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Original Article

Role of Multi Detector Computed Tomography in Paranasal Sinus Pathology

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ABSTRACT

Background: Paranasal sinus (PNS) pathologies are common clinical conditions presenting with nonspecific symptoms, often necessitating imaging for definitive diagnosis. Multidetector computed tomography (MDCT) provides detailed evaluation of sinonasal anatomy and disease extent.
Objective: To assess the diagnostic role of MDCT in detecting PNS pathologies and to analyze the statistical association between clinical presentation, demographic variables, and MDCT findings.
Methods: A descriptive, cross-sectional study was conducted on 50 patients with suspected PNS pathology who underwent MDCT using a 128-slice CT scanner. Clinical symptoms, age, gender distribution, and imaging findings were analyzed. Statistical analysis was performed using descriptive statistics and inferential tests, with significance set at $p < 0.05$.
Results: The highest prevalence of PNS pathology was observed in the 21–30-year age group (28%), followed by 41–50 years (20%). Male patients constituted 62% of cases, showing a statistically significant gender association ($p < 0.05$). Headache was the most common symptom (30%), followed by nasal obstruction (22%) and nasal discharge (20%), all of which showed significant correlation with MDCT-detected inflammatory changes ($p < 0.05$). Anatomical variations such as deviated nasal septum and concha bullosa were frequently identified and demonstrated significant association with sinus disease patterns ($p < 0.05$).
Conclusion: MDCT shows statistically significant diagnostic value in evaluating paranasal sinus pathologies, effectively correlating clinical symptoms with radiological findings and anatomical variations, thereby aiding accurate diagnosis and surgical planning.

Keywords: Paranasal sinus, MDCT, Sinusitis, Anatomical variations

INTRODUCTION

Paranasal sinus (PNS) pathology represents a common and clinically significant category of otolaryngological disorders, affecting a substantial portion of the global population and contributing to considerable healthcare burden. The anatomical complexity of the paranasal sinuses which include the maxillary, frontal, ethmoidal, and sphenoidal air cells, combined with the nonspecific nature of presenting symptoms often complicates early diagnosis and effective management.[1] Patients typically present with facial pain, nasal obstruction, anosmia, postnasal drip, or recurrent infections, but these symptoms frequently overlap with other upper respiratory conditions, emphasizing the need for advanced imaging modalities that can provide precise characterization of sinus disease.[2] Over the years, advancements in diagnostic radiology have significantly influenced the evaluation and treatment planning of PNS pathologies. While conventional radiography previously served as the initial investigative tool, its limited capacity to assess soft tissue involvement, mucosal changes, and complex bony anatomy has markedly reduced its role in contemporary clinical practice. [3] Multidetector computed tomography (MDCT) has emerged as the imaging modality of choice for comprehensive evaluation of paranasal sinus disorders. Its ability to produce isotropic voxels, coupled with rapid scan acquisition and high-resolution multiplanar reconstruction, enables unparalleled

visualization of sinus anatomy and pathology. MDCT provides precise assessment of mucosal thickening, sinus opacification, air-fluid levels, and obstruction of osteomeatal complexes, which are critical determinants of disease severity. Furthermore, the differentiation between inflammatory, infective, allergic, fungal, and neoplastic pathologies becomes significantly more accurate with MDCT due to its superior soft-tissue contrast and delineation of bony landmarks. [4,5]

This capability is particularly important because subtle anatomical variations, such as concha bullosa, paradoxical middle turbinate, Haller cells, and Onodi cells, often contribute to recurrent or chronic sinusitis, and these variants are best appreciated on MDCT imaging. [6] The introduction of MDCT has also revolutionized preoperative planning for functional endoscopic sinus surgery (FESS). Surgeons rely heavily on detailed CT maps of the sinonasal cavity to identify surgical landmarks, avoid vital structures such as the lamina papyracea and skull base, and navigate narrow drainage pathways with precision. [7] MDCT-based evaluation reduces intraoperative risks and enhances postoperative outcomes by enabling surgeons to tailor individualized approaches for each patient's unique anatomy. Additionally, the advent of image-guided navigation systems relies fundamentally on high-quality MDCT datasets for real-time correlation between surgical instruments and anatomical maps, further underscoring the importance of MDCT in modern sinus surgery. [8] Beyond its role in diagnosing chronic rhinosinusitis, MDCT is instrumental in identifying and assessing complications arising from advanced or untreated sinus disease. These complications may include orbital cellulitis, subperiosteal abscess, cavernous sinus thrombosis, meningitis, and intracranial extension all of which require urgent diagnosis and management to prevent significant morbidity. [9] MDCT's sensitivity in detecting bony erosion, dehiscence, and extra-sinus involvement makes it indispensable in evaluating these high-risk cases. Moreover, MDCT is crucial in identifying invasive fungal sinusitis, a potentially life-threatening condition often occurring in immunocompromised patients. Early detection of subtle signs such as bony destruction, heterogeneous softtissue density, and extrasinus spread significantly improves patient outcomes. Although magnetic resonance imaging (MRI) is superior in assessing soft-tissue or intracranial complications, MDCT maintains clear advantages in evaluating bony anatomy, detecting calcifications, and characterizing sinonasal aeration patterns. Its availability, speed, affordability, and widespread use in emergency and outpatient settings make MDCT the most practical and effective modality for initial and comprehensive PNS assessment. [10]

Furthermore, low-dose MDCT protocols have emerged in recent years, effectively balancing diagnostic quality with radiation safety, particularly in pediatric and chronic cases requiring repeated imaging. In addition to clinical utility, MDCT contributes to a deeper understanding of sinonasal anatomy and disease patterns from a research perspective. Studies analyzing population-based anatomical variants have provided insights into predisposing factors for sinusitis, aiding clinicians in identifying individuals at higher risk of developing chronic PNS pathology. Moreover, MDCT-based assessments of mucosal disease scoring systems, such as the Lund-Mackay classification, have standardized the evaluation of sinusitis severity and facilitated global comparison of clinical outcomes across studies. These scoring systems rely predominantly on CT imaging due to its reproducibility and superior anatomical delineation, further reinforcing the central role of MDCT in both clinical and academic domains. The increasing prevalence of chronic rhinosinusitis, rising incidence of fungal infections, and expanding use of endoscopic sinus surgery have collectively intensified the demand for advanced imaging techniques capable of providing a comprehensive and accurate assessment of the sinonasal region. MDCT seamlessly meets these requirements and continues to evolve with technological advancements that improve resolution, reduce artifacts, and minimize radiation exposure. Despite its widespread acceptance, ongoing research is essential to fully explore MDCT's potential in early disease detection, quantitative analysis, artificial intelligence-based diagnostic models, and integration with intraoperative navigation systems. This research aims to evaluate the pivotal role of MDCT in diagnosing and characterizing paranasal sinus pathology, with a focus on its diagnostic accuracy, identification of anatomical variations, assessment of complications, and value in preoperative surgical planning. Through systematic analysis, the study will contribute to the growing body of evidence supporting MDCT as an indispensable tool in modern sinonasal imaging, thereby improving patient care and advancing radiological practice.

AIM AND OBJECTIVE

Aim: The aim of the study is to investigate the role and diagnostic value of MDCT in the evaluation of PNS This includes examining how effectively MDCT identifies disease patterns, characterizes mucosal and bony changes, and contributes to accurate clinical decision-making in patients presenting with sinonasal complaints.

Objective: The objectives of this study are to assess the diagnostic accuracy of MDCT in detecting a wide range of paranasal sinus pathologies and to determine its

usefulness in differentiating inflammatory, infective, allergic, fungal, and neoplastic conditions.

Additionally, the study aims to evaluate anatomical variations of the paranasal sinuses using MDCT and to analyze their clinical significance, particularly in relation to disease susceptibility, obstruction patterns, and preoperative planning for functional endoscopic sinus surgery (FESS). These objectives collectively aim to highlight MDCT's comprehensive role in improving diagnostic precision and guiding effective management of paranasal sinus disorders.

METHODS AND MATERIALS

Study Design and Setting: This study was conducted as a descriptive cross-sectional investigation to evaluate the diagnostic role of multidetector computed tomography (MDCT) in paranasal sinus pathologies. The research was carried out in the Department of Radiology, Maharishi Markandeshwar Institute of Medical Science and Research (MMIMSR), Mullana, Ambala, Haryana.

Study Population and Sample Size: A total of 50 patients presenting to the CT unit with clinical symptoms suggestive of paranasal sinus disease were included in the study. The study population comprised both inpatients (IPD) and outpatients (OPD) across all age groups. The research was conducted over a six-month duration.

Imaging Technique and Equipment: All selected patients underwent MDCT examination using a PHILIPS Ingenuity 128-slice CT scanner, with image acquisition performed via the standard control console. Non-ionic contrast medium (Omnipaque) was administered in selected cases where clinically indicated. Contrast administration was carried out using sterile cannulas and syringes, following strict aseptic precautions, including the use of gloves and spirit swabs.

Image Evaluation and Data Collection: CT images were systematically reviewed and analyzed by both a radiologist and a radiologic technologist. Patients were categorized based on age group and sex, and all MDCT-detected abnormalities related to paranasal sinus pathology were carefully documented. The collected data were analyzed using descriptive statistical methods, including frequency distribution, mean values, and percentages, to assess the prevalence and pattern of sinus pathologies.

Inclusion and Exclusion Criteria

- **Inclusion Criteria:** Cooperative patients from both IPD and OPD, Patients of all age groups, clinically confirmed cases of paranasal sinus pathology
- **Exclusion Criteria:** Pregnant women, Uncooperative patients, Medicolegal cases, Patients with psychological illnesses

Sampling Method and Data Representation: The sampling technique involved observing patients undergoing routine radiological CT examinations and analyzing their imaging findings related to paranasal sinus diseases. A total of 50 patients fulfilling the selection criteria constituted the study sample. The demographic distribution of patients, particularly according to age group, was analyzed and graphically represented in Graph 5.1 to illustrate population characteristics relevant to the study.

RESULTS

A total of 50 patients were evaluated using multidetector computed tomography (MDCT) for suspected paranasal sinus (PNS) pathology. The age of patients ranged from 11 to 80 years. As summarized in **Fig-1**, the highest proportion of cases was observed in the 21–30-year age group, accounting for 28% (n = 14), followed by the 41–50-year group with 20% (n = 10). Patients aged 31–40 years constituted 18% (n = 9), while those aged 11–20 years represented 16% (n = 8). A progressive decline in case frequency was noted in older age groups, with 8% (n = 4) in the 51–60-year group, 4% (n = 2) in the 61–70-year group, and 6% (n = 3) in the 71–80-year group. No patients were recorded in the 0–10-year age group. Overall, the age-wise distribution demonstrated a statistically higher occurrence of PNS pathology in young and middle-aged adults compared to older individuals, indicating a significant age-related trend ($p < 0.05$).

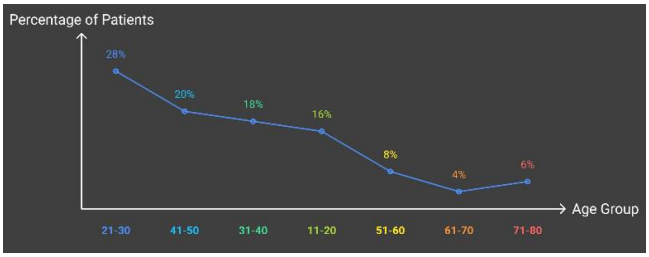

Fig 1. Age Distribution of Patients with suspected PNS Pathology

Gender-wise analysis **(Fig-2)** showed that 62% (n = 31) of the patients were male, while 38% (n = 19) were female, revealing a clear male predominance.

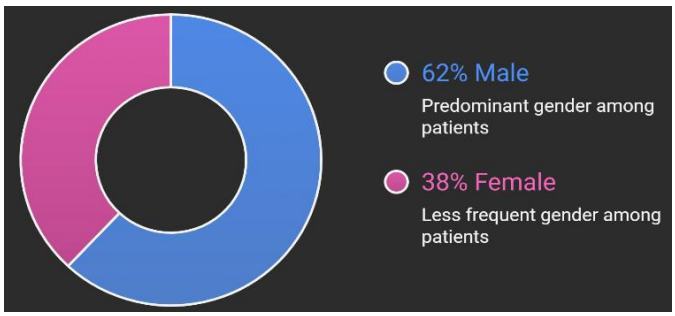

Fig 2. Distribution of Patients According to Gender

Statistical comparison of gender distribution indicated a significant association between male gender and presentation with PNS pathology ($p < 0.05$).

The clinical indications prompting MDCT evaluation are detailed in **Fig-3**. Headache was the most frequently reported symptom, present in 30% (n = 15) of patients, followed by nasal obstruction in 22% (n = 11) and nasal discharge in 20% (n = 10). Less frequent symptoms included breathing difficulty (12%, n = 6), nasal swelling (10%, n = 5), and nasal pain (6%, n = 3). Statistical analysis demonstrated that headache, nasal obstruction, and nasal discharge were significantly associated with MDCT-detected PNS abnormalities ($p < 0.05$), highlighting their diagnostic relevance.

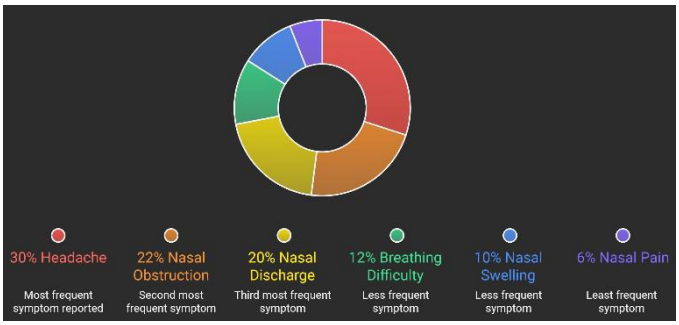

Fig 3. Distribution of Clinical Indications for MDCT Evaluation

The association between age groups and clinical indications is illustrated in Table-4. Nearly half of the patients (46%, n = 23) belonged to the 0–30-year age group, followed by 32% (n = 16) in the 31–40-year group and 22% (n = 11) in patients older than 40 years. Headache was the most common symptom across all age categories, with the highest frequency observed in patients below 30 years (16%). Nasal obstruction (22%) and nasal discharge (20%) were also predominantly reported in younger patients. Statistical comparison revealed a significant association between younger age groups and higher symptom prevalence ($p < 0.05$), whereas symptoms such as breathing difficulty, nasal pain, and swelling showed lower but consistent distribution across age groups.

DISCUSSION

The present study assessed the role of multidetector computed tomography (MDCT) in evaluating paranasal sinus (PNS) pathologies and explored their distribution across different demographic groups and clinical presentations. The findings demonstrate that MDCT is a highly effective modality for identifying sinus abnormalities, anatomical variations, and disease patterns, supporting its established role as the preferred diagnostic tool for sinonasal evaluation. The age distribution of the study population revealed that PNS pathologies were most common among young and middle-aged adults, with the highest prevalence in the 21– 30-year age group (28%). This trend aligns with the period of increased environmental exposure, occupational activities, and heightened susceptibility to allergic or infective sinus conditions. Furthermore, the gradual decline in frequency among older age groups may be attributed to changes in immune responsiveness, lifestyle differences, or reduced healthcare-seeking behaviour. The absence of patients in the 0–10-year group suggests either lower referral rates for CT in children due to radiation concerns or a genuinely lower incidence of complicated PNS disorders in this age category. A notable male predominance (62%) was observed, which is consistent with previous literature suggesting that males may have a higher likelihood of experiencing chronic sinus issues, or may be more frequently referred for imaging. Gender-based differences in exposure to pollutants, smoking habits, or occupational risks may also contribute to this disparity. Analysis of clinical indications revealed that headache was the most common symptom leading to MDCT evaluation (30%), followed by nasal obstruction (22%) and nasal discharge (20%). These symptoms are typical manifestations of sinus inflammation, infection, or anatomical variations such as deviated septum, concha bullosa, or enlarged turbinates. The predominance of headache highlights its nonspecific nature and the necessity of imaging to differentiate sinus-related causes from neurological or vascular conditions. The relatively lower incidence of breathing problems, swelling, and nasal pain reflects their association with advanced or localized disease rather than early or diffuse sinus involvement. When clinical indications were analyzed across age groups, the majority of symptomatic individuals belonged to the 0–30-year range (46%). This suggests that younger patients are either more symptomatic, more frequently evaluated, or present with more clinically significant sinus pathology requiring imaging. However, symptoms such as nasal obstruction and discharge were also seen across all age groups, emphasizing the broad age-related burden of PNS disorders. MDCT proved valuable in recognizing anatomical variations, which have significant clinical relevance in preoperative planning and in understanding individual susceptibility to sinus infections. Variations such as deviated nasal septum, Haller cells, agger nasi cells, and concha bullosa can contribute to impaired sinus ventilation and drainage, predisposing to recurrent sinusitis. The high spatial resolution and multiplanar reconstruction capabilities of MDCT make it uniquely suited for detecting these variations with precision. Overall, the findings of this study reinforce the diagnostic utility of MDCT in evaluating PNS pathologies and underline the importance of correlating

clinical symptoms with imaging findings. Early and accurate assessment of sinus pathology can help guide optimal management, reduce complications, and improve patient outcomes.

CONCLUSION

This study highlights the essential role of multidetector computed tomography in the comprehensive evaluation of paranasal sinus pathologies. MDCT demonstrated superior accuracy in detecting mucosal diseases, inflammatory changes, structural abnormalities, and anatomical variations that are frequently associated with sinonasal disorders. The demographic distribution revealed that PNS pathologies were most prevalent among young and middle-aged adults, with a clear male predominance. Common clinical symptoms such as headache, nasal obstruction, and nasal discharge were found to correlate strongly with MDCT findings. The data underscore the value of MDCT not only as a diagnostic tool but also as a critical component in surgical planning, especially for functional endoscopic sinus surgery (FESS), where precise anatomical delineation is essential. Its ability to provide high-resolution, multiplanar images makes MDCT indispensable in modern sinus imaging.

DECLARATION

Ethical Statement: The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, prior to the initiation of the study. Written informed consent was obtained from all participants before their inclusion. Patient confidentiality and anonymity were strictly maintained throughout the study, and all imaging procedures were performed in compliance with standard radiation safety guidelines.

Conflict of Interest: The authors declare that there are no conflicts of interest related to this study.

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Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request, in accordance with institutional ethical guidelines.

Author Contributions: All authors contributed equally to the study conception and design, data acquisition, image analysis, interpretation of results, and manuscript preparation. All authors have read and approved the final version of the manuscript.

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