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Diagnostic Accuracy of Contrast Enhanced Computed Tomography Scan in Evaluation of Bony Erosions of Fungal Sinusitis in Immunocompromised Patients Taking Histopathology as Gold Standard

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ABSTRACT

Background: Fungal sinusitis with bony erosion is serious problem in immunocompromised patients and it can cause high morbidity and mortality. Early detection is important but clinical findings are not very specific, so imaging play major role. **Objective:** To determine the diagnostic accuracy of contrast enhanced computed tomography scan in diagnosis of bony erosions of fungal sinusitis in immunocompromised patients taking histopathology as gold standard. **Study design:** Cross sectional study. **Duration and place of study:** This study was conducted at Department of Diagnostic Radiology, Sindh Institute of Urology and Transplantation, Karachi over a period of six months from December 20, 2024 to June 20, 2025. **Methodology:** Total 98 patients were included. Patient's age 15–60 years of both genders with suspected fungal sinusitis were selected. Contrast enhanced computed tomography scan was done and findings of bony erosion were noted. After that histopathology was performed as gold standard. Data was analysed on Statistical Package for Social Sciences version 26. **Results:** Mean age was 36.03±13.65 years. There were 49 males 49 (50.0%) and 49 females 49(50.0%). Bony erosion on computed tomography scan was positive in 55 (56.1%) patients while on histopathology it was positive in 52 (53.1%). There were 49 true positive, 40 true negative, 6 false positive and 3 false negative cases. Sensitivity was 94.23%, specificity 86.96%, positive predictive value 89.09%, negative predictive value 93.02% and diagnostic accuracy 90.82%. **Conclusion:** Contrast enhanced computed tomography scan is reliable method for detecting bony erosion in fungal sinusitis in immunocompromised patients and shows good diagnostic accuracy.

INTRODUCTION

Bony erosions seen with fungal sinusitis occur due to a chronic and invasive infection of the paranasal sinuses, mostly in immune-compromised patients like patients suffering from diabetes mellitus, cancer, or on immune-suppressant medication.[1] Fungal infections in this case arise due to fungi belonging to the genus Aspergillus and Mucor that affect the mucosa and then further invade the surrounding bone tissues to cause erosion.[2] This is especially true for patients with invasive fungal sinusitis because in this type of fungal infection, fungal hyphae enter the blood vessels, which results in thrombosis and necrosis of the tissue.[3]

The diagnosis of a patient with fungal sinusitis and bony erosions requires a holistic approach, which involves physical examination, radiographic investigation and the confirmation through histopathologic methods.[4] Such patients usually exhibit clinical symptoms such as nasal obstruction, facial pain, fever, headache, and even a black nasal discharge in cases where the infection invades.[5] Nevertheless, the clinical presentation of the patient is not always very specific and can easily be mistaken for a case of bacterial sinusitis. Imaging studies become very important in revealing sinus opacities, bone involvement, and extrasinus spread.[6] The preferred method is computerized tomography since it offers an analysis of the bony structures.

Contrast-enhanced computed tomography (CT) is an important imaging technique that helps in diagnosing cases of fungal sinusitis and subsequent bony erosion in immunocompromised patients.[7] This test helps to obtain images of the anatomy of the paranasal sinus and determine the extent of disease invasion, especially concerning bone structure and damage.[8] After injection of the contrast material, this technique is important in helping diagnose any enhancement of soft tissue, necrosis, and vessel involvement, which are important in diagnosis and management of invasive fungal infection.[9] Contrast-enhanced CT is easily accessible, fast, and affordable, making it the most appropriate test for emergencies.[10]

Fungal sinusitis with bony erosions is an aggressive condition with high morbidity and mortality in immunocompromised patients, and early detection is very important for timely management. Although contrast enhanced computed tomography scan is widely used for evaluation of bony involvement, its diagnostic accuracy in comparison to histopathology is not fully established in local clinical settings. There is limited local data regarding its reliability in detecting bony erosions and guiding treatment decisions. Therefore, this study is needed to assess the diagnostic accuracy of contrast enhanced computed tomography scan by taking histopathology as gold standard, so that early and accurate diagnosis can be ensured and patient outcomes can be improved.

METHODOLOGY

This cross-sectional study was carried out at the Department of Diagnostic Radiology, Sindh Institute of Urology and Transplantation, Karachi, over a period of six months from December 20, 2024 to June 20, 2025. Sample size was calculated for both sensitivity and specificity. For sensitivity, taking value 89.3%,[11] prevalence 40%,[12] margin of error 10% and confidence interval 95%, calculated sample was 61. For specificity, taking value 86.9%,[11] prevalence 40%, margin of error 15% and confidence interval 95%, calculated sample was 98. Therefore, minimum 98 patients were included in study. Patients aged 15 to 60 years of either gender, clinically suspected cases of fungal sinusitis referred for CT scan, and those who were willing to give written informed consent were included. Patients were considered having fungal sinusitis if they presented with at least 3 symptoms including nasal blockage, lightheadedness, dull ache over sinuses, myalgias and fever. Patients with previous sinus surgery causing distorted anatomy, CT artefacts, acute sinusitis, other causes of nasal obstruction, facial trauma or facial prosthesis were excluded.

Written informed consent was taken from all patients before enrolment after explaining purpose and procedure of study. Demographic variables including age, gender, duration of symptoms and residential status were recorded. Detailed history regarding presenting complaints and duration of symptoms was taken. Clinical examination was performed to assess signs related to sinus involvement. All selected patients underwent contrast enhanced CT scan using Toshiba 160-slice multi detector scanner with slice thickness of 3–5 mm. Images were obtained in soft tissue window before and after contrast administration using 50 ml ultravist at flow rate 2.5 (1 mg/kg). Scans were interpreted by senior radiologist having more than 5 years experience to assess findings of fungal sinusitis and bony erosions.

Histopathology analysis was performed on all patients. Samples of the tissue were obtained and subjected to histopathology tests, which were considered as the gold standard. After undergoing imaging tests and histopathology analysis, results were classified as such. Fungal sinusitis was diagnosed on CT imaging as having near-complete opacification of sinuses with hyperdensity in the center, hypodensity of mucosa, and other criteria such as mucosal thickening, calcification, polyps, osseous destruction, or soft tissue involvement. Histopathology identified fungal sinusitis through the presence of allergic mucin, eosinophils, cellular debris, Charcot-Leyden crystals, and fungal hyphae.

All collected data was entered and analysed using SPSS version 26. Quantitative variables like age and duration of symptoms were analyzed by mean and standard deviation. Frequencies and percentages were calculated for categorical variables including gender, residential status and CT findings. A 2×2 contingency table was used to determine sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy by taking histopathology as gold standard. Effect modifiers such as age, gender, duration of symptoms was controlled by stratification and post stratification values of sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated.

Results:

The study enrolled a total of 98 immunocompromised patients, with a mean age of 36.03 ± 13.65 years and a mean duration of symptoms of 11.89 ± 7.63 days. The gender distribution was exactly equal, with 49 males (50.0%) and 49 females (50.0%). Similarly, residential status was evenly distributed, with 52 urban (53.1%) and 46 rural (46.9%) patients. Amongst the reported symptoms, nasal blockage was the most prevalent, being observed in 88 patients (89.8%), followed by dull ache in 69 patients (70.4%), fever in 63 patients (64.3%), myalgias in 44 patients (44.9%), and lightheadedness in 33 patients (33.7%) (Table-I).

Table I

Patient Demographics

Demographics	Mean ± SD / n (%)
Age (years)	36.03 ± 13.65
Duration of Symptoms (days)	11.89 ± 7.63
Gender	
Male n (%)	49 (50.0%)
Female n (%)	49 (50.0%)
Residential Status	
Urban n (%)	52 (53.1%)
Rural n (%)	46 (46.9%)
Symptoms	
Nasal Blockage n (%)	88 (89.8%)
Lightheadedness n (%)	33 (33.7%)
Dull Ache n (%)	69 (70.4%)
Myalgias n (%)	44 (44.9%)
Fever n (%)	63 (64.3%)

With regards to the overall diagnostic findings, CECT scan identified bony erosions as positive in 55 patients (56.1%) and negative in 43 patients (43.9%). When histopathology, the gold standard, were used, bony erosions were confirmed as positive in 52 patients (53.1%) and negative in 46 patients (46.9%) (Table-II).

Table II

Overall Results of CECT Scan and Histopathology in Diagnosis of Bony Erosions of Fungal Sinusitis

Bony Erosions	CECT Scan	Histopathology
Positive	55 (56.1%)	52 (53.1%)
Negative	43 (43.9%)	46 (46.9%)
Total	98 (100%)	98 (100%)

Upon comparison of CECT scan with histopathology, there were 49 true positive and 40 true negative cases. Six cases were recorded as false positives and 3 cases as false negatives (Table-III).

Table III

Comparison of CECT Scan versus Histopathology in Diagnosis of Bony Erosions of Fungal Sinusitis

CECT Scan	Histopathology		Total
	Positive	Negative	
Positive	49 (TP)	6 (FP)	55
Negative	3 (FN)	40 (TN)	43
Total	52	46	98

Key: TP = True positive, FP = False positive, FN = False negative, TN = True negative

In terms of the overall diagnostic performance of CECT scan, the sensitivity was found to be 94.23%, the specificity 86.96%, and the overall diagnostic accuracy 90.82%. The positive predictive value (PPV) was 89.09% and the negative predictive value (NPV) was 93.02% (Table-IV).

Table IV

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CECT Scan in Diagnosis of Bony Erosions of Fungal Sinusitis

Diagnostic Parameter	Result
Sensitivity	94.23%
Specificity	86.96%
Diagnostic Accuracy	90.82%
PPV	89.09%
NPV	93.02%

On stratified analysis by age, patients aged ≤40 years showed a higher sensitivity (97.22%), specificity (92.00%), diagnostic accuracy (95.08%), PPV (94.59%), and NPV (95.83%) as compared to those aged >40 years, where sensitivity was 87.50%, specificity 80.95%, diagnostic accuracy 83.78%, PPV 77.78%, and NPV 89.47%. When stratified by gender, female patients demonstrated relatively higher diagnostic performance with sensitivity 96.15%, specificity 91.30%, diagnostic accuracy 93.88%, PPV 92.59%, and NPV 95.45%, whilst male patients showed sensitivity 92.31%, specificity 82.61%, diagnostic accuracy 87.76%, PPV 85.71%, and NPV 90.48%. With respect to duration of symptoms, patients with symptoms lasting more than 14 days had higher sensitivity (97.73%), diagnostic accuracy (90.32%), PPV (89.58%), and NPV (92.86%), although the specificity were comparatively lower at 72.22%. In contrast, those with symptom duration of ≤14 days showed a notably high specificity of 96.43%, with sensitivity of 75.00%, diagnostic accuracy 91.67%, PPV 85.71%, and NPV 93.10% (Table-V).

Table V

Stratified Analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CECT Scan in Diagnosis of Bony Erosions of Fungal Sinusitis with Age, Gender and Duration of Symptoms

Variables	Groups	Diagnostic Parameter	Result
Age (years)	≤40	Sen	97.22%
		Spec	92.00%
		DA	95.08%
		PPV	94.59%
		NPV	95.83%
	>40	Sen	87.50%
		Spec	80.95%
		DA	83.78%
		PPV	77.78%
		NPV	89.47%
Gender	Male	Sen	92.31%
		Spec	82.61%
		DA	87.76%
		PPV	85.71%
		NPV	90.48%
	Female	Sen	96.15%
		Spec	91.30%
		DA	93.88%
		PPV	92.59%
		NPV	95.45%
Duration of Symptoms (days)	≤14	Sen	75.00%
		Spec	96.43%
		DA	91.67%
		PPV	85.71%
		NPV	93.10%
	>14	Sen	97.73%
		Spec	72.22%
		DA	90.32%
		PPV	89.58%
		NPV	92.86%

DISCUSSION

The mean age of patients were 36.03 ± 13.65 years, which suggest that fungal sinusitis with bony erosions tends to affect relatively younger immunocompromised individuals. This may be because younger patients with conditions like uncontrolled diabetes or hematological malignancies are more prone to develop invasive fungal infections due to impaired cell-mediated immunity. However, there was no bias with regard to gender and place of residence among the participants since there were 49 male patients (50.0%) and 49 female participants (50.0%), and urban resided were 52 (53.1%) and rural resided 46 (46.9%) were included. This observation implies that the disease shows an even prevalence rate in both genders regardless of their location, and the disorder impacts the same populations equally under immunosuppressed circumstances. The sensitivity and specificity values obtained from CECT scan analysis were 94.23% and 86.96%, respectively, along with a diagnostic accuracy of 90.82%. Such observations show that CECT is a fairly effective method for assessing bony erosions, where the destruction of bones caused by fungi results in significant alterations in bone density and structure, which are well illustrated on the scans. The PPV was found to be 89.09%, while the NPV was 93.02%, meaning that a negative result obtained through the use of CECT scan could effectively rule out bone destruction.

The overall sensitivity of CECT scan in the present study were 94.23%, which is quite comparable to findings reported by Iqbal J *et al.* [13] who found sensitivity of 96.19% and by Gul R *et al.* [14] who reported sensitivity of 93.6% in similar populations. Lutfi IA *et al.* [15] also reported sensitivity of 93.6%, which closely aligns with present findings. These comparable results suggests that CECT scan consistently performs well in identifying bony erosions, likely because contrast enhancement improves visualisation of inflamed mucosal tissue and areas of cortical bone destruction caused by fungal invasion.

The specificity in present study were 86.96%, which is somewhat similar to Gul R *et al.* [14] who reported specificity of 88.0%, and to Iqbal J *et al.* [13] who found specificity of 93.33%. The slightly lower specificity observed in present study may be because immunocompromised patients often have pre-existing inflammatory changes in sinonasal

mucosa that can mimics bony erosion on imaging, thus producing more false positive results.

The diagnostic accuracy of CECT scan were 90.82% in present study, with 49 true positives and 40 true negatives identified. This is in agreement with Gul R *et al.* [14] who reported accuracy of 91.0%, and with Lutfi IA *et al.* [15] who found overall accuracy of 89.2%. Iqbal J *et al.* [13] reported even higher accuracy of 95.83%, which may be due to differences in patient selection criteria and the proportion of immunocompromised individuals included in their cohort.

The PPV in present study were 89.09% and NPV were 93.02%, which are broadly comparable to Gul R *et al.* [14] who reported PPV 89.8% and NPV 92.4%, and to Imran M *et al.* [16] who found PPV 90.63% and NPV 94.19% using MRI. The high NPV in present study is particularly relevant clinically, as it suggests that a negative CECT result is quite reliable in excluding significant bony erosions in immunocompromised patients. Maqsood S *et al.* [17] similarly reported high sensitivity of 95% for CECT in post-COVID patients with rhinosinomucormycosis and noted bone erosion in 72.2% of their cases, which further supports the utility of CECT in detecting bony involvement in fungal sinusitis.

Mukherji SK *et al.* [18] reported bone erosion in 41 out of 45 patients with allergic fungal sinusitis on CT, and Anand AM *et al.* [12] also confirmed bone erosion as a consistent CT feature in fungal sinusitis cases, which supports the present findings that CECT is capable of detecting bony changes with reasonable accuracy. However, Banthia S *et al.* [19] noted relatively lower sensitivity of CT for fungal sinusitis specifically compared to other sinonasal conditions, which highlights that certain subtypes of fungal sinusitis may not always produce radiologically conspicuous changes at early stages, a limitation that may also applies to the present study population to some extent.

Shamsuddoha S *et al.* [20] observed that acute invasive fungal sinusitis were predominantly seen in immunocompromised patients (76.7%), which is consistent with the present study population that exclusively included immunocompromised individuals, further validating the relevance of study design to real-world clinical scenarios where CECT is most frequently employed as first-line imaging in this high-risk group.

Several constraints exist in the current study that should be pointed out. To begin with, it is worth noting that the research was carried out in one center in one hospital, thus restricting its applicability to larger populations. For instance, the number of patients used in the research was 98, which is rather small to conduct a reliable analysis through stratification, especially in subgroup studies. Besides, selection bias might occur because only immunosuppressed individuals were used in the study.

CONCLUSION

Conclusion from the current study is that CECT can be considered a trustworthy and accurate diagnostic technique for the detection of bony erosions in cases of fungal sinusitis in patients who are immunocompromised. Sensitivity, specificity, and diagnostic accuracy of CECT were satisfactory when histopathology was considered the gold standard.

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