Original Article

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Radiology Section

Diagnostic Accuracy of Computed Tomography by Fungal Sinusitis: A Case-control Study

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ABSTRACT

Introduction: Recent decades show a considerable increase in fungal infections, hence can lead to fungal sinusitis. Immunosuppression, postorgan transplant, diabetes mellitus, and Human Immunodeficiency Virus (HIV) infection have led to a rise in the incidence of fungal infections. Recent advances in nasal endoscopy, Computed Tomography (CT), and Histopathological Examination (HPE) techniques have led to better detection of fungal aetiology.

Aim: To determine the most significant CT findings in fungal sinusitis or combination of findings in comparison to HPE.

Materials and Methods: This retrospective, case-control study was done at Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India, from January 2017 to December 2020. Total 90 patients were studied. Of which, 50 cases of fungal sinusitis confirmed with histopathological confirmation and available non contrast CT Paranasal Sinus (PNS) images where time interval between CT and Functional Endoscopic Sinus Surgery (FESS) not exceeding ten days were included. The control group had 40 patients with chronic sinusitis with HPE negative results. CT PNS was performed on PHILIPS 16 slice scanner without contrast administration. Data was entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) version 22.0 software.

Results: Mean age of the cases (fungal sinusitis) were 46.7±17 years and 39±13.1 years of controls. Of the total 90 subjects, heterogeneous mucosal thickening was seen in 41 (45.6%), intrasinus hyperattenuation in 36 (40%), bone sclerosis in 44 (48.9%), bone erosion in 36 (40%), sinus expansion in 23 (25.6%) subjects. Fungal sinusitis patients had more proportion of these findings when compared to control group and hence p-value was significant (p-value <0.05).

Conclusion: The CT diagnostic features of the fungal sinusitis are heterogeneous mucosal thickening, intrasinus hyperattenuation, bone sclerosis, bone erosion and sinus expansion which were significant. These findings help to differentiate fungal sinusitis from non fungal sinusitis.

Keywords: Bone erosion, Bone sclerosis, Intrasinus hyperattenuation, Paranasal sinuses, Sinus expansion

INTRODUCTION

Recent decades show a considerable increase in fungal infections, and fungal sinusitis is one such manifestation that involves PNS. In India, Allergic Fungal Rhinosinusitis (AFRS) is the most prevalent (56-57%) form of Chronic Rhinosinusitis (CRS), followed by chronic invasive granulomatous fungal rhinosinusitis (2-17%), fungal ball/mycetoma (2-4%), and chronic invasive fungal rhinosinusitis (1-3%). Understanding of the different types of fungal sinusitis and their specific radiologic features allow the radiologist to play an important role in correct and timely diagnosis. To avoid catastrophic consequences, early identification and treatment are critical [1]. Certain conditions like immunosuppression, postorgan transplant, diabetes mellitus, and HIV infection have led to a rise in the incidence of fungal infections [2]. The incidence of fungal sinusitis is about 10% of chronic sinusitis. It has no gender predilection. Recent advances in nasal endoscopy, CT, and HPE techniques have led to easy detection of fungal aetiology [3].

Fungal sinusitis is classified into two types- invasive and non invasive. Non invasive types include sinus fungal ball (mycetoma) and allergic fungal rhinosinusitis. Severe forms of these types have a higher mortality rate. Imaging modalities including CT and Magnetic Resonance Imaging (MRI), aids in early diagnosis. Imaging diagnosis of fungal sinusitis would guide pathologists for specific processing and staining needed for histopathological confirmation [4].

Plain radiography of PNS is a common and widely available investigation though it has limitations such as inadequate coverage of anterior ethmoid air cells and adjacent nasal cavities. CT is a standard imaging tool in preoperative evaluation before Functional Endoscopic Sinus Surgery (FESS). It provides a road map for the surgical approach. Apart from information about distribution and extent, anatomic variants can also be identified, reducing risks and complications related to the FESS procedure [5].

CT findings in fungal sinusitis include sinus hyperattenuating foci, sinus expansion, bony erosion, bony sclerosis, airfluid level and extrasinus extension [2,6]. Presence of foci of intrasinus hyperattenuation or metallic density within the sinus suggests chronic fungal sinusitis. These foci appear as hyperattenuation within the sinus [7]. MRI is the best imaging modality to evaluate extra sinus involvement such as peri-antral fat stranding, intraorbital invasion and intracranial invasion such as involvement of the cavernous sinus, and the brain parenchyma [8].

CT is the best imaging modality for fine details of bone structures of the orbit, lamina papyraceae and cribriform plate. In comparison to CT, MRI is less sensitive in evaluation of bone details as bone appears hypointense. So, CT is preferred in preoperative assessment for Functional Endoscopic Sinus Surgery (FESS) [9].

The purpose of the study was to determine the most significant CT finding or combination of findings in histopathological confirmed cases. Further, the inclusion of such findings in the diagnostic criteria will enhance the accuracy of the CT based diagnosis of fungal sinusitis.

MATERIALS AND METHODS

This retrospective, case-control study was done at Department of Radiology, Sri Manakula Vinayagar Medical College and Hospital, Puducherry (SMVMCH), India from January 2017 to December

2020. Before initiation of the study, Institutional Ethics Committee approval was taken.

Inclusion criteria:

Cases: Subjects of fungal sinusitis confirmed with histopathological confirmation and available non contrast CT Paranasal Sinus (PNS) images where time interval between CT and Functional Endoscopic Sinus Surgery (FESS) not exceeding ten days were included. Total 40 patients were selected consecutively in this group.

Controls: The control group (non fungal sinusitis) was of chronic sinusitis patients who met the same inclusion criteria except for negative results for fungal sinusitis on HPE.

Exclusion criteria:

Cases: Subjects who had distorted sinus anatomy on previous surgery or artefacts on CT images were excluded.

Controls: The exclusion criteria remained the same for both groups and 50 such patients were enrolled.

Procedure

Two radiologists with more than 5 years experience in CT PNS, who interpreted the CT images were blinded to the HPE results. No significant interobserver variability was seen. CT findings in these 2 groups were compared. The significance of each finding and the combination of these findings were determined. CTPNS was performed on PHILIPS 16 slice scanner without contrast administration. According to the protocol, images were acquired as 1 mm thick sections with sparing of 0.8 mm and an in-plane Field of Vision (FOV) from 170 to190 mm. Reconstructions using a bone algorithm were performed at a section thickness of 0.75 mm with 0.5 mm spacing. The scan was obtained in the axial plane from above the frontal sinuses through the hard palate. Multiplanar reformats were done in coronal and sagittal planes.

STATISTICAL ANALYSIS

Data was entered into Microsoft Excel and analysed using SPSS version 22.0 software. Data was represented in the form of percentage. For continuous variables, mean and standard deviation were used and for categorical variables, Chi-square test was used. The level of significance adopted was 0.05. Further sensitivity, specificity, Positive Predictive Validity (PPV), Negative Predictive Validity (NPV) and accuracy of each CT finding was calculated.

RESULTS

The total number of patients fulfilling the inclusion criteria was 90 of which 38 (42.2%) were males and 52 (57.8%) were females. Among them, 50 (55.6%) were diagnosed as fungal sinusitis with mean age 46.7±17 years by histopathological correlation and the rest 40 (44.4%) had chronic non fungal sinusitis with mean age 39±13.1 years [Table/Fig-1]. Maximum patients in the fungal sinusitis group were between 41-60 years age group of which 38 (42.2%) were males and 52 (57.8%) were females. Among males, 21 patients (42%) had fungal sinusitis and 17 (42.5%) had non fungal sinusitis. Among females, 29 (58%) were fungal sinusitis patients and 23 (57.5%) were not fungal [Table/Fig-2].

Age group (in years)	Cases	Control	Total
≤30	10 (20%)	14 (35%)	24 (26.7%)
31-40	9 (18%)	13 (32.5%)	22 (24.4%)
41-50	11 (22%)	3 (7.5%)	14 (15.6%)
51-60	12 (24%)	6 (15%)	18 (20%)
61-70	2 (4%)	4 (10%)	6 (6.7%)
>70	6 (12%)	0	6 (6.7%)
Total	50 (100%)	40 (100%)	90 (100%)

[Table/Fig-1]: Comparison of age group with cases and controls (N=90).

Gender	Cases	Controls	Total	Chi-square value	p-value
Male	21 (42%)	17 (42.5%)	38 (42.2%)	0.002	0.962
Female	29 (58%)	23 (57.5%)	52 (57.8%)		

[Table/Fig-2]: Comparison of gender with cases and controls (N=90).

In this study involving 90 patients, heterogeneous mucosal thickening was seen in 41 (45.6%), intrasinus hyperattenuation in 36 (40%), bone sclerosis in 44 (48.9%), bone erosion in 36 (40%), sinus expansion in 23 (25.6%) subjects [Table/Fig-3]. Orbital extension and intracranial extension were not found in our study. Out of heterogeneous mucosal thickening in 41 patients, 35 (70%) had fungal sinusitis and 6 (15%) had chronic non fungal sinusitis.

Parameters	Cases	Controls	Total	Chi-square value	p-value
CT findings					
Mucosal thickening	35 (70%)	6 (15%)	41 (45.6%)	27.103	<0.001
Intrasinus hyperattenuation	32 (64%)	4 (10%)	36 (40%)	27.00	<0.001
CT-Bone changes					
Bone sclerosis	31 (62%)	13 (32.5%)	44 (48.9%)	7.739	0.005
Bone erosion	33 (66%)	3 (7.5%)	36 (40%)	31.688	<0.001
Sinus expansion	21 (42%)	2 (50%)	23 (25.6%)	15.991	<0.001

[Table/Fig-3]: Comparison of CT findings with cases and controls (N=90).
A p-value <0.05 was considered as statistically significant

Thus, heterogeneous mucosal thickening as a predictor for fungal sinusitis had sensitivity of 70%, specificity of 85% with a PPV of 85.37%, and NPV of 69.39%. A p-value was statistically significant (p-value <0.001).

Intrasinus hyperattenuation was seen in 36 patients, 32 (64%) had fungal sinusitis while 4 (10%) had chronic non fungal sinusitis. Intrasinus hyperattenuation had sensitivity of 64% and specificity of 90% with PPV of 88.89% and NPV of 66.67% in predicting fungal sinusitis (p-value <0.001).

Of 44 patients with bone sclerosis, 31 (62%) were positive for fungal aetiology and 13 (32.5%) had chronic non fungal sinusitis. Thus, bone sclerosis had sensitivity of 62% and specificity of 67.5% with PPV of 70.45% and NPV of 58.7% (p-value=0.005).

In 36 patients with bone erosion, 33 (66%) were with fungal sinusitis and 3 (7.5%) with chronic non fungal sinusitis. Bone erosion has a sensitivity of 66% and specificity of 92.5% with PPV of 91.6% and NPV of 68.5% (p-value <0.001).

Among 23 patients with sinus expansion, 21 (42%) were fungal sinusitis patients. This finding as a predictor of fungal sinusitis had sensitivity of 42% and specificity of 95% with PPV of 91.3% and NPV of 56.7% (p-value <0.001) [Table/Fig-4].

Parameters	Sensitivity	Specificity	PPV	NPV	Accuracy
CT findings					
Mucosal thickening	70%	85%	85.37%	69.39%	76.67%
Intrasinus hyperattenuation	64%	90%	88.89%	66.67%	75.56%
CT- Bone changes					
Bone sclerosis	62%	67.50%	70.45%	58.70%	64.44%
Bone erosion	66%	92.50%	91.60%	68.52%	77.78%
Sinus expansion	42%	95%	91.30%	56.72%	65.56%

[Table/Fig-4]: Predictive validity of CT features for fungal sinusitis as compared to HPE.

DISCUSSION

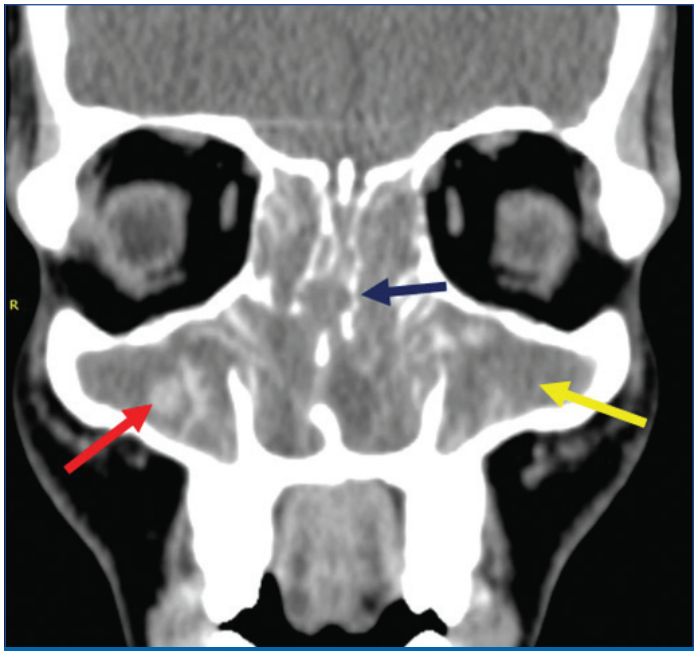
This study is done to enhance the accuracy of CT in fungal sinusitis, by identifying the significance of common CT findings. The present study evaluates accuracy of five CT findings- heterogeneous

mucosal thickening, intrasinus hyperattenuation, bone sclerosis, bone erosion and sinus expansion.

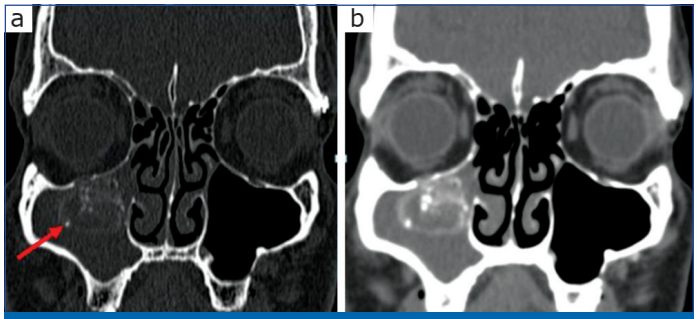
Naz N et al., assessed the accuracy of CT in diagnosis of fungal sinusitis. Authors concluded that CT has a high sensitivity and acceptable specificity. Accuracy was not determined for individual parameter and was assessed by comparing the CT diagnosis with HPE results [9]. Iqbal J et al., assessed accuracy of CT in diagnosing fungal sinusitis in reference to culture examination. According to this study, CT has high accuracy in diagnosis of fungal rhinosinusitis. This study does not evaluate accuracy of individual parameters [10].

In Gupta K and Saggar K study, heterogeneous mucosal thickening is the most common finding seen in fungal sinusitis (p-value <0.001). Heterogeneous mucosal thickening is the near complete opacification with foci of hyperattenuation on noncontrast CT. Heterogeneous appearance is the result of soft tissue density, mixed with hyperattenuating foci within the affected sinus [11]. Among various CT findings, heterogeneous mucosal thickening had an accuracy of 76.67%. In terms of accuracy, it was next to erosion. This finding was seen in 15% of non fungal sinusitis also. In the study done by Kanwar SS et al., the presence of inspissated secretions within the sinuses mimic hyperdense contents in fungal sinusitis [5]. Non contrast CT show heterogenous appearance of the involved sinus, called double density sign. Opacified sinus shows central hyperattenuation with peripheral hypoattenuation. This is best seen in soft tissue window. It is also called as starry sky pattern or serpiginous pattern [10,12].

In present study, intrasinus hyperattenuation had an accuracy of 75.56%. It was the most common finding next to heterogeneous mucosal thickening and erosion (p-value <0.001). Intrasinus hyperattenuation was seen in 10% of those do not have fungal sinusitis. In these conditions, it was predominantly peripheral than central. Patients with fungal sinusitis had centrally located foci within the sinus [Table/Fig-5,6]. These foci are more centrally placed in the fungal sinusitis while it is peripherally located in non fungal sinusitis. It is an uncommon finding in latter. Central distribution of hyperattenuating foci was seen in fungal sinusitis in our study which is consistent with the study done by Yoon JH et al., to investigate intrasinus hyperattenuation pattern in fungal sinusitis and its differentiation from non fungal sinusitis [13].



[Table/Fig-5]: AFRS- Non contrast CT paranasal sinus in coronal section at the level of maxillary ostium shows significant mucosal thickening (yellow arrow) in bilateral maxillary, ethmoid sinuses, and nasal spaces with central areas of hyperdensities(red arrow). Extensive bone erosions are seen in ethmoid air cells (blue arrow). No intraorbital/ intracranial extension.



[Table/Fig-6]: Fungal ball- Non contrast CT coronal section a) bone window and b) soft tissue window images- Right maxillary sinus shows complete opacification due to heterogenous mucosal thickening and central serpiginous hyperattenuating areas(red arrow). Sclerosis and bone remodeling in lateral wall seen.

Bone changes in the study include sclerosis, erosion and bony expansion. Sclerosis of sinus wall was seen in 62% of fungal sinusitis and 32.5% of non fungal sinusitis. This parameter has an accuracy of 64.44% (p-value=0.005). It has least accuracy when compared to the other parameters. In a study done by Dall'Igna C et al., fungal sinusitis patients had sclerosis but it had no statistical significance. Sclerosis was present in many patients with non fungal sinusitis also. Pillai S et al., in their evaluated findings in fungal infection including presence of airfluid level, hyperdensities, bone sclerosis, erosion and extension beyond the sinuses. They found sclerosis of the wall as one of the significant parameters. Regarding bone sclerosis, the present study has results similar to studies done by Pillai S et al., [14].

In this study, authors found bone erosion, a significant parameter, with p-value <0.001 and accuracy being 77.78%. In study done by Dall'Igna C et al, fungal sinusitis patients found sinus wall erosion and statistical significance was seen [2]. Pillai S et al., described radiological findings in fungal sinusitis [14]. Bone erosion occurred in 25.9% of fungal sinusitis and had statistical significance with p-value <0.05. Dousary SA found sinus expansion, thinning and erosion associated with fungal infection of sinuses [15]. Chen JC and Ho CY, found erosion of inner wall of the sinus as significant parameter in fungal sinusitis. This finding was seen in 72.9% of fungal sinusitis patients and it is due to pressure necrosis [16]. In this study, authors found sinus expansion, present in 42% as significant parameter, with p-value <0.001 and accuracy being 65.56%.

Chen JC and Ho CY, describes intrasinus hyperattenuation, wall erosion, bony wall sclerosis, heterogenous soft tissue density and absence of air fluid level as significant findings. This study describes erosion as the expansion and thinning of the sinus wall. They concluded that erosion of sinus wall and intrasinus hyperattenuation as significant findings among various findings [16]. Salamah MA et al., describes a high incidence of multiple and bilateral sinus involvement, as well as a significant ratio of bone and tissue damage, including remodelling, wall weakening, and surrounding soft tissue involvement, which worsens with illness duration [17].

In the present study, authors found heterogeneous mucosal thickening, intrasinus hyperattenuation, bone sclerosis, bone erosion and sinus expansion as significant parameters. The present study had no patients with air fluid level within the sinus. Coronavirus Disease- 2019 pandemic has led to increased incidence and awareness of fungal sinusitis. In order to diagnose such conditions early and alleviate the complications, appropriate imaging diagnostic model should be formulated. Further focused studies might be done to evaluate CT characteristics in various fungal species.

Limitation(s)

The present study had relatively smaller sample size. On HPE, it was limited to non invasive forms and had no cases of intracranial or intraorbital extension. Aggressive forms of fungal sinusitis were not present in the study period. This study does not identify the CT criteria based on subtypes of chronic fungal sinusitis.

CONCLUSION(S)

The CT diagnostic criteria of the fungal sinusitis include heterogeneous mucosal thickening, intrasinus hyperattenuation, bone sclerosis, bone erosion and sinus expansion. These findings help to differentiate fungal sinusitis from non fungal sinusitis. Inclusion of these parameters enhances accuracy of the CT based diagnosis. Combination of sinus expansion with bone erosions and intrasinus hyperdensities improve the diagnostic accuracy of fungal sinusitis in computed tomography.

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