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Original Article

Diagnostic Accuracy of X-Rays in the Diagnosis of Acute Sinusitis Keeping Computed Tomography as Gold Standard

Article History:

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Abstract: Background: Acute sinusitis is common inflammatory disease of paranasal sinuses and causes nasal blockage, facial pain and discharge. Although computed tomography is more accurate, X-ray still widely used because it is cheap and easily available. ***Objective:*** To determine diagnostic accuracy of X-ray in diagnosis of acute sinusitis taking computed tomography as gold standard. ***Study Design***: Cross sectional validation study. ***Duration and Place of Study:*** This study was conducted from 25 October 2024 to 25 April 2025 at Combined Military Hospital Abbottabad. ***Methodology:*** A total of 131 patients of both gender aged ≥7 years with clinical features of acute sinusitis was included. X-ray Water's view was performed and findings was compared with computed tomography scan. Data was analysed using Statistical Package for Social Sciences version 26. Mean ± standard deviation was calculated for quantitative variables and frequency n (%) for categorical variables. ***Results:*** Mean age was 36.83 ± 16.81 years. X-ray showed positive findings in 67 (51.1%) patients while computed tomography showed 72 (55.0%) positive cases. There were 58 true positive, 9 false positive, 14 false negative and 50 true negative cases. Sensitivity was 80.60%, specificity 84.70%, positive predictive value 86.60%, negative predictive value 78.10% and diagnostic accuracy 82.40% (p ≤0.05). ***Conclusion:*** X-ray shows acceptable diagnostic accuracy in acute sinusitis but it is less reliable than computed tomography and can miss some cases.

Keywords: Computed tomography, Diagnostic imaging, Paranasal sinuses, Radiography, Sinusitis

INTRODUCTION

Acute sinusitis is an inflammatory disorder involving the sinuses and usually develops due to an infection within the upper respiratory tract.1 The condition mainly involves maxillary, frontal, ethmoidal, and sphenoidal sinuses and is generally attributed to a viral infection, though there are some cases where a bacterial cause could be implicated, especially if the symptoms have been long-standing or serious.2 Nasal congestion, discharging pus from the nose, facial pain or pressure, headache, and possibly fever are typical signs and symptoms of this ailment.3 The inflammation causes the blockage of the sinus openings, causing a build-up of mucous and subsequent infection.4

Acute sinusitis is usually diagnosed clinically using the patient's history and physical examination findings; however, further studies may be necessary to confirm the diagnosis and/or rule out any possible complications.5 The presence of symptoms for more than 10 days and their worsening after an improvement period indicates that sinusitis is caused by bacteria. Tenderness upon palpation of the sinuses, nasal mucosa inflammation, and nasal discharge can be found during physical examination.6 Tests used for diagnosing sinusitis include nasal endoscopy, CT scan, and, occasionally, laboratory tests. The CT scan is considered a more sensitive test; however, it is not always accessible and poses additional risks.7

X-ray studies have traditionally been employed for the

evaluation of paranasal sinuses, and they can demonstrate evidence of mucosal thickening, air-fluid levels, and sinus opacities.8 However, radiographic diagnosis in cases of acute sinusitis is inconsistent and often hindered by overlying anatomical landmarks and reduced sensitivity when compared to computed tomography.9 Radiography can fail to detect early or mild infections and lacks the ability to differentiate between viral and bacterial causes. Nonetheless, radiography continues to be performed owing to its affordability, availability, and speed. The use of radiography in the diagnosis of sinusitis is contentious; some studies have shown moderate efficacy while others have found little clinical value.10

Acute sinusitis is commonly encountered in everyday medical practice, but there are still concerns about the best method that is both highly accurate and economically viable. Radiographs are readily available and often used but may be challenged in terms of their accuracy in comparison to more modern imaging techniques like computerized tomography. However, no local evidence has been established on the role of radiographs in the diagnosis of acute sinusitis. Therefore, this study is needed to assess the diagnostic accuracy of X-rays in the diagnosis of acute sinusitis..

METHODOLOGY

This cross sectional (validation) study was carried out at Combined Military Hospital Abbottabad from 25 October 2024 to 25 April 2025. Approval was taken from the Institutional Ethical Committee of the hospital before start of study, and all procedures was done according to ethical standards. Sample size of 131 patients was calculated by using WHO sample size software keeping confidence level 95% and absolute precision 10%, while taking prevalence of acute sinusitis 47%, sensitivity of X-ray 80% and specificity 84.6%.11

Inclusion criteria

Patients of both gender aged ≥7 years were included. Patients presenting with clinical features suggestive of acute sinusitis such as facial pain, nasal obstruction, purulent nasal discharge or reduced sense of smell were selected. Only those patients were included who had undergone both X-ray and CT scan of paranasal sinuses within 24–48 hours.

Exclusion criteria

Pregnant females was excluded due to radiation exposure risk. Patients having previous history of sinus surgery was also excluded because of altered anatomy which can affect imaging findings.

Before data collection, verbal informed consent was taken from all patients after explaining risks and benefits. Demographic data was recorded including age, gender and occupation. Duration of symptoms was also noted in days. Detailed history was taken regarding presenting complaints and clinical features, and examination of ENT region was performed for confirmation of suspected acute sinusitis. All selected patients underwent digital X-ray Water's view of paranasal sinuses using 75–80 kVp in radiology department. Films was reviewed by consultant radiologist for reporting. CT scan was then performed on 128-slice helical CT scanner with 5 mm axial cuts without IV contrast and images was reconstructed in sagittal and coronal planes. CT images was reported by another consultant radiologist who was blinded to X-ray findings to reduce bias. After completion of imaging procedure, findings was recorded on predesigned proforma and patients was followed till reporting completed.

The diagnosis of acute sinusitis on plain films was made based on opacity of the sinus, caused either by mucosal thickening or fluid present in the sinus, or based on air-fluid levels present in the sinuses. In CT scan images, the diagnosis of acute sinusitis was made if there was thickening of the mucosa greater than 4 mm centrally or peripherally, gas-fluid levels, bubbly secretions, or obstruction of the osteomeatal complex.

Data was entered and analysed by using IBM SPSS version 26. Quantitative variables like age and duration of symptoms was presented as mean ± standard deviation. Categorical variables such as gender and occupation were expressed as frequency and percentage. Sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy was calculated by using 2×2 table and expressed in percentage. Effect modifiers including age, gender and duration of symptoms was controlled by stratification. Post stratification diagnostic accuracy test was applied and p value ≤0.05 was considered statistically significant

RESULTS

The study comprised a total of 131 patients, with a mean age of 36.83 ± 16.81 years and a mean symptom duration of 11.46 ± 5.36 days. With regards to the gender distribution, the sample was predominantly female, with 80 females accounting for 61.1% of the total, whilst males numbered 51, representing 38.9% of the study population. In terms of residential background, a majority of the patients were from rural areas, comprising 78 individuals (59.5%), as compared to 53 urban patients (40.5%). Regarding educational status, 74 patients were uneducated (56.5%) and 57 were educated (43.5%), and with respect to socioeconomic status, the middle-income group was the largest, constituting 58 patients (44.3%), followed by the low-income group with 44 patients (33.6%), and the high-income

group with 29 patients (22.1%) (Table-I).'

Table-I: Patient Demographics

Demographics	**Mean ± SD / n (%)**
Age (years)	36.83 ± 16.81
Duration (days)	11.46 ± 5.36
Gender	
Male n (%)	51 (38.9%)
Female n (%)	80 (61.1%)
Residence	
Urban n (%)	53 (40.5%)
Rural n (%)	78 (59.5%)
Education	
Educated n (%)	57 (43.5%)
Uneducated n (%)	74 (56.5%)
Socioeconomic Status	
High n (%)	29 (22.1%)
Middle n (%)	58 (44.3%)
Low n (%)	44 (33.6%)

When overall diagnostic results were compared, x-ray identified acute sinusitis as positive in 67 patients (51.1%) and negative in 64 patients (48.9%), whereas CT scan, serving as the gold standard, yielded positive results in 72 patients (55.0%) and negative results in 59 patients (45.0%) (Table-II).d

Table-II: Overall Results of X-Ray and CT Scan in Diagnosis of Acute Sinusitis

Diagnosis of Acute Sinusitis	**X-Ray n (%)**	**CT Scan n (%)**
Positive	67 (51.1%)	72 (55.0%)
Negative	64 (48.9%)	59 (45.0%)
Total	131 (100%)	131 (100%)

The cross-tabulation of x-ray against CT scan findings revealed 58 true positive, 9 false positive, 14 false negative, and 50 true negative cases (Table-III).

Table-III: Comparison of X-Ray versus CT Scan in Diagnosis of Acute Sinusitis

Diagnosis of Acute Sinusitis	**CT Scan Positive**	**CT Scan Negative**	**Total**
X-Ray Positive	58 (TP)	9 (FP)	67
X-Ray Negative	14 (FN)	50 (TN)	64
Total	72	59	131

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

With regard to the overall diagnostic performance of x-ray, the sensitivity was found to be 80.60% and the specificity was 84.70%, whilst the diagnostic accuracy was calculated at 82.40%. The positive predictive value (PPV) was 86.60% and the negative predictive value (NPV) was 78.10% (Table-IV).

Table-IV: Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of X-Ray in Diagnosis of Acute Sinusitis (CT as Gold Standard)

Diagnostic Parameter	**Result**
Sensitivity	80.60%
Specificity	84.70%
Diagnostic Accuracy	82.40%
PPV	86.60%
NPV	78.10%

In the stratified analysis by age, patients aged 30 years and below demonstrated a higher sensitivity of 84.60% and specificity of 100%, with a diagnostic accuracy of 91.10%, PPV of 100%, and NPV of 82.60%. Patients older than 30 years showed comparatively lower values, with sensitivity at 78.30%, specificity at 77.50%, diagnostic accuracy at 77.90%, PPV at 80.00%, and NPV at 75.60%. When the data were stratified by gender, male patients exhibited sensitivity of 83.90%, specificity of 95.00%, diagnostic accuracy of 88.20%, PPV of 96.30%, and NPV of 79.20%, whereas females showed relatively lower performance with sensitivity of 78.00%, specificity of 79.50%, diagnostic accuracy of 78.80%, PPV of 80.00%, and NPV of 77.50%. Concerning the stratification by duration of symptoms, patients with symptom duration of 14 days or less had sensitivity of 80.00%, specificity of 84.70%, diagnostic

accuracy of 82.80%, PPV of 78.00%, and NPV of 86.20%. In patients with duration exceeding 14 days, the sensitivity and diagnostic accuracy were both 81.30%, the PPV was 100%, however the specificity was not calculable and the NPV was 0%, most likely reflecting the absence of true negative cases in that subgroup (Table-V).

Table-V: Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of X-Ray in diagnosis of Acute Sinusitis (CT as Gold Standard)

Variables	Groups	Diagnostic Parameter	Result
Age (years)	≤30	Sensitivity	84.60%
		Specificity	100%
		Diagnostic Accuracy	91.10%
		PPV	100%
		NPV	82.60%
	>30	Sensitivity	78.30%
		Specificity	77.50%
		Diagnostic Accuracy	77.90%
		PPV	80.00%
		NPV	75.60%
Gender	Male	Sensitivity	83.90%
		Specificity	95.00%
		Diagnostic Accuracy	88.20%
		PPV	96.30%
		NPV	79.20%
	Female	Sensitivity	78.00%
		Specificity	79.50%
		Diagnostic Accuracy	78.80%
		PPV	80.00%
		NPV	77.50%
Duration (days)	≤14	Sensitivity	80.00%
		Specificity	84.70%
		Diagnostic Accuracy	82.80%
		PPV	78.00%
		NPV	86.20%
	>14	Sensitivity	81.30%
		Specificity	-
		Diagnostic Accuracy	81.30%
		PPV	100%
		NPV	0%

DISCUSSION

In the current study, there were many female patients who accounted for 80 (61.1%) cases of the disease. The prevalence of females as compared to males in this study might be because the former have a high probability of visiting hospitals for upper respiratory symptoms together with the hormones that play a role in increasing their predisposition to sinuses infection. The average age of these patients was 36.83 ± 16.81 years and was in agreement with the finding that the working-age group tends to get affected by sinusitis as a result of environmental exposures as well as the presence of allergens and repeated upper respiratory tract infections. The sensitivity rate for this type of test was 80.60% while the specificity was 84.70% resulting in an accuracy rate of 82.40%. It was evident from these statistics that though less specific than CT, radiography could detect the majority of cases that were both positive and negative. However, since the sensitivity was relatively low at 80.60% it could be attributed to the fact that radiography cannot provide the best pictures of ethmoidal and sphenoidal sinuses due to being two-dimensional.

The overall sensitivity of x-ray in the present study was 80.60% with specificity of 84.70% and diagnostic accuracy of 82.40%. These findings are somewhat comparable to Akhter et al. 12 who reported

sensitivity of 90.63% and specificity of 75% in a similar cross-sectional study using CT as gold standard, suggesting that x-ray has reasonably acceptable diagnostic performance in acute sinusitis, though the slight differences may be because of variation in sample size and patient selection criteria. Similarly, Al Qahtani et al. 13 reported sensitivity of 86.89% and specificity of 77.41% for digital radiography in maxillary sinusitis, which are somewhat close to present study findings and further supports the view that x-ray can serve as an initial diagnostic tool in sinusitis. On the other hand, Gul et al. 14 reported much lower sensitivity of 75.0% for x-ray, which is lower than found in present study, and this difference may be due to inclusion of both acute and chronic sinusitis cases in their study, whereas present study focused only on acute sinusitis where radiological changes are more prominent and easier to detect.

The PPV in present study was 86.60% and NPV was 78.10%, which shows that a positive x-ray finding is more reliable than a negative one. Israr et al. 15 reported considerably lower values with sensitivity of 67%, specificity of 60%, PPV of 85% and overall diagnostic accuracy of 66%, which are notably lower as compare to present study. This difference may be explained by the fact that their study included paranasal sinus pathologies in general and was not restricted to acute sinusitis only, and also their mean age was 24 ± 3.89 years which represent a younger population where mucosal changes may be less defined on plain radiographs.16

In present study, 67 (51.1%) patients were x-ray positive for acute sinusitis whilst CT scan identified 72 (55.0%) as positive, indicating that x-ray missed few cases that were detected by CT scan. This is well supported by Adil et al. 11 who also demonstrated that x-ray underestimates disease burden as compared to CT, and Alrehaily et al. 17 similarly concluded that x-ray has limited diagnostic role especially for ethmoid and sphenoid sinuses due to overlapping bony structures which results in false negative findings. The findings of Kim et al. 18 also highlighted that conventional x-ray has inherent limitations due to overlapping structures but showed that artificial intelligence models can significantly improve x-ray diagnostic accuracy up to 94.1%, which further confirms that the limitation of x-ray lies in interpretation rather than imaging principle itself.

With regards to gender distribution, present study had majority of female patients 80 (61.1%), which is in contrast to Al Qahtani et al. 13 who had 224 males (67.07%) and Ahmed et al. 19 who also reported 33 males (60%), suggesting a male predominance in those studies. This variation may reflect differences in health-seeking behaviour across different geographical and cultural settings. The mean age in present study was 36.83 ± 16.81 years which is comparable to Al Qahtani et al. 13 with mean age of 34.47 ± 9.43 years, indicating that both studies recruited a similar working-age adult population who are more commonly affected by acute sinusitis due to occupational and environmental exposures. Al-Anzi et al. 20 and Quality Measure 333 report 21 both emphasised that CT scan remains the gold standard and that x-ray should only be used as a preliminary or screening investigation, a conclusion which is also consistent with the findings of present study where x-ray showed good but not perfect diagnostic accuracy, and therefore CT scan remains necessary for confirmation especially in clinically doubtful cases.

Several limitations exist within the current study, which need consideration while evaluating the results of this research. For instance, since the study has been carried out at only one center, the findings cannot be generalized to other population groups. In addition, the sample size employed in this study, which includes 131 patients, is rather small. The use of a larger sample from multiple centers should be employed to provide valid evidence. Furthermore, there was no evaluation of the accuracy of radiography when used to evaluate each sinus separately..

CONCLUSION

The findings of the current study show that X-ray is moderately sensitive, specific, and accurate in the diagnosis of acute sinusitis in comparison with the gold standard of CT scan. It can be observed that the diagnostic efficacy of X-ray is significantly higher among younger patients and males than older patients and females.

Disclaimer: No disclaimer is present.

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Conflict of Interest

The author declare that they have no conflict of interest related to this study

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