic challenges. Previous researches established that CT imaging offers a reliable non-invasive modality for detecting fungal sinusitis mainly in settings where timely diagnosis is critical for preventing serious complications such as orbital or intracranial extension.11,12 The diagnostic accuracy reported in the studies is generally high with sensitivities ranging from 76% to 100% and specificities from 73.5% to 93.33%.13-15 This variability often comes from differences in study design, patient selection, the specific CT criteria employed and the selected gold standard which may be histopathology, culture or endoscopic findings.

A critical examination of previous studies reveals several key CT features associated with fungal sinusitis. These include heterogeneous mucosal thickening, intrasinus hyperattenuation (often presenting as a central serpiginous pattern or the "double density sign"), bone erosion, bone sclerosis, and sinus expansion.14 The presence of bony changes in particular is a significant differentiator from non-fungal chronic sinusitis and is crucial for assessing disease extent and surgical planning.8 Nevertheless, the specificity of distinct findings can be limited as some features like mucosal thickening are also prevalent in bacterial sinusitis. Also a combination of radiological signs is typically required to increase diagnostic confidence.16-17

The demographic and clinical background of fungal sinusitis further enlightens the interpretation of imaging studies. Environmental factors, such as residence in areas with high humidity and pollution, and comorbidities like diabetes mellitus are recognized as significant risk factors.13 These epidemiological understandings are important as they highlight the populations in which a high index of suspicion for fungal sinusitis should be maintained.

Despite its established value the literature also points to limitations in relying only on CT for diagnosis. False positives can occur mostly when CT findings are interpreted in isolation without clinical correlation.18 The diagnostic performance can vary when comparing different subtypes of fungal sinusitis.19 This underscores the need of integrating CT findings with clinical presentation, endoscopic evaluation and definitive histopathological confirmation to achieve an accurate diagnosis.

Regarding diagnostic performance, in the present study the CT scan demonstrated diagnostic accuracy 85.31%, sensitivity 94.67% and specificity 75%. Iqbal et al. reported a higher sensitivity 96.19% and specificity 93.33%, other studies like that of Mughal et al. documented sensitivity 100% but a specificity as low as 15.8% for allergic fungal sinusitis.13,19 The present specificity of 75% suggests that although CT is excellent at ruling in disease a moderate number of false-positive results can also be expected. This is a recognized challenge often attributable to the overlapping imaging features between fungal and severe bacterial or inflammatory sinus disease. The PPV was 80.68%, and the NPV was 92.73% respectively emphasize that a negative CT scan is a strong indicator against fungal sinusitis while a positive result requires further confirmatory testing.

This study adds to the regional data from Pakistan, where environmental conditions are favorable to fungal growth and it provides present metrics for diagnostic accuracy in a diverse patient population that includes varied socioeconomic and educational backgrounds. It strengthens the position of CT as an essential first-line investigative tool that can effectively prioritize patients, potentially reducing delays in surgical intervention for true positive cases.

Conclusion

In conclusion, the presents study showed that Computed tomography is an efficient, and effective modality in the diagnosis of fungal sinusitis keeping histopathology as a gold standard. The modality yielded diagnostic accuracy was 85.31%, sensitivity 94.67% and specificity 75%. The findings of this study recommends CT as an excellent first-line imaging modality, but its findings should be interpreted in combination with clinical evaluation and confirmed by histopathology.

Declarations
Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (317/LRH/MTI)
Consent for publication
Approved
Funding
Not applicable

Conflict of interest

The authors declared no conflicts of interest.

Author Contribution

B (Trainee Medical Officer)
Contributed to study design, data collection, data analysis, and initial manuscript drafting
NA (Assistant Professor)
Proofreading, and final revisions of the manuscript

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

References

1.   Goyal SS, Doering M, Kendall PL, Farrell N, Schneider JS, Roland LT. Progression of noninvasive fungal sinusitis to invasive fungal sinusitis: a systematic review. Int Forum Allergy Rhinol. 2023;13(6):1024-1033. https://doi.org/10.1002/alr.23097
2.   Slonimsky G, McGinn JD, Goyal N, Crist H, Hennessy M, Gagnon E, et al. A model for classification of invasive fungal rhinosinusitis by computed tomography. Sci Rep. 2020;10(1):12591. https://doi.org/10.1038/s41598-020-69434-z
3.   Nathan K, Majhi SK, Bhardwaj R, Gupta A, Ponnusamy S, Basu C, et al. The role of diagnostic nasal endoscopy and a computed tomography scan (nose and PNS) in the assessment of chronic rhinosinusitis: a comparative evaluation of the two techniques. Sinusitis. 2021;5(1):59-66. https://doi.org/10.3390/sinusitis5010007
4.   Groppo ER, El-Sayed IH, Aiken AH, Glastonbury CM. Computed tomography and magnetic resonance imaging characteristics of acute invasive fungal sinusitis. Arch Otolaryngol Head Neck Surg. 2011;137(10):1005-1010. https://doi.org/10.1001/archoto.2011.170

5.　　　Brooks L, Puccia R, Broglie L, Gorelik M, Park M, Chun RH. Utility of diagnostic sinus CT for diagnosis of invasive fungal sinusitis in immunocompromised children. Int J Pediatr Otorhinolaryngol. 2025;198:112593. https://doi.org/10.1016/j.ijporl.2025.112593

6.　　　Ito K, Hara Y, Iizuka N, Sawada E, Suemitsu M, Kuyama K, et al. Differential diagnosis between fungal maxillary sinusitis and odontogenic sinusitis using CT images. Int J Oral Health Sci. 2019;17(3-4):100-107.

7.　　　Roland LT, Humphreys IM, Le CH, Babik JM, Bailey CE, Ediriwickrema LS, et al. Diagnosis, prognosticators, and management of acute invasive fungal rhinosinusitis: multidisciplinary consensus statement and evidence-based review with recommendations. Int Forum Allergy Rhinol. 2023;13(9):1615-1714. https://doi.org/10.1002/alr.23132

8.　　　Singh AK, Gupta P, Verma N, Khare V, Ahamad A, Verma V, et al. Fungal rhinosinusitis: microbiological and histopathological perspective. J Clin Diagn Res. 2017;11(7):DC10-DC14.

9.　　　Khullar T, Kumar J, Sindhu D, Garg A, Meher R. CT imaging features in acute invasive fungal rhinosinusitis: recalling the oblivion in the COVID era. Curr Probl Diagn Radiol. 2022;51(5):798-805. https://doi.org/10.1067/j.cpradiol.2022.02.001

10.　　　Julka BS, Patil SB, Chandrakiran C. Incidence and prevalence of fungal sinusitis in cases of chronic rhinosinusitis. Indian J Otolaryngol Head Neck Surg. 2023;75(Suppl 1):1041-1046. https://doi.org/10.1007/s12070-023-03572-0

11.　　　Naz N, Ahmad Z, Malik SN, Zahid T. Diagnostic accuracy of CT scan in fungal sinusitis: diagnosis and extent. Ann Pak Inst Med Sci. 2016;12(2):61-65.

12.　　　Abbasi HH, Batool F, Azam M, Qadir H, Shoaib M, Tariq Z. Diagnostic accuracy of CT PNS in diagnosing fungal sinusitis and its relation with endoscopy and histopathological findings. J Pak Soc Intern Med. 2024;5(4):745-749.

13.　　　Iqbal J, Rashid S, Darira J, Shazlee MK, Ahmed MS, Fatima S. Diagnostic accuracy of CT scan in diagnosing paranasal fungal infection. J Coll Physicians Surg Pak. 2017;27(5):271-274.

14.　　　Anand AM, George R, Padmanabhan E, Amirthalingam U. Diagnostic accuracy of computed tomography in fungal sinusitis: a case-control study. Int J Anat Radiol Surg. 2023;12(1):RO08-RO11. https://doi.org/10.7860/IJARS/2023/55429.2859

15.　　　Lutfi IA, Maheswari N, Devi D, Afridi FI. Accuracy of computed tomography in characterizing the paranasal fungal infection. Pak J Med Dent. 2015;4(4):13-16.

16.　　　Khattar VS, Hathiram B. Radiologic appearances in fungal rhinosinusitis. Otorhinolaryngol Clin (Int J). 2009;1(1):15-23. https://doi.org/10.5005/jp-journals-10003-1002

17.　　　Middlebrooks EH, Frost CJ, De Jesus RO, Massini TC, Schmalfuss IM, Mancuso AA. Acute invasive fungal rhinosinusitis: a comprehensive update of CT findings and design of a diagnostic chart. AJNR Am J Neuroradiol. 2015;36(8):1529-1535. https://doi.org/10.3174/ajnr.A4295

18.　　　Lanza DC, Dhong HJ, Tantilipikorn P, et al. Fungus and chronic rhinosinusitis: from bench to clinical understanding. Ann Otol Rhinol Laryngol Suppl. 2006;196:27-34. https://doi.org/10.1177/00034894061150s905

19.　　　Khalid S, Dhanani R, Mughal A, Khan H, Wasif M. Diagnostic accuracy of CT scans in allergic fungal sinusitis: a cross-sectional study. J Clin Images Med Case Rep. 2022;3(11):2145. https://doi.org/10.52768/2766-7820/2145