RESEARCH ARTICLE

Diagnostic accuracy of double density sign on CT scan of para-nasal sinuses for fungal sinusitis taking microbiology culture as gold standard

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Abstract

Objective: To compare double-density sign on non-contrast computed tomography scan of paranasal sinuses with fungal sinusitis on histopathology.

Method: This prospective study was conducted at the Shifa International Hospital, Islamabad, Pakistan, from July 1, 2021, to June 30, 2023, and comprised patients of either gender aged 20-60 years who were set to undergo functional endoscopic sinus surgery. Demographic characteristics and non-contrast computed tomography scan findings were recorded pre-operatively, while microbiological and histopathology results were recorded post-operatively. The microbiological finding was taken as the gold standard. Data was analysed using SPSS 23.

Results: Of the 201 patients, 123(61.2%) were males and 78(38.8%) were females. The overall mean age was 41.62±8.52 years. The diagnostic accuracy of a double-density sign on computed tomography scan showed sensitivity 90%, specificity 90.8%, positive predictive value 84%, and negative predictive value 94.4%.

Conclusion: A higher rate of sensitivity and specificity indicated that non-contrast computed tomography scan was an effective modality that could be used for the diagnosis of fungal sinusitis.

Keywords: Diagnostic accuracy, Fungal sinusitis, Double density. (JPMA 74: 1261; 2024)

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Introduction

Fungal sinusitis is a serious condition that affects a growing number of individuals worldwide.[1] Patients presenting with such infection usually complain of thick mucus nasal discharge, headache, loss of sense of smell which may or may not be accompanied by visual or facial deformities depending on the invasion of the surrounding structures by the pathogen.[2]

The pathogenesis of the condition is not very well understood, but a number of factors are proposed to cause the infection. One hypothesis is the exposure of fungal spores in people with history of allergies leading allergic reaction mediated by immunoglobulin E (IgE). This leads to infection and inflammation of the surrounding structures with invasion of the bony elements and soft tissues in the vicinity.[3]

Detailed history, examination and radiographic evaluation are essential for the early diagnosis of the patients, but the definitive diagnosis is achieved by histopathological analysis of the excised sample following a surgical procedure. Functional endoscopic sinus surgery (FESS) is usually performed in such patients for sampling for histopathological examination to confirm the diagnosis and clearance of sinuses to decrease the fungal load. Role of radiography has been equivocal in the early diagnosis of the infection. Computed tomography (CT) scan of the paranasal sinus is routinely employed in patients with the symptoms of fungal sinusitis. It helps to identify and localise the site of fungus usually visualised as an opacification or a double-density sign on CT scan.[4,5]

Treatment protocol of the patients presenting with fungal sinusitis involves medical and surgical treatment. Pharmacological agents that have shown benefit include topical steroids, antifungals and anti-allergic medications. However, newer immune-modulator agents, like omalizumab, are also found to be effective against IgE in allergic fungal sinusitis. The mainstay of treatment is still the surgical excision of the fungal load from the sinuses, which effectively reduces the pathogenic load, and the stimulation of IgE resulting in resolution of the symptoms.[6]

Allergic fungal sinusitis is a treatable and reversible condition which requires prompt diagnosis and treatment. Several complications ranging from ocular to localised bony invasions can result if the treatment is delayed. A number of ocular complications, like diplopia, headache, loss of vision and loss of smell, can arise if the presentation or the diagnosis of the condition is delayed.[7] The coronavirus disease-2019 (COVID-19) pandemic led to an

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increase in the number of patients who were immunocompromised and prone to developing fungal sinusitis.[8]

The complications of allergic fungal sinusitis can be reduced and reversed by prompt diagnosis and commencement of treatment.[9] CT scan is an effective radiological investigation which can be performed earlier for diagnosis of the condition. CT scan shows opacification of the sinuses if there is sinusitis, and also shows the extent of the disease. CT scan identifies the site involved in sinusitis. The current study was planned to evaluate the diagnostic accuracy of the double-density sign on CT scan of paranasal sinuses for early diagnosis of fungal sinusitis.

Patients and Methods

This prospective study was conducted at the Ear-Nose-Throat (ENT) Department of the Shifa International Hospital, Islamabad, Pakistan, from July 1, 2021, to June 30, 2023, and comprised patients of either gender aged 20-60 years who were set to undergo FESS. On the basis of results from previous studies with sensitivity of 89.3%,[10] specificity of 86.9%,[10] fungal sinusitis prevalence 26.7%,[11] 9% desired precision and confidence interval of 95%[12] a sample size of n=179 was calculated. Calculation was done using online sample size calculator available at www.statulator.com/samplesize/ss1P.html.[12]

Sampling Technique is non-randomized convenience sampling for recruiting 201 patients in the study.

After approval from the institutional ethics review committee, the sample was raised using detailed inclusion and exclusion criteria (Table 1).

After taking written informed consent, all patients presenting to the ENT outpatient department (OPD) with symptoms of sinusitis had their preoperative CT scans performed. Each scan was reported by the radiologist, and reviewed by the surgeon preoperatively, and marked as positive or negative for double-density sign.

FESS for clearance of the sinuses was performed under general anaesthesia (GA). The specimen was sent for fungal potassium hydroxide (KOH), fungal culture and histopathological analysis. Fungal culture reports were recorded and considered confirmatory for making the final diagnosis of fungal sinusitis. The microbiological finding was taken as the gold standard.

Table-1: Inculsion and exclusion criteria used in the study.

Inclusion Criteria	Inclusion Criteria
● Patients from both genders (male and female) were included in the study. ● All patients planned for Functional Endoscopic Sinus Surgery for acute and chronic sinusitis were included	● Patients not willing to participate in study were excluded. ● Post-surgical patients ● Patients with known history of neoplastic disease ● Patients with nasal obstruction planned for endoscopic septal spur removal were excluded. ● Already diagnosed with fungal sinusitis before surgery were excluded ● Patients with incomplete data were excluded.

Data was analysed using SPSS 23. Data was expressed as frequencies and percentages or as mean ± standard deviation, as appropriate. Diagnostic accuracy was calculated using sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Stratification on the basis of age and gender was performed, and post-stratification chi-square test was used, with $p \leq 0.05$ taken as significant.

Results

Of the 201 patients, 123(61.2%) were males and 78(38.8%) were females. The overall mean age was 41.62±8.52 years.

The diagnostic accuracy of a double-density sign on CT scan showed sensitivity 90%, specificity 90.8%, PPV 84% and NPV 94.4% (Table 2).

Microbiological identification of the specimens revealed that the most common fungal pathogen causing allergic fungal sinusitis was mucormycosis, followed by aspergillosis (Table 3).

Table-2: Diagnostic accuracy of double-density sign on computed tomography (CT) scan (n=201).

CT scan findings	Microbiological findings (Positive)	Microbiological findings (Negative)	*p*-value
Double-density sign, Positive	63 (TP)	12 (FP)	<0.01
Double-density sign, Negative	07 (FN)	119 (TN)	

Sensitivity: 90%; Specificity: 90.8%; Positive predictive value (PPV): 84%, Negative predictive value (NPV): 94.4%; Diagnostic accuracy: 90.54%; TP: True positive; FP: False positive; FN: False negative; TN: True negative.

Table-3: Frequency of pathogens causing allergic fungal sinusitis.

Fungal pathogens	n (%)
Mucor	31 (15.4)
Aspergillus	27 (13.4)
Mucor and aspergillus	11 (5.5)
Candida	01 (0.5)

Discussion

Fungal sinusitis is divided into invasive or non-invasive types. Both invasive and non-invasive forms of the disease are serious conditions associated with significant morbidity. Invasive fungal sinusitis is associated with high mortality if left untreated.[13] Invasive fungal sinusitis is a severe condition progressing rapidly in less than a month, with a mortality rate of up to 50-80%.[14] Invasive fungal sinusitis is found most commonly in patients with an

Table-4: Comparison of current findings with earlier studies done in Pakistan.

	Sample Size	Duration of study (months)	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive Value %	Diagnostic accuracy %
Khalid et al -2022[12]	72	7	100	15.8	23.8	100	57.9
Naz et al-2016[13]	98	12	89	86	95	71	88.7
Iqbal et al-2014[14]	120	6	96	93	99	77	95.8
Current study	201	24	90	90.8	84	94	90.5

immunocompromised status, particularly those with haematological malignancies, meaning decreased neutrophil count. Early diagnosis and prompt treatment is very important because the fungus can spread rapidly into vital structures. The involvement of orbit and cranial cavity is associated with high morbidity and mortality rates.[10]

Although CT scan is a commonly used modality in the diagnosis of sinusitis, its role in the identification of paranasal fungal infection and the extent of invasion by the pathogen is still debatable. The current study was aimed at evaluating the diagnostic accuracy of CT scan in the diagnosis of fungal sinusitis during the preoperative period in order to help early diagnosis and prompt treatment which can decrease the mortality rate.

Similar studies have been conducted earlier in Pakistan.[11,15,16] The gold standard for diagnosis of fungal sinusitis in some studies is histopathology, while some have used microbiological cultures as the gold standard for diagnosis (Table 4). In the current study, the gold standard for diagnosis was the microbiological culture.

The current study revealed that when a plain, non-contrast CT scan of paranasal sinuses was used as a diagnostic tool, sensitivity of the test was 90%, specificity was 90.8%, PPV was 75%, NPV was 86% and diagnostic accuracy was 90.54%.

The current study had a decent sample size with a reasonably long duration, and indicated a good diagnostic accuracy of CT scan. As mentioned in literature, sensitivity, specificty, PPV and NPV metrics should be regarded as important when describing and assessing a diagnostic test's adequacy and usefulness.[17]

A similar study showed allergic fungal sinusitis in younger to middle age groups, with a mean age of 37.3±15.3 years[18] which was comparable to the current study's mean age of 41.62±8.52 years.

A study reported that paranasal sinus infection was seen more in the male gender.[19] Out of 201 patients in the current study, 123 (61.2%) were males and 78(38.8%) were females.

CT scan is helpful as it provides a guide for the surgeon. The severity and extent of the disease can be assessed using a CT scan. There are various theories regarding the formation of double-density sign. A study reported that this was due to thick fungal mucin which may contain heavy metal deposits. These metal deposits are surrounded by hyperplastic mucosa, thus leading to the formation of two different densities that appear on CT scan as a double-density sign.[19] Also, the hyperattenuating signal on CT scans of a patient with allergic fungal sinusitis may be caused by the presence of inspissated allergic mucin with the fungal hyphae within it.[20] Both of these with different densities may appear as a double-density image on CT scan.

A study conducted over 10 years on patients presenting with allergic fungal sinusitis revealed that the most common pathogen detected in the specimens was aspergillus niger.[21] In the current study, the most common pathogen detected was mucormycosis (15.4%) compared to aspergillus (13.4%) cases (Table 2). This was probably because the study duration coincided with the COVID-19 pandemic during which a rise in the number of patients with mucormycosis was noted worldwide.[22-24] The risk factors for mucormycosis infection in patients with COVID-19 are diabetes mellitus, use of steroids, obesity, and development of cytokine storms. The triad of steroids, COVID-19 infection and diabetes mellitus caused increased morbidity by causing angioinvasive mucormycosis.[25]

The current study had limitations as it was conducted at a single centre. However, due to adequate sample size, the findings can prove to be beneficial in the early detection of fungal sinusitis.

Conclusion

A high rate of sensitivity and specificity indicated that a plain, non-contrast CT scan of paranasal sinuses scan was an effective modality which could be used for the diagnosis of fungal sinusitis. It could help in early diagnosis and commencement of prompt treatment, leading to better prognosis.

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Author Contribution:

HW: Data collection, writing, SPSS calculation, analysis and interpretation of results.
SSA: Design and concept, analysis and interpretation of results, final approval.
MU: Data collection, writing, editing and interpretation of results.
AFD: Writing and editing of results and SPSS calculations.