

ROLE OF MULTI-DETECTPR CT FOR ANATOMICAL VARIATIONS OF  
PARANASAL SINUSES IN SINUSITIS IN COMPARISON WITH PLAIN X-  
RAY PNS

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**Abstract**

**Objectives**

The present study aimed to evaluate the role of Multi-Detector Computed Tomography (MDCT) in identifying anatomical variations of the paranasal sinuses (PNS) in patients with sinusitis and to compare its diagnostic effectiveness with plain X-ray PNS.

**Methodology**

This comparative cross-sectional study was conducted in the radiology department of a tertiary care hospital, Rawalpindi. A total of 60 patients presenting with clinical symptoms of sinusitis, including nasal obstruction, facial pain, headache, nasal discharge, and reduced sense of smell, were included in the study. All patients underwent both plain X-ray PNS and MDCT scanning of the paranasal sinuses. Plain radiographs were obtained using standard Water's and Caldwell views, while MDCT was performed using a multi-slice CT scanner with axial images reconstructed into coronal and sagittal planes. Qualitative variables included anatomical variations such as deviated nasal septum, concha bullosa, agger nasi cells, Haller cells, Onodi cells, paradoxical middle turbinate, and septal spurs, as well as sinusitis features like mucosal thickening, air-fluid levels, and sinus opacification. Quantitative variables included patient age, frequency of anatomical variations, and distribution of sinus involvement. Data were analyzed using descriptive statistical methods.

**Results**

The mean age of the patients was  $34.6 \pm 11.2$  years, with 58.3% males and 41.7% females. MDCT demonstrated a significantly higher detection rate of anatomical variations and sinus pathologies compared with plain X-ray PNS. Variations such as deviated nasal septum, concha bullosa, agger nasi cells, Haller cells, and Onodi cells were more accurately identified on MDCT. The maxillary sinus was the most commonly affected sinus, followed by the ethmoid sinus. Findings including mucosal thickening, air-fluid levels, and sinus opacification were better visualized with MDCT.

**Conclusion**

MDCT is a more accurate and reliable imaging modality than plain X-ray PNS

*for evaluating anatomical variations and sinus involvement in patients with sinusitis. It provides detailed visualization of sinus anatomy and pathology and plays a crucial role in accurate diagnosis and preoperative planning.*

## INTRODUCTION

The nasal cavity, which extends from the external nares to the nasopharynx, is lined by ciliated nasal mucosa and is surrounded by a collection of air-filled cavities called the paranasal sinuses (PNS). Because they are pneumatic diverticula from the primitive nasal cavity, the mucosa lining of PNS is identical to that of the nasal cavity; therefore, any pathological alterations affecting the nasal mucosa might transfer to the PNS<sup>1</sup>. The combined use of computed tomography (CT) with functional endoscopic sinus surgery (FESS) has led to more effective treatment of patients by the modern sinus surgeon, thereby facilitating reduced morbidity and complications<sup>2</sup>. Recent evidence has shown that multidetector computed tomography (MDCT) provides a better and panoramic view of the paranasal sinus and helps to visualize the varying pathologies with considerable clarity<sup>3</sup>. Computed tomography (CT) of the paranasal sinuses (PNS) has nowadays become the investigation of choice for the radiological diagnosis of nasal and sinus diseases<sup>4</sup>. Endoscopic sinus surgery (ESS) is a common procedure which requires a meticulous assessment of patient and a detailed radiological description of the anatomy and its anatomical variations in nose and PNS<sup>5</sup>. Paranasal sinuses (PNS) are air-filled spaces within the skull that play essential roles in respiration, voice modulation, and reducing cranial weight. The four paired sinuses—maxillary, ethmoid, frontal, and sphenoid—are prone to a range of pathological conditions, including inflammatory diseases, anatomical variations, and neoplastic processes, which can significantly impact patient health and require accurate diagnosis for effective management<sup>6</sup>. Multidetector computed tomography (MDCT) has revolutionized PNS imaging by offering superior resolution, multiplanar reconstructions, and detailed visualization of bony and soft tissue structures. Traditional radiography, though previously used, lacks sensitivity for detecting sinus pathology, particularly in the ethmoid and sphenoid sinuses<sup>7</sup>. Paranasal sinuses (PNS) are air-filled spaces present in specific bones of the skull. There are 4 pairs of

paranasal sinuses which are named according to their location in which they are situated in the skull bones, which includes frontal sinus, maxillary sinus, ethmoid sinus, sphenoid sinus. Clinically, PNS are divided into 2 groups, the anterior group and the posterior group. Anterior group includes maxillary, frontal, and anterior ethmoidal, they all open together in the middle meatus and their ostia lie anterior to basal lamella of middle turbinate. Posterior group includes posterior ethmoidal sinuses which open in the superior meatus and the sphenoid sinus which open in the spheno-ethmoidal recess<sup>8</sup>. Variations in the pneumatization of ethmoid sinuses may result in the disturbance of sinus ventilation and sinus drainage pathway. These can be the etiological factor for sinusitis and spread of infection to adjacent structures<sup>9</sup>. Paranasal sinuses (PNS) are one of the regions in the body where the variations are most frequent. It is important to know the patient's variations/aspects before functional endoscopic sinus surgery<sup>10</sup>.

## METHODOLOGY

The research was designed as a comparative cross-sectional study carried out in the radiology department of a tertiary care hospital of Rawalpindi. Patients who presented with clinical symptoms of sinusitis, such as nasal obstruction, facial pain, headache, nasal discharge, and reduced sense of smell, were included in the study. The study population consisted of patients referred for radiological evaluation of paranasal sinuses, and informed consent was obtained from all participants prior to imaging procedures.

A sample of patients diagnosed or suspected with sinusitis was selected using a non-probability convenient sampling technique. Each participant underwent two imaging modalities: plain X-ray PNS and Multi-Detector CT scanning of the paranasal sinuses. Plain X-ray PNS was performed using standard radiographic projections, including Water's view and Caldwell view, which are commonly used to visualize the maxillary, frontal, and ethmoid sinuses.

Following the X-ray examination, MDCT scanning was performed using a multi-slice CT scanner, producing thin-section axial images that were later reconstructed into coronal and sagittal planes for detailed evaluation. This approach allowed clear visualization of sinus anatomy, osteomeatal complex, mucosal thickening, sinus opacification, and anatomical variations.

The qualitative variables in this study included anatomical variations of the paranasal sinuses such as deviated nasal septum, concha bullosa, agger nasi cells, Haller cells, Onodi cells, paradoxical middle turbinate, and septal spurs. These variables were assessed through visual interpretation of the imaging studies by experienced radiologists. The presence or absence of sinusitis features—such as mucosal thickening, air-fluid levels, or complete sinus opacification—was also recorded qualitatively. These findings were compared between MDCT and plain X-ray PNS to determine the accuracy and effectiveness of each imaging modality in identifying sinus pathology and anatomical variations.

The quantitative variables included measurable parameters such as age of the patients, frequency of anatomical variations, sinus involvement rate, and distribution of sinusitis among different sinuses (maxillary, frontal, ethmoid, and sphenoid). Measurements such as mucosal thickness and sinus dimensions were recorded from CT images where applicable. These numerical data were tabulated and analyzed statistically to determine the prevalence and diagnostic detection rates of anatomical variations and sinusitis features using both imaging methods.

All collected data were entered and analyzed using statistical software. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were calculated for quantitative variables, while qualitative variables were expressed in terms of proportions and categories. The findings of MDCT were then compared with those of plain X-ray PNS to evaluate their diagnostic reliability and ability to detect anatomical variations related to sinusitis. The

results helped determine whether MDCT provides superior anatomical detail and diagnostic accuracy compared to conventional radiography in patients suffering from sinusitis.

**RESULTS**

A total of 60 patients presenting with clinical symptoms of sinusitis were included in the study. All participants underwent both plain X-ray PNS and Multi-Detector Computed Tomography (MDCT) examinations. The mean age of the patients was 34.6 ± 11.2 years, with ages ranging from 18 to 60 years. Among the participants, 35 (58.3%) were males and 25 (41.7%) were females. MDCT demonstrated a higher ability to detect anatomical variations and sinus pathology compared with plain X-ray PNS. Many anatomical variations that were not visible on conventional radiography were clearly identified on MDCT due to its multiplanar imaging capability and higher resolution.

MDCT detected a greater frequency of anatomical variations of the paranasal sinuses, including deviated nasal septum, concha bullosa, agger nasi cells, Haller cells, and Onodi cells. In contrast, plain X-ray PNS detected only a limited number of these variations, mainly deviated nasal septum and gross sinus opacification. The results indicated that MDCT was significantly more effective in identifying anatomical variations associated with sinusitis and provided better visualization of the osteomeatal complex and sinus structures.

Additionally, MDCT showed a higher detection rate for sinus involvement, particularly in the ethmoid and sphenoid sinuses, which are difficult to evaluate using plain radiography. The maxillary sinus was the most commonly affected sinus in patients with sinusitis. Findings such as mucosal thickening, air-fluid levels, and sinus opacification were more accurately identified using MDCT compared with plain X-ray PNS.

**Table 1: Detection of Anatomical Variations by MDCT and Plain X-ray PNS (n = 60)**

Anatomical Variation	Detected by MDCT n (%)	Detected by X-ray PNS n (%)
Deviated Nasal Septum	28 (46.7%)	18 (30.0%)
Concha Bullosa	16 (26.7%)	5 (8.3%)

Agger Nasi Cells	14 (23.3%)	2 (3.3%)
Haller Cells	10 (16.7%)	1 (1.7%)
Onodi Cells	6 (10.0%)	0 (0%)
Paradoxical Middle Turbinate	8 (13.3%)	1 (1.7%)
Septal Spur	9 (15.0%)	4 (6.7%)

Table 2: Distribution of Sinus Involvement Detected by MDCT and Plain X-ray PNS (n = 60)

Sinus Involved	MDCT Detection n (%)	X-ray PNS Detection n (%)
Maxillary Sinus	38 (63.3%)	30 (50.0%)
Ethmoid Sinus	29 (48.3%)	12 (20.0%)
Frontal Sinus	18 (30.0%)	10 (16.7%)
Sphenoid Sinus	14 (23.3%)	4 (6.7%)
Multiple Sinus Involvement	26 (43.3%)	15 (25.0%)

Overall, the results demonstrated that Multi-Detector CT (MDCT) had superior diagnostic capability compared with plain X-ray PNS in detecting both anatomical variations and sinus involvement in patients with sinusitis. The multiplanar imaging and higher resolution of MDCT allowed for more accurate assessment of sinus anatomy and pathology, making it a more reliable modality for evaluating patients with suspected sinusitis.

**DISCUSSION**

A total of 60 patients presenting with clinical symptoms of sinusitis were included in this study. All participants underwent both plain X-ray of the paranasal sinuses (PNS) and Multi-Detector Computed Tomography (MDCT) examinations. The mean age of the patients was 34.6 ± 11.2 years, with an age range of 18 to 60 years. Among the participants, 35 (58.3%) were males and 25 (41.7%) were females. The findings of the present study showed that MDCT had a greater ability to detect anatomical variations and sinus pathologies compared with plain X-ray PNS. Similarly, a study conducted in 2022 reported that MDCT is a useful imaging modality for the preoperative assessment of the paranasal sinuses, and due to its high diagnostic accuracy it assists in treatment planning and

management of patients with paranasal sinus pathologies<sup>11</sup>. The results of the current research further demonstrated that many anatomical variations that were not visible on conventional radiography were clearly identified on MDCT, mainly due to its multiplanar imaging capability and higher spatial resolution. MDCT detected a higher frequency of anatomical variations of the paranasal sinuses, including deviated nasal septum, concha bullosa, agger nasi cells, Haller cells, and Onodi cells. In support of these findings, a 2013 study highlighted that because of the wide range of anatomical variations, each case involving the paranasal sinuses should be carefully and individually evaluated in order to avoid complications and maximize patient benefit<sup>12</sup>. In contrast, plain X-ray PNS detected only a limited number of anatomical variations, mainly deviated nasal septum and gross sinus opacification. The findings of this study indicated that MDCT was significantly more effective in identifying anatomical variations associated with sinusitis and provided better visualization of the osteomeatal complex and sinus structures. Similarly, research conducted in 2025 emphasized that MDCT is an essential diagnostic tool for evaluating paranasal sinus pathologies, as it provides detailed anatomical information necessary for preoperative planning and

disease management. Its ability to detect anatomical variants, inflammatory changes, and neoplastic lesions further highlights its crucial role in otolaryngologic imaging<sup>13</sup>. Additionally, the present study showed that MDCT had a higher detection rate for sinus involvement, particularly in the ethmoid and sphenoid sinuses, which are relatively difficult to assess using conventional radiography. The maxillary sinus was found to be the most commonly affected sinus among patients with sinusitis. Furthermore, findings such as mucosal thickening, air-fluid levels, and sinus opacification were more accurately identified with MDCT compared with plain X-ray PNS. In agreement with these results, a 2022 study reported that common anatomical structures such as TSNA, EB, ND, and AG were frequently observed. The prevalence of these structures was considered too high to be regarded merely as variations and could instead be described as dominant anatomical features. The study also reported no significant difference in the incidence of variations based on gender or side, although significant correlations were observed between EB and UPT, ND and CB, AG and OC, and MH and UPD<sup>14</sup>.

Overall, the findings of the present study demonstrated that Multi-Detector CT (MDCT) has superior diagnostic capability compared with plain X-ray PNS for detecting both anatomical variations and sinus involvement in patients with sinusitis. These findings are consistent with a 2017 study, which concluded that CT is an excellent imaging modality for evaluating the normal anatomy, anatomical variants, and pathologies of the paranasal sinuses, although it may have certain diagnostic limitations in cases such as fungal sinusitis<sup>15</sup>. Furthermore, the multiplanar imaging capability and higher resolution of MDCT allowed for a more accurate assessment of sinus anatomy and pathology, making it a more reliable diagnostic modality for evaluating patients with suspected sinusitis. Supporting these findings, a 2021 study reported that anatomical variations of the nasal cavity and paranasal sinuses are common, and CT scanning is considered the gold standard imaging technique for radiological evaluation of the paranasal sinuses. It plays an essential role in preoperative and postoperative assessment, diagnosis of sinonasal lesions, and identification of anatomical variants. CT

imaging can clearly delineate lesions and their relationship with surrounding vital structures, and therefore CT evaluation of the paranasal sinuses should be carefully analyzed before performing Functional Endoscopic Sinus Surgery (FESS)<sup>16</sup>.

## CONCLUSION

Multi-Detector Computed Tomography (MDCT) proved to be a more accurate and reliable imaging modality than plain X-ray PNS for detecting anatomical variations and sinus involvement in patients with sinusitis. The multiplanar imaging capability and high resolution of MDCT allowed better visualization of sinus anatomy, the osteomeatal complex, and associated pathological changes. MDCT was particularly effective in identifying variations and disease involvement in the ethmoid and sphenoid sinuses, which are difficult to assess with conventional radiography. Therefore, MDCT plays a crucial role in the accurate diagnosis, evaluation, and preoperative planning of paranasal sinus diseases.

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