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A PROSPECTIVE STUDY TO EVALUATE THE ROLE OF COMPUTED TOMOGRAPHY IN PARANASAL SINUS PATHOLOGIES

Radio-Diagnosis

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ABSTRACT

INTRODUCTION: Paranasal sinus pathologies are a broad spectrum of inflammatory, infective, fungal, polypoidal, benign and malignant diseases that have common clinical features. Clinical assessment alone may not reliably define the extent of disease, anatomical variations, bony involvement or extrasinus extension. Computed tomography allows for high resolution assessment of sinonasal anatomy and pathology and is pivotal to diagnosis, detection of complications and planning management.**OBJECTIVES:** To study the various pathologies affecting the paranasal sinuses on computed tomography and to study the computed tomographic features of diseases of paranasal sinuses. **METHODS:** This cross-sectional study included 100 patients of varied age groups presenting with symptoms and signs of paranasal sinus disease and referred from the Department of ENT, B.R.D. Medical College, Gorakhpur, for CT evaluation. CT PNS was performed on a 64-slice multi-detector CT scanner in axial and coronal planes with sagittal and coronal reformations wherever required. Clinical profile, CT diagnosis, CT features, sinus involvement, laterality, anatomical variants, osteomeatal complex obstruction, predictors of complicated disease, diagnostic accuracy and management advice were analysed using MS Excel and SPSS version 26.0.**RESULTS:** The mean age of participants was 36 ± 14 years with male majority [62 (62.0%)]. The commonest symptoms were headache [62 (62.0%)], nasal obstruction [58 (58.0%)] and nasal discharge [54 (54.0%)]. The most common CT diagnosis was inflammatory sinusitis [50 (50.0%)], sinonasal polyps [20 (20.0%)], and fungal sinusitis [8 (8.0%)]. Mucosal thickening was the commonest CT feature (72 (72.0%)) followed by air-fluid level (25 (25.0%)). Maxillary sinus was most frequently involved [76 (76.0%)], and osteomeatal complex obstruction was present in 58 (58.0%) cases. Independent predictors of complicated disease were fungal sinusitis (adjusted OR 6.5; p=0.002) and diabetes mellitus (adjusted OR 3.0; p=0.03). CT showed a sensitivity of 92.0%, a specificity of 85.0%, a positive predictive value of 88.0%, a negative predictive value of 90.0% and an overall accuracy of 89.0%.**CONCLUSION:** Computed tomography is an essential and reliable modality for evaluating paranasal sinus pathologies. It accurately identifies disease type, sinus involvement, anatomical variants, OMC obstruction, fungal features, bony erosion, extrasinus extension and predictors of complicated disease, and supports clinical decision-making for medical therapy, FESS, biopsy/FNAC, oncology referral and observation.

KEYWORDS

Computed Tomography, Paranasal Sinuses, Ct Pns, Chronic Rhinosinusitis, Osteomeatal Complex, Fungal Sinusitis, Sinonasal Polyps, Maxillary Sinus.

INTRODUCTION

Paranasal sinus diseases represent a clinically important group of disorders involving inflammatory, infective, structural, fungal, polypoidal, benign and malignant conditions. These pathologies often present with nonspecific and overlapping symptoms such as headache, nasal obstruction, nasal discharge, postnasal discharge, anosmia, facial discomfort and epistaxis. Because the paranasal sinuses are anatomically related to the nasal cavity, orbit, skull base, dental structures and craniofacial skeleton, delayed or inaccurate diagnosis may lead to persistent morbidity and complications. Clinical examination alone may not adequately define the extent, origin or anatomical basis of sinonasal disease.[1]

Computed tomography has become the imaging modality of choice for detailed assessment of the paranasal sinuses. Excellent visualisation of bony walls, mucosal lining, sinus aeration, osteomeatal complex, anatomical variants and disease extension. [2,3] CT is particularly useful to detect mucosal thickening, air-fluid levels, hyperdense fungal material, bony erosion, mass lesions and spread outside the sinuses. When clinical features are overlapping, it helps in differentiating inflammatory disease from polypoidal, fungal, benign and malignant lesions.[4,6]

Besides diagnosis, CT plays an important role in preoperative planning. Anatomical variants like deviated nasal septum, concha bullosa, agger nasi cells, Haller cells and Onodi cells can alter sinus drainage pathways and affect the safety and outcome of functional endoscopic sinus surgery . A detailed CT evaluation helps radiologists and surgeons define disease pattern, spot hazardous variants and plan appropriate management.[7,8,9]

Several previous studies have stressed the usefulness of CT in the evaluation of paranasal sinus disease, correlation of CT findings with clinical and histopathological diagnoses, and recognition of anatomical variations relevant to sinonasal pathology.[1,4,11] Institution-based data documenting complete CT spectrum of paranasal sinus pathologies, radiological features, predictors of complicated disease and management implications are clinically useful. Hence, the present study was undertaken to evaluate the role of computed tomography in paranasal sinus pathologies and to assess the computed tomographic features of diseases involving the paranasal sinuses.

MATERIALS & METHODS

Study design: Cross-sectional study.

Place of study: Department of Radiodiagnosis, B.R.D. Medical College, Gorakhpur.

Study population: Patients of varied age groups presenting with symptoms and signs of paranasal sinus diseases such as headache, nasal obstruction, nasal discharge, anosmia, postnasal discharge and epistaxis, referred from the Department of ENT, B.R.D. Medical College, Gorakhpur, were studied.

Sample size: Approximately 100 patients were included in the study.

Study period: One year. Patient enrolment was done over 12 months, and duration of follow-up for each patient was 1 month.

Inclusion criteria: Patients referred for CT of paranasal sinuses who were suspected to have paranasal sinus disease, and patients suspected to have some paranasal sinus pathology on conventional radiographs

and then referred for CT PNS.

Exclusion criteria: Patients with maxillofacial/head trauma, pregnant women, children less than 5 years of age, psychiatric patients and non-cooperative patients were excluded.

CT technique: Detailed clinical history was taken and clinical examination was performed. CT scan was performed on a 64-slice multi-detector CT scanner (GE Healthcare Optima 64-slice). CT scan of paranasal sinuses was done in coronal and axial planes. A lateral 256 mm scout scan was performed at 120 kVp and 100 mA. Axial scanning was done in supine position. Reformatting in coronal and sagittal planes was performed using inbuilt CT software. When required, direct coronal imaging was performed with patients in prone or supine position, with gantry angle perpendicular to the plane of the hard palate. Three-millimetre sections were taken from the anterior margin of the nose to the posterior margin of the sphenoid sinus. CT features such as involved sinuses, lesion size, air-fluid level, mucosal changes, necrosis, calcification, cystic changes, hyperdense areas, contrast enhancement and bony changes were recorded.

Data collection tools: A semi-structured, interviewer-administered questionnaire was used to collect socio-demographic details, pre-existing comorbidities, personal habits and clinical characteristics. Outcomes and complications were recorded in the study proforma.

Data analysis: Data were entered in MS Excel and analysed using SPSS version 26.0. Outcomes were expressed as frequencies and proportions. Normality of continuous variables was tested by the Kolmogorov-Smirnov test. Mean ± SD or median with IQR was calculated for continuous variables. Chi-square test and appropriate tests of significance were applied according to the type and distribution of variables. A p-value of <0.05 was considered statistically significant. Suitable graphs and tables were prepared.

Ethical considerations: Institutional ethics committee approval was obtained before the start of the study. Written informed consent was obtained from all patients before enrolment.

RESULTS

Baseline profile of study participants

The study included 100 patients presenting with clinical features suggestive of paranasal sinus pathology. The mean age was 36 ± 14 years, and the largest proportion belonged to the 30-44 years age group. Males were more common than females, and most patients were from rural areas. Baseline habits, anthropometry, comorbidities, past history, laboratory profile and prior radiological investigations are consolidated in Table 1 to avoid repetitive standalone tables.

Table 1A. Baseline socio-demographic profile of study participants (N = 100)

Variable	Category / Parameter	Value
Age group (years)	<18	8 (8.0)
	18-29	22 (22.0)
	30-44	34 (34.0)
	45-59	24 (24.0)
	≥60	12 (12.0)
Mean age (years)		36 ± 14 years
Sex	Male	62 (62.0)
	Female	38 (38.0)
Education	Illiterate/Primary	26 (26.0)
	Secondary	42 (42.0)
	Graduate+	32 (32.0)
Socioeconomic status (Kuppuswamy)	Upper	5 (5.0)
	Upper middle	15 (15.0)
	Lower middle	30 (30.0)
	Upper lower	35 (35.0)
	Lower	15 (15.0)
Residence	Rural	68 (68.0)
	Urban	32 (32.0)

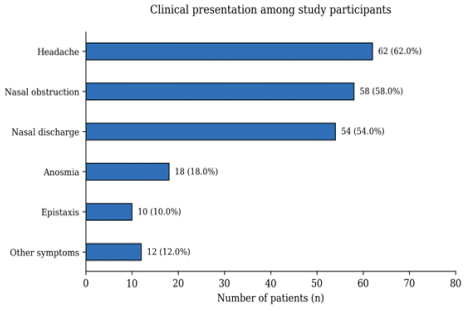
Table 1B. Baseline habits, anthropometry, comorbidity, history and supportive investigation profile (N = 100)

Variable	Category / Parameter	Value
Alcohol consumption	Yes	18 (18.0)
	No	82 (82.0)
Smoking	Yes	14 (14.0)
	No	86 (86.0)
Anthropometry	Height (cm)	165 ± 8
	Weight (kg)	64 ± 11
	BMI (kg/m²)	23.5 ± 3.6
Comorbidity	Diabetes mellitus	16 (16.0)
	Hypertension	10 (10.0)
	Other comorbidities	6 (6.0)
	Mean DM duration	5.2 ± 3 years
Past history	Previous maxillofacial surgery	5 (5.0)
	Past inpatient admission	18 (18.0)
Laboratory investigations	Hemoglobin (g/dL)	12.4 ± 1.6
	WBC count (×10³/μL)	8.1 ± 2.4
	Platelet count (×10⁵/μL)	2.6 ± 0.7
	CRP (mg/L)	6.2 ± 3.1
	ESR (mm/hr)	18 ± 10
Prior radiological investigations	Prior radiograph of PNS	40 (40.0)
	Prior CT of PNS	12 (12.0)
	No prior imaging	48 (48.0)

The baseline profile showed a young-to-middle-aged symptomatic population with male predominance and rural representation. Supportive variables such as personal habits, diabetes, hypertension, prior imaging and laboratory indices were documented to contextualize CT findings and identify clinical factors associated with complicated disease.

Clinical presentation

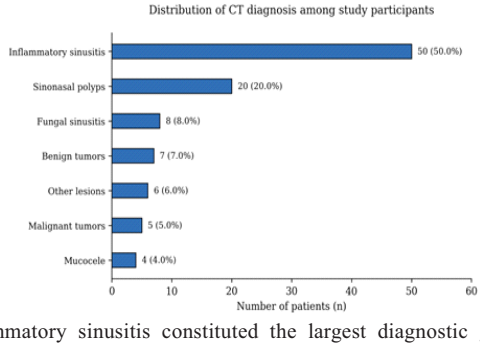
Figure 1. Clinical presentation among patients with paranasal sinus pathologies



Headache, nasal obstruction and nasal discharge were the dominant presenting symptoms, confirming that paranasal sinus pathologies commonly present with nonspecific and overlapping clinical features. Less frequent symptoms such as anosmia and epistaxis were clinically relevant because they may suggest ethmoid/polypoidal disease or aggressive sinonasal lesions.

Spectrum of CT diagnoses

Figure 2. Distribution of CT diagnosis among study participants



Inflammatory sinusitis constituted the largest diagnostic group, followed by sinonasal polyps and fungal sinusitis. Benign tumors, malignant tumors, mucocele and other lesions formed smaller but clinically important categories, demonstrating that CT defined the full disease spectrum rather than only inflammatory pathology.

Major CT imaging features

Table 2. CT diagnosis distribution and major CT imaging features (N = 100)

Domain	Category / CT feature	n (%)
CT diagnosis	Inflammatory sinusitis	50 (50.0)
	Sinonasal polyps	20 (20.0)
	Fungal sinusitis	8 (8.0)
	Benign tumors	7 (7.0)
	Malignant tumors	5 (5.0)
	Mucocele	4 (4.0)
	Other lesions	6 (6.0)
CT feature	Mucosal thickening	72 (72.0)
	Air-fluid level	25 (25.0)
	Hyperdense material	10 (10.0)
	Contrast enhancement	18 (18.0)
	Bony erosion	12 (12.0)
	Extrasinus extension	5 (5.0)

Mucosal thickening was the predominant CT feature, supporting the inflammatory burden in the cohort. Air-fluid level represented active inflammatory or infective disease, whereas hyperdense material, bony erosion, contrast enhancement and extrasinus extension helped characterize fungal, aggressive, neoplastic or complicated disease patterns.

Sinus involvement, laterality and lesion mapping

Figure 3. Pattern of sinus involvement on CT PNS

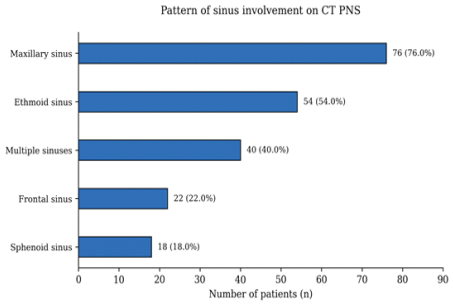


Table 3. Sinus involvement, laterality and lesion location mapping on CT (N = 100)

Domain	Category	n (%)
Sinus involvement	Maxillary	76 (76.0)
	Ethmoid	54 (54.0)
	Frontal	22 (22.0)
	Sphenoid	18 (18.0)
Laterality	Unilateral	56 (56.0)
	Bilateral	44 (44.0)
Lesion location	Maxillary sinus only	30 (30.0)
	Ethmoid sinus only	12 (12.0)
	Multiple sinuses	40 (40.0)
	Nasal cavity extension	10 (10.0)
	Orbital extension	5 (5.0)
	Intracranial extension	3 (3.0)

Maxillary sinus involvement was most frequent, followed by ethmoid sinus involvement. Multiple sinus disease was identified in 40.0% of cases, indicating spread across sinus compartments. Lesion mapping also identified nasal cavity, orbital and intracranial extension, which are crucial for surgical and referral planning.

Osteomeatal complex obstruction and anatomical variants

Table 4. Osteomeatal complex obstruction and anatomical variants on CT PNS (N = 100)

Domain	Category	Value	p-value
OMC status	Obstructed	58 (58.0)	—
	Not obstructed	42 (42.0)	—
OMC obstruction by diagnosis	Inflammatory sinusitis	34 (68.0)	0.01
	Sinonasal polyps	16 (80.0)	0.01
	Fungal sinusitis	5 (62.5)	0.01
	Neoplasms	3 (25.0)	0.01
Anatomical variant	Deviated nasal septum (DNS)	38 (38.0)	—
	Concha bullosa	26 (26.0)	—
	Agger nasi cells	20 (20.0)	—
	Haller cells	12 (12.0)	—
	Onodi cells	8 (8.0)	—

OMC obstruction was present in more than half of the patients and showed a statistically significant association with CT diagnosis. It was most frequent in sinonasal polyps and inflammatory sinusitis, emphasizing the role of drainage pathway obstruction. DNS and concha bullosa were the most frequent anatomical variants, both important for FESS planning.

CT features associated with fungal sinusitis

Table 5. CT features associated with fungal sinusitis

Feature	Present n (%)	p-value
Hyperdense material	7 (87.5)	0.001
Bony erosion	3 (37.5)	0.02

Hyperdense material was strongly associated with fungal sinusitis and represented the most useful CT marker for fungal disease in this cohort. Bony erosion was also significantly associated with fungal sinusitis, supporting the role of CT in identifying potentially aggressive or complicated fungal pathology.

Clinical and radiological associations

Table 6. Compact presentation of clinical and radiological associations

Analysis domain	Variable	Result	p-value
Symptom association with CT diagnosis	Headache	Inflammatory 56%; Polyps 80%; Fungal 88%	—
	Nasal obstruction	Inflammatory 60%; Polyps 95%; Fungal 50%	—
	Nasal discharge	Inflammatory 70%; Polyps 65%; Fungal 40%	—
Age distribution across CT diagnosis	Inflammatory	Mean age 34 years	—
	Polyps	Mean age 37 years	—
	Fungal	Mean age 41 years	—
	Benign tumors	Mean age 45 years	—
	Malignancy	Mean age 52 years	—
Correlation of symptoms with sinus involvement	Headache	Maxillary 60%; Ethmoid 55%; Frontal 70%; Sphenoid 72%	0.04
	Nasal obstruction	Maxillary 65%; Ethmoid 75%; Frontal 40%; Sphenoid 30%	0.01
	Nasal discharge	Maxillary 70%; Ethmoid 68%; Frontal 45%; Sphenoid 35%	0.03
	Anosmia	Maxillary 25%; Ethmoid 40%; Frontal 10%; Sphenoid 8%	0.02

Symptom patterns varied across CT diagnoses and sinus compartments. Headache was common across inflammatory, polypoidal and fungal disease, whereas nasal obstruction was particularly frequent in sinonasal polyps. Malignant tumors showed the highest mean age among CT diagnoses. Symptom-sinus correlations were statistically significant for headache, nasal obstruction, nasal discharge and anosmia, supporting the clinicoradiological value of CT localization.

Predictors of complicated disease

Table 7. Predictors of complicated paranasal sinus disease

Analysis	Variable / Predictor	Effect estimate	p-value
Univariate analysis	Diabetes	OR 4.8	0.01
	Smoking	OR 2.3	0.23
	Duration >12 weeks	OR 4.1	0.03
	Fungal sinusitis	OR 44.4	0.001
Multivariate logistic regression	Fungal sinusitis	Adjusted OR 6.5	0.002
	Diabetes mellitus	Adjusted OR 3.0	0.03
	Symptom duration >12 weeks	Adjusted OR 2.2	0.08

Diabetes, symptom duration >12 weeks and fungal sinusitis were significant univariate predictors of complicated disease. On multivariate analysis, fungal sinusitis and diabetes mellitus remained independent predictors, whereas symptom duration >12 weeks showed increased risk but did not reach statistical significance.

ROC analysis, diagnostic accuracy and management guidance

Figure 4. ROC-derived AUC values for prediction of complicated disease

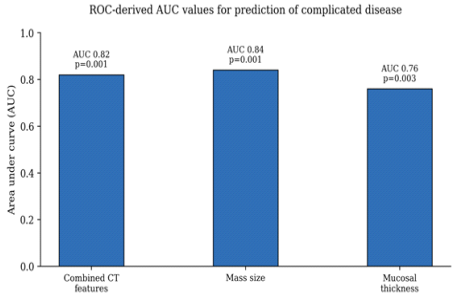


Table 8. ROC analysis, diagnostic accuracy and management guidance based on CT findings

Domain	Parameter / Category	Value	p-value
ROC analysis	Combined CT features	AUC 0.82	0.001
	Mass size	AUC 0.84	0.001
	Mucosal thickness	AUC 0.76	0.003
Diagnostic accuracy	Sensitivity	92.0%	—
	Specificity	85.0%	—
	Positive Predictive Value (PPV)	88.0%	—
	Negative Predictive Value (NPV)	90.0%	—
	Overall accuracy	89.0%	—
Management advised after CT	Medical therapy	48 (48.0)	—
	FESS surgery	28 (28.0)	—
	Biopsy/FNAC	14 (14.0)	—
	Oncology referral	5 (5.0)	—
	Observation	5 (5.0)	—

ROC analysis showed good predictive utility of mass size, combined CT features and mucosal thickness for complicated disease. CT demonstrated high diagnostic performance with sensitivity of 92.0%, specificity of 85.0% and overall accuracy of 89.0%. CT findings directly influenced management, with medical therapy advised most often, followed by FESS, biopsy/FNAC, oncology referral and observation.

DISCUSSION

In the present study, computed tomography was evaluated as a comprehensive imaging modality in 100 patients with suspected paranasal sinus pathologies. The mean age of the study population was 36 ± 14 years, with a male predominance of 62.0% and rural representation of 68.0%. Headache (62.0%), nasal obstruction (58.0%) and nasal discharge (54.0%) were the leading clinical symptoms, confirming that sinonasal disease frequently presents with overlapping symptoms that are not specific for a particular disease category. Kanwar et al.[1] also reported headache and nasal discharge as common presenting complaints, supporting the need for CT-based anatomical and pathological characterization.

Inflammatory sinusitis was the most frequent CT diagnosis in the present study, accounting for 50.0% of cases, followed by sinonasal polyps (20.0%) and fungal sinusitis (8.0%). Benign tumors (7.0%), malignant tumors (5.0%), mucocele (4.0%) and other lesions (6.0%) formed smaller but clinically important groups. These findings were comparable with Kanwar et al.[1] and Kandukuri and Phatak[4], who emphasized the utility of CT in detecting the spectrum of sinonasal diseases and differentiating inflammatory from non-inflammatory pathology. The dominance of inflammatory and polypoidal disease in the present cohort reflects the common clinical referral pattern from ENT practice.

The major CT imaging features in the present study were mucosal thickening (72.0%), air-fluid level (25.0%), contrast enhancement (18.0%), bony erosion (12.0%), hyperdense material (10.0%) and extrasinus extension (5.0%). Mucosal thickening and air-fluid levels reflected common inflammatory and infective pathology, whereas hyperdense material and bony erosion were particularly useful for identifying fungal or aggressive disease. Ata-Ali et al.[9] reported mucosal thickening as a frequent finding in maxillary sinus evaluation, while Raz et al.[15] described hyperdense sinus contents and bony changes as important CT features in fungal sinusitis. In the present study, hyperdense material was significantly associated with fungal sinusitis [7 (87.5%); p=0.001], and bony erosion was also significant [3 (37.5%); p=0.02].

Maxillary sinus involvement was most common (76.0%), followed by ethmoid (54.0%), frontal (22.0%) and sphenoid sinus involvement (18.0%). Multiple sinus involvement was present in 40.0% of cases. This predominance of maxillary sinus disease is consistent with Kanwar et al.[1] and may be attributed to the size of the maxillary sinus, its drainage pattern through the osteomeatal complex and its close relationship with dentoalveolar structures. Little et al.[16] emphasized the clinical importance of odontogenic contributions to maxillary sinus disease, which may be under-recognized without imaging evaluation.

Osteomeatal complex obstruction was present in 58.0% of cases and showed significant association with CT diagnosis (p=0.01). OMC obstruction was most frequent in sinonasal polyps (80.0%), followed by inflammatory sinusitis (68.0%) and fungal sinusitis (62.5%). Anatomical variants included DNS (38.0%), concha bullosa (26.0%), agger nasi cells (20.0%), Haller cells (12.0%) and Onodi cells (8.0%). Varshney et al.[5], Vaid and Vaid[6] and Shpilberg et al.[7] emphasized that CT identification of anatomical variants is essential for sinus disease assessment and surgical planning. The present findings reinforce the role of CT as both a diagnostic and preoperative mapping tool.

Clinical and radiological associations further supported CT utility. Headache was associated with maxillary (60%), ethmoid (55%), frontal (70%) and sphenoid (72%) sinus involvement (p=0.04). Nasal obstruction was most frequent in ethmoid disease (75%) and maxillary disease (65%) (p=0.01), while nasal discharge was highest in maxillary (70%) and ethmoid sinus involvement (68%) (p=0.03). Anosmia was more associated with ethmoid sinus disease (40%) (p=0.02). Whyte and Boeddinghaus[12] described the anatomical and functional relevance of maxillary sinus imaging, and Takabayashi and Schleimer[13] highlighted the relationship of nasal polyposis and olfactory dysfunction, which supports the observed symptom distribution.

Predictor analysis showed that diabetes (OR 4.8; p=0.01), symptom duration >12 weeks (OR 4.1; p=0.03) and fungal sinusitis (OR 44.4; p=0.001) were significant univariate predictors of complicated disease, while smoking was not significant (OR 2.3; p=0.23). On multivariate analysis, fungal sinusitis (adjusted OR 6.5; p=0.002) and diabetes mellitus (adjusted OR 3.0; p=0.03) remained independent predictors of complicated disease. This is clinically relevant because fungal sinusitis and diabetes mellitus increase the risk of aggressive local extension, bony involvement and complications, making early CT diagnosis essential.

CT demonstrated high diagnostic performance in the present study, with sensitivity of 92.0%, specificity of 85.0%, PPV of 88.0%, NPV of 90.0% and overall accuracy of 89.0%. ROC analysis showed AUC values of 0.84 for mass size, 0.82 for combined CT features and 0.76 for mucosal thickness. Avrunin et al.[10] also reported that CT-based assessment improves diagnostic accuracy in sinusitis evaluation. In the present study, CT directly contributed to management planning, with medical therapy advised in 48.0%, FESS in 28.0%, biopsy/FNAC in 14.0%, oncology referral in 5.0% and observation in 5.0% of cases. These findings confirm the practical clinical value of CT beyond diagnosis alone.

The strengths of the present study include a defined symptomatic population, systematic CT PNS evaluation, inclusion of anatomical variants, assessment of OMC obstruction, analysis of fungal sinusitis features, identification of predictors of complicated disease, ROC analysis and diagnostic accuracy assessment. Limitations include the single-center design, sample size of 100, limited subgroup size for uncommon pathologies and lack of uniform histopathological

confirmation for all cases. Despite these limitations, the study provides clinically relevant evidence supporting CT as a central imaging modality in paranasal sinus disease evaluation.

CONCLUSION

The present study demonstrated that computed tomography is a highly effective modality for comprehensive evaluation of paranasal sinus pathologies. Inflammatory sinusitis was the most common diagnosis (50.0%), while mucosal thickening (72.0%), osteomeatal complex obstruction (58.0%) and maxillary sinus involvement (76.0%) were the dominant CT findings. CT was useful in identifying anatomical variants, sinus involvement, laterality, fungal features, bony erosion, extrasinus extension and complicated disease. Fungal sinusitis and diabetes mellitus were independent predictors of complicated disease. CT showed high diagnostic performance, with sensitivity of 92.0%, specificity of 85.0% and overall accuracy of 89.0%. These findings support CT as an essential imaging modality for diagnosis, risk stratification, preoperative planning and management guidance in patients with paranasal sinus disease.

DECLARATIONS

Conflict of Interest: None.
Funding: None.
Ethical Approval: Obtained.
Consent: Written informed consent secured.

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