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DIAGNOSTIC ACCURACY OF X-RAY PARA NASAL SINUS IN CLINICALLY SUSPECTED SINUSITIS TAKING COMPUTED TOMOGRAPHY SCAN AS GOLD STANDARD: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Sinusitis is a prevalent inflammatory disorder affecting the paranasal sinuses, leading to significant morbidity and reduced quality of life. Imaging plays a pivotal role in its diagnosis, with computed tomography (CT) regarded as the gold standard. However, X-ray paranasal sinus (PNS) imaging remains widely utilized due to its accessibility, lower cost, and reduced radiation exposure, particularly in primary care settings. Limited local evidence exists regarding the diagnostic accuracy of X-ray PNS compared to CT.

Objective: To determine the diagnostic accuracy of X-ray PNS in clinically suspected cases of sinusitis, using CT as the reference standard.

Methods: A cross-sectional validation study was conducted over six months in the Department of Radiology, Khyber Teaching Hospital, Peshawar, including 197 patients aged 18–65 years with clinically suspected sinusitis. Non-probability consecutive sampling was used. Each participant underwent both X-ray PNS (Water's, Caldwell's, and Lateral views) and CT scan of the paranasal sinuses. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Data were analyzed using SPSS version 27.

Results: Among 197 participants, sinusitis was detected in 132 (67.0%) cases by X-ray PNS and 145 (73.6%) cases by CT. X-ray PNS demonstrated a sensitivity of 86.2%, specificity of 86.5%, PPV of 94.7%, NPV of 69.2%, and overall diagnostic accuracy of 86.3%. Higher diagnostic accuracy was observed in patients aged 30–50 years and those with normal BMI.

Conclusion: X-ray PNS is a reliable and practical diagnostic tool for evaluating clinically suspected sinusitis, especially where CT is not readily available. While CT remains superior for detailed assessment, X-ray PNS offers a valuable alternative for timely diagnosis and management in resource-limited settings.

Keywords: Computed Tomography, Diagnostic Accuracy, Paranasal Sinuses, Radiography, Sensitivity and Specificity, Sinusitis, X-Ray.

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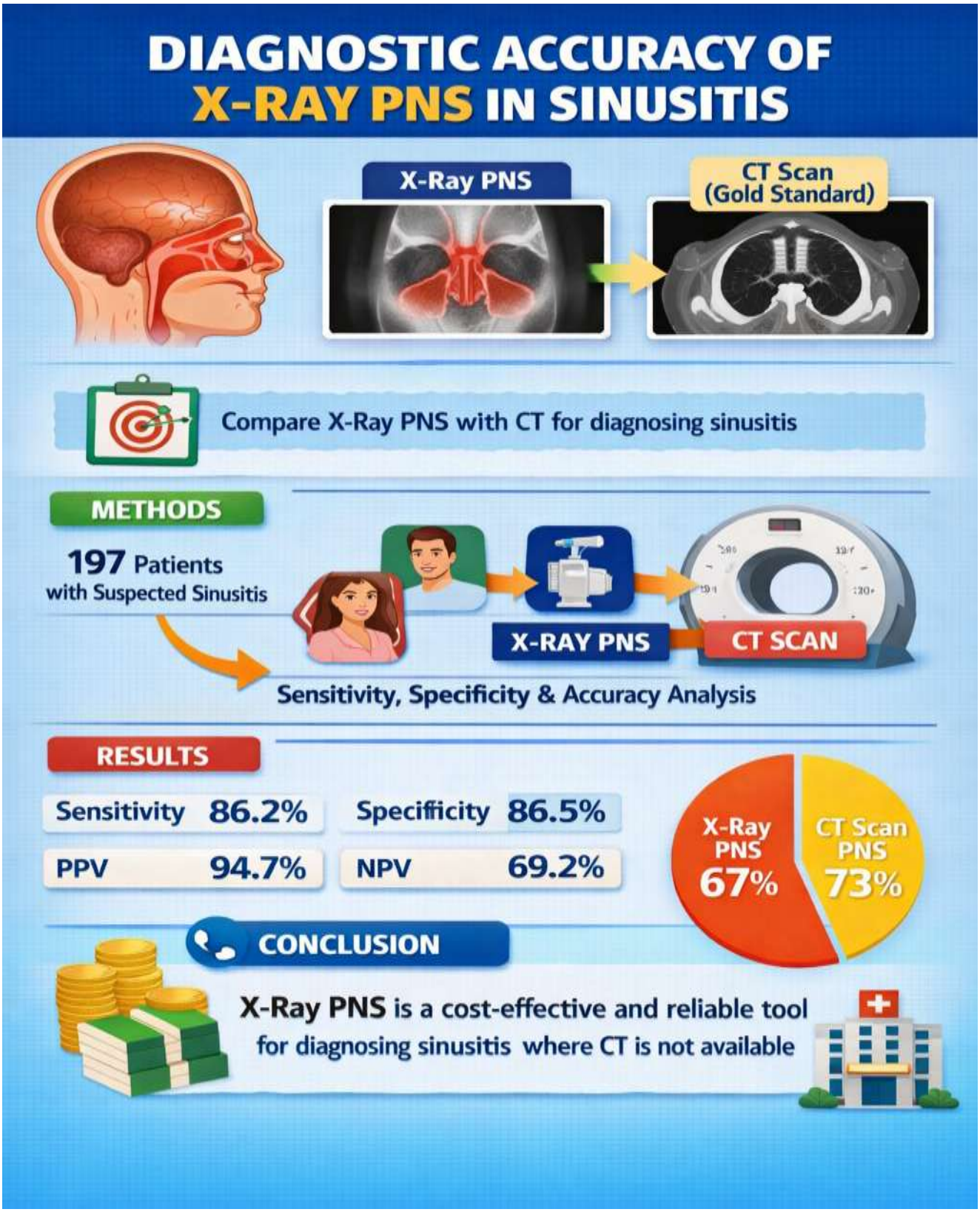

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INTRODUCTION

Sinusitis is a common inflammatory condition that significantly impacts global health, leading to considerable morbidity and reduced quality of life among affected individuals (1). Among its various forms, paranasal sinusitis represents a prevalent type characterized by inflammation of the paranasal sinuses—air-filled cavities within the frontal, ethmoid, sphenoid, and maxillary bones that surround the nasal cavity. These sinuses play essential physiological roles in humidifying and filtering inhaled air while contributing to the resonance and tonal quality of the human voice (2,3). Clinically suspected sinusitis typically presents with symptoms such as nasal obstruction, purulent nasal discharge, and a diminished sense of smell, which often guide initial clinical assessment and management (4,5). Previous studies have demonstrated that anatomical variations such as gross deviation of the nasal septum and bilateral inferior turbinate hypertrophy are common findings among patients with sinusitis, occurring in approximately 16.7% and 20.8% of cases, respectively (6). Given its high prevalence, sinusitis is encountered across various medical specialties, including primary care, otolaryngology, pulmonology, and allergy/immunology (7). Therefore, a thorough understanding of its pathophysiology, clinical presentation, diagnostic modalities, and treatment options is vital for effective patient management (8). Imaging plays a pivotal role in diagnosing and evaluating sinusitis, helping clinicians assess disease extent, detect complications, and select appropriate therapeutic strategies. The X-ray of the paranasal sinuses (PNS) remains a widely used initial diagnostic tool due to its accessibility, cost-effectiveness, and ease of performance (9). However, with advancements in imaging technology, computed tomography (CT) has emerged as the gold standard for sinus evaluation, offering superior visualization of sinus anatomy and pathology (10).

Despite this, X-ray imaging continues to hold clinical relevance in resource-limited settings or in cases of uncomplicated acute sinusitis, where CT may not be readily available (11). Notably, studies have reported that the overall frequency of sinusitis detected through imaging is approximately 26%, with X-ray PNS demonstrating a sensitivity of 90.63% and a specificity of 75% when compared to CT findings (12,13). The selection between X-ray PNS and CT imaging is largely influenced by the patient's clinical presentation, symptom duration, response to therapy, and resource availability. While CT provides comprehensive diagnostic information, it is associated with higher radiation exposure and greater cost, which may limit its feasibility for routine use. Conversely, X-ray PNS remains a practical and valuable diagnostic tool in many healthcare settings, particularly for screening and initial assessment. Given the limited local data comparing the diagnostic performance of X-ray PNS with CT, the present study aims to determine the diagnostic accuracy of X-ray paranasal sinus imaging in clinically suspected cases of sinusitis, taking CT as the gold standard. The findings of this research are expected to provide valuable insights for clinicians, helping optimize diagnostic decision-making, balance resource utilization, and improve patient care outcomes. The objective of this study is therefore to determine the diagnostic accuracy of X-ray PNS in clinically suspected sinusitis, using computed tomography as the reference standard.

METHODS

The present study was designed as a cross-sectional validation study conducted in the Department of Radiology at Khyber Teaching Hospital-MTI, Peshawar. The duration of the study was six months following approval of the research synopsis by the College of Physicians and Surgeons Pakistan (CPSP) and the institutional ethical review committee. The ethical approval was obtained prior to the initiation of data collection, ensuring that all procedures adhered to ethical standards for human research as per institutional and CPSP guidelines. Informed written consent was obtained from all participants after explaining the study's objectives, potential benefits, and confirming that no risks were associated with participation. The sample size was calculated using the World Health Organization (WHO) sample size calculator, based on an expected sinusitis frequency of 26% (12), a sensitivity of 90.63% (13), and a specificity of 75% (13) for X-ray paranasal sinus (PNS) in diagnosing sinusitis. With a 95% confidence level and an absolute precision of 8%, the total sample size was determined to be 197 patients. Non-probability consecutive sampling was employed to recruit participants who fulfilled the inclusion criteria. The study population included both male and female patients aged 18 to 65 years who were clinically suspected of having sinusitis, presenting with symptoms such as runny nose, postnasal drip, and tenderness around the forehead. Patients with allergic rhinitis, viral upper respiratory infections, or known structural abnormalities of the nasal cavity and paranasal sinuses were excluded to minimize confounding factors.

Data collection commenced after ethical approval. Eligible participants were enrolled consecutively from the outpatient and inpatient departments of the hospital's radiology unit. Demographic information, including age, gender, body mass index (BMI), educational status, occupation, socioeconomic status, and area of residence, was recorded on a structured proforma. Each participant underwent an X-ray PNS examination as the initial diagnostic imaging procedure. During the procedure, patients were positioned upright, and proper

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head alignment was maintained to ensure optimal visualization of all paranasal sinuses. Standard radiographic views, including Water's, Caldwell's, and Lateral views, were obtained to assess the frontal, ethmoid, maxillary, and sphenoid sinuses. Findings such as mucosal thickening, air-fluid levels, and homogenous opacities were documented. Subsequently, all patients underwent computed tomography (CT) scans of the paranasal sinuses, considered the gold standard for diagnosis. CT findings were assessed for the presence of mucosal thickening, air-fluid levels, and obstruction of the ostiomeatal complex. Both X-ray PNS and CT scan interpretations were performed under the supervision of a qualified radiologist with a minimum of five years of post-fellowship experience to ensure consistency and diagnostic reliability. The data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were applied to summarize the data. Continuous variables such as age, weight, height, and BMI were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on the normality of data assessed using the Shapiro–Wilk test. Categorical variables, including X-ray PNS and CT findings, education, occupation, socioeconomic status, and area of residence, were presented as frequencies and percentages. Diagnostic accuracy was determined using a 2×2 contingency table with CT findings as the gold standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of X-ray PNS were calculated using standard formulas:

- Sensitivity = A / (A + C) × 100
- Specificity = D / (B + D) × 100
- Positive Predictive Value = A / (A + B) × 100
- Negative Predictive Value = D / (C + D) × 100
- Diagnostic Accuracy = (A + D) / Total Patients × 100

Stratification was performed for potential effect modifiers, including age, BMI, education, occupation, socioeconomic status, and area of residence. Post-stratification, Chi-square or Fisher's exact tests were applied at a 5% significance level to evaluate associations. Results were presented in tabulated form for clarity and comparison. All participants were managed according to standard clinical protocols after imaging, and no experimental interventions were performed. Confidentiality of all participants' information was maintained throughout the study, and data were anonymized before analysis.

RESULTS

A total of 197 patients were included in the study, comprising 112 males (56.9%) and 85 females (43.1%), with a mean age of 38.6 ± 10.4 years. The average BMI was 25.9 ± 3.8 kg/m². Most participants belonged to the middle socioeconomic class (48.7%), followed by the lower (32.5%) and upper (18.8%) classes. Regarding occupational status, 62.4% were employed and 37.6% were unemployed. The majority of participants resided in urban areas (55.3%), while 44.7% were from rural settings. Educational status revealed that 22.8% had primary, 36.0% had middle, and 41.1% had higher education levels (Table 1). Radiological findings indicated that sinusitis was identified on X-ray PNS in 132 patients (67.0%) and on CT scan in 145 patients (73.6%) (Table 2). Comparison of X-ray and CT findings demonstrated 125 true positive, 7 false positive, 20 false negative, and 45 true negative cases (Table 3). Based on these data, the sensitivity of X-ray PNS in diagnosing sinusitis was 86.2%, specificity 86.5%, positive predictive value 94.7%, negative predictive value 69.2%, and overall diagnostic accuracy 86.3% (Table 4). Further stratified analysis showed that diagnostic accuracy was slightly higher among patients aged 30–50 years (88.1%) compared to younger and older age groups. Accuracy was also higher in patients with a normal BMI (87.5%) than those who were overweight or obese (83.3%). Socioeconomic and educational factors did not significantly influence diagnostic accuracy ($p > 0.05$). Figure 1 demonstrates the comparative distribution of sinusitis detection on X-ray PNS and CT, while Figure 2 summarizes the diagnostic accuracy metrics. Both visuals indicate a strong concordance between X-ray and CT findings, supporting the reliability of X-ray PNS as an accessible diagnostic tool for clinically suspected sinusitis.

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Table 1: Demographic Characteristics of the Study Participants (n = 197)

Variable	Distribution
Age (years)	Mean ± SD: 38.6 ± 10.4
Gender	
Male	112
Female	85
BMI (kg/m²)	Mean ± SD: 25.9 ± 3.8
Socioeconomic Status	
Lower	64
Middle	96
Upper	37
Occupation Status	
Employed	123
Unemployed	74
Residence	
Rural	88
Urban	109
Education	
Primary	45
Middle	71
Higher	81

Table 2: Diagnostic Findings of Sinusitis on X-Ray PNS and CT Scan

Findings	Frequency
Sinusitis on X-Ray PNS	
Yes	132
No	65
Sinusitis on CT	
Yes	145
No	52

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Table 3: 2×2 Contingency Table Comparing X-Ray PNS with CT Findings

	CT Positive	CT Negative
X-Ray PNS Positive	125 (TP)	7 (FP)
X-Ray PNS Negative	20 (FN)	45 (TN)

Table 4: Diagnostic Performance of X-Ray PNS Using CT as Gold Standard

Parameter	Value (%)
Sensitivity	86.2
Specificity	86.5
Positive Predictive Value	94.7
Negative Predictive Value	69.2
Diagnostic Accuracy	86.3

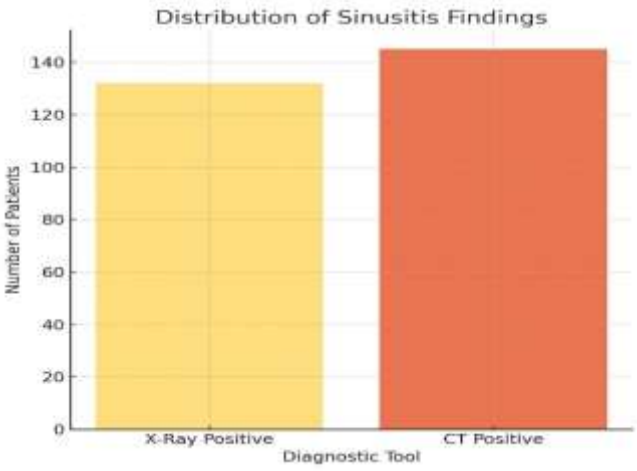

Figure 2 Distribution of Sinusitis Findings

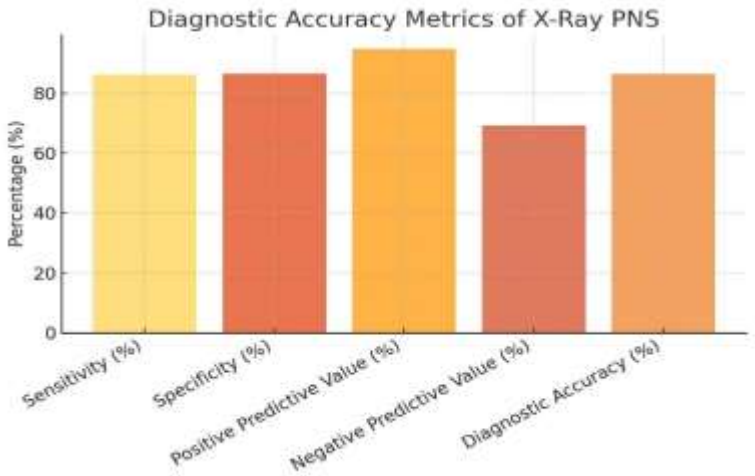

Figure 2 Diagnostic accuracy Metrics of X-Ray PNS

DISCUSSION

The findings of this study demonstrated that X-ray paranasal sinus (PNS) imaging yielded a high diagnostic performance in patients with clinically suspected sinusitis when compared with computed tomography (CT) as the reference standard. In the current cohort, X-ray PNS showed sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy that align with several contemporary reports on sinus imaging. These results support the continued, albeit selective, use of plain radiography in assessing sinus disease, particularly in settings where CT availability is limited or in initial evaluation phases. The sensitivity (86.2%) and specificity (86.5%) observed in this study reflect a relatively robust ability of X-ray PNS to detect true cases of sinusitis and to correctly exclude patients without disease. Although CT remains the gold standard due to its superior anatomical resolution and comprehensive visualization of sinonasal structures, previous research has similarly reported moderate to high diagnostic metrics for plain radiography under certain clinical conditions. A meta-analysis indicated that radiographs exhibit moderate sensitivity (~73%) and specificity (~80%) relative to gold standards such as sinus puncture or advanced imaging modalities (although this analysis included varied imaging contexts) (14). Additionally, studies focused on chronic rhinosinusitis in adult populations have shown that

plain radiography may demonstrate reasonable agreement with CT findings for maxillary sinus involvement, albeit with reduced reliability for ethmoid, frontal, and sphenoid sinuses (15,16). These observations reinforce the notion that X-ray PNS can serve as a preliminary imaging option, particularly for the maxillary sinuses where radiographic changes are more readily detectable.

Comparative literature indicates that CT consistently outperforms plain radiography. Recent cross-sectional studies have documented higher sensitivity and specificity for CT in detecting sinusitis (e.g., >95% for both parameters) compared to X-rays, underscoring the enhanced diagnostic certainty provided by tomographic imaging (17). Moreover, CT's ability to display intricate ostiomeatal complex anatomy and subtle mucosal changes facilitates comprehensive evaluation and treatment planning, which plain films cannot reliably achieve due to two-dimensional overlap of bony structures and limited contrast resolution (18,19). The current study's results contribute to the ongoing dialogue regarding the role of plain radiography in sinusitis diagnosis. The relatively high PPV (94.7%) suggests that patients with positive X-ray findings are likely to have sinusitis confirmed on CT. However, the lower NPV (69.2%) highlights a limitation: negative X-ray results cannot reliably rule out sinusitis. This pattern is consistent with previous findings that plain radiography may miss disease, particularly in sinus segments other than the maxillary sinuses (20). From a clinical standpoint, this implies that X-ray negative patients with persistent or severe symptoms should undergo further evaluation with CT or endoscopic examination to avoid missed diagnoses. One strength of this study lies in its structured comparison of X-ray and CT outcomes with a clearly defined 2×2 contingency framework and explicit diagnostic criteria. The relatively large sample size (n=197) and stratification of demographic factors enhance the generalizability within the studied population. Moreover, the supervision of image interpretation by experienced radiologists minimized interpretive variability and strengthened internal validity.

Nevertheless, limitations must be acknowledged. First, the cross-sectional design precludes assessment of the temporal progression of sinus disease and the dynamic response to therapy. Second, although CT was used as the gold standard, no correlation with clinical endoscopy or microbiological confirmation was performed, which might have further refined diagnostic categorization. Third, the study did not differentiate between acute and chronic sinusitis subtypes, which may exhibit distinct radiographic characteristics affecting diagnostic performance. Finally, inherent selection bias may exist in a radiology-based sample, as patients referred for imaging often present with more pronounced symptoms. Future research should consider longitudinal designs evaluating the predictive value of imaging findings over time and the integration of advanced imaging techniques such as low-dose CT or cone-beam CT to balance radiation exposure with diagnostic detail. Additionally, investigations incorporating nasal endoscopy and clinical symptom scoring alongside imaging modalities may yield a more holistic assessment of diagnostic pathways. With the advent of artificial intelligence and machine learning, emerging studies are exploring automated interpretation of PNS imaging, which could enhance diagnostic accuracy and efficiency in resource-constrained environments (21,22). In summary, the study demonstrated that X-ray PNS has appreciable diagnostic value in suspected sinusitis, particularly when CT is unavailable or when resource constraints preclude immediate advanced imaging. While CT remains the definitive modality for detailed sinus evaluation, plain radiography retains a role as an accessible and cost-effective initial tool, especially for confirming gross sinus pathology.

CONCLUSION

The study concluded that X-ray paranasal sinus (PNS) imaging demonstrates high diagnostic accuracy, sensitivity, and specificity in identifying clinically suspected sinusitis when compared with computed tomography (CT) as the gold standard. Although CT remains superior for detailed anatomical evaluation, X-ray PNS serves as a reliable, cost-effective, and readily available diagnostic alternative, particularly in resource-limited or primary care settings. These findings support its continued use as an initial imaging modality to facilitate timely diagnosis and management of sinusitis, optimizing patient care and healthcare resource utilization.

AUTHOR CONTRIBUTIONS

Author	Contribution
Ayesha Begum	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hina Gul*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Sara Daud	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Iqra Sardar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nida Ghassan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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