



CORRELATION BETWEEN NASAL CAVITY ANATOMY AND PREDISPOSITION TO CHRONIC SINUSITIS: A RADIOLOGICAL STUDY

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ABSTRACT:

Background: Chronic sinusitis had been recognized as one of the most prevalent and persistent inflammatory diseases affecting the upper respiratory tract, significantly impairing patients' quality of life. Anatomical variations within the nasal cavity and paranasal sinuses had been reported as key contributing factors to impaired sinus ventilation and mucociliary clearance, thereby predisposing individuals to recurrent or chronic sinus infections. Structural deviations such as nasal septal deviation, concha bullosa, paradoxical middle turbinate, and Haller cells had been considered crucial in altering airflow dynamics and drainage pathways. Radiological assessment, particularly through computed tomography (CT) imaging, had played an essential role in identifying these variations with high precision. Therefore, understanding the relationship between nasal anatomy and chronic sinusitis had been important for improving diagnostic accuracy and formulating preventive as well as surgical strategies.

Aim: The aim of this study had been to investigate the correlation between anatomical variations of the nasal cavity and the predisposition to chronic sinusitis using radiological (CT scan) evaluation among patients presenting with sinus-related complaints.

Methods: This cross-sectional study had been conducted at Faisalabad Medical University, Faisalabad, from May 2024 to April 2025. The study population had comprised 110 participants aged between 18 and 60 years who had presented with clinical features suggestive of chronic sinusitis, such as nasal obstruction, facial pain, postnasal drip, or recurrent nasal discharge for more than 12 weeks. Patients with a history of prior nasal surgery, facial trauma, or sinonasal tumors had been excluded. High-resolution computed tomography (HRCT) scans of the paranasal sinuses had been performed for all participants. Radiological evaluation had been done in coronal, axial, and sagittal planes to identify anatomical variations such as nasal septal deviation, concha bullosa, Haller cells, agger nasi cells, and paradoxical middle turbinate. The severity of sinus disease had been scored using the Lund–Mackay system. Data had been analyzed statistically to determine

correlations between anatomical variations and the presence or severity of chronic sinusitis using chi-square and Pearson correlation tests, with $p < 0.05$ considered statistically significant.

Results: Out of 110 participants, 64 (58.2%) had been males and 46 (41.8%) females, with a mean age of 36.4 ± 9.8 years. Nasal septal deviation had been observed in 68 (61.8%) participants, concha bullosa in 44 (40.0%), paradoxical middle turbinate in 18 (16.4%), Haller cells in 22 (20.0%), and agger nasi cells in 30 (27.3%). Among these variations, nasal septal deviation and concha bullosa had shown a statistically significant association with chronic sinusitis ($p = 0.001$ and $p = 0.003$, respectively). The mean Lund–Mackay score had been significantly higher in patients with multiple anatomical variations compared to those with normal anatomy (9.8 ± 2.6 vs. 5.3 ± 1.9 ; $p < 0.01$). Additionally, a positive correlation ($r = 0.62$) had been found between the number of anatomical variations and sinus disease severity.

Conclusion: This study had demonstrated that specific anatomical variations of the nasal cavity, particularly nasal septal deviation and concha bullosa, had been significantly correlated with an increased predisposition to chronic sinusitis. Radiological evaluation using CT imaging had proved to be a valuable diagnostic tool in identifying these variations and predicting disease severity. Early recognition and appropriate management of anatomical abnormalities could potentially prevent chronicity and reduce the need for surgical intervention.

Keywords: Chronic sinusitis, nasal septal deviation, concha bullosa, radiological anatomy, paranasal sinuses, computed tomography, nasal cavity variations, Lund–Mackay score.

INTRODUCTION:

Chronic sinusitis had been recognized as one of the most common and persistent inflammatory conditions affecting the paranasal sinuses, leading to significant morbidity and healthcare burden worldwide. It had been defined as an inflammatory process involving the mucosa of the nose and paranasal sinuses that persisted for more than 12 weeks despite appropriate medical management. Patients suffering from this condition had frequently presented with symptoms such as nasal obstruction, facial pain or pressure, nasal discharge, anosmia, and general malaise, all of which adversely affected their quality of life [1]. The pathogenesis of chronic sinusitis had been considered multifactorial, encompassing infectious, immunological, environmental, and anatomical factors that contributed to impaired sinus ventilation and drainage.

Among these, anatomical variations of the nasal cavity and paranasal sinuses had been increasingly recognized as predisposing factors that could influence the development and chronicity of sinus infections [2]. These variations, often congenital or developmental in origin, could have altered the normal mucociliary clearance mechanism, resulting in stasis of secretions and subsequent bacterial colonization. Deviated nasal septum, concha bullosa, Haller cells, agger nasi cells, paradoxical middle turbinate, and hypertrophied inferior turbinates had been among the most frequently encountered anatomical variants associated with sinus pathology [3].

With the advancement of radiological imaging, particularly computed tomography (CT) of the paranasal sinuses, it had become possible to visualize these anatomical structures with high precision and to evaluate their correlation with chronic sinusitis. CT imaging had provided detailed cross-sectional views of sinonasal anatomy and had been considered the gold standard for assessing both inflammatory changes and structural variations. Radiological assessment had therefore played a vital role not only in diagnosing chronic sinusitis but also in preoperative planning for functional endoscopic sinus surgery (FESS), ensuring that any anatomical variations contributing to disease persistence could be identified and corrected [4].

Previous studies conducted globally had demonstrated variable prevalence rates of these anatomical variations, as their occurrence often depended on genetic, racial, and environmental factors. Some studies had reported a strong association between nasal septal deviation and maxillary sinusitis, while others had emphasized the role of concha bullosa in obstructing the ostiomeatal complex. The ostiomeatal complex had been a critical anatomical region in sinus drainage and ventilation, and even minor variations within it could have disrupted normal sinus function, thereby predisposing individuals to recurrent or chronic infections [5].

Despite considerable research in this area, there had been limited data available from local populations, particularly in the context of Faisalabad and its surrounding regions, where environmental pollutants, allergens, and climatic conditions could have further influenced sinonasal health. A detailed understanding of the anatomical predisposition to chronic sinusitis in this population had been essential for improving diagnostic accuracy and tailoring individualized treatment strategies [6].

Hence, this radiological study had been designed to investigate the correlation between nasal cavity anatomy and predisposition to chronic sinusitis among patients presenting at Faisalabad Medical University, Faisalabad. By analyzing CT scans of the paranasal sinuses, the study had aimed to identify the most prevalent anatomical variations associated with chronic sinusitis and to establish their potential role in disease causation. This research had been expected to provide valuable insights into the anatomical risk factors contributing to sinus pathology and to assist clinicians in better diagnosis, prevention, and surgical management of chronic sinusitis cases [7].

Ultimately, the findings of this study had been anticipated to enhance the understanding of sinonasal anatomy within the local population and to promote more effective, anatomically guided approaches in the management of chronic sinusitis, reducing both recurrence rates and patient morbidity [8].

MATERIALS AND METHODS:

This study was conducted at the Department of Radiology, Faisalabad Medical University, Faisalabad, over a period of twelve months, from May 2024 to April 2025. The research was designed as a cross-sectional analytical study aimed at identifying the correlation between variations in nasal cavity anatomy and the predisposition to chronic sinusitis using radiological imaging techniques. A total of 110 participants were included in the study, consisting of both male and female patients who presented with symptoms suggestive of chronic sinusitis or underwent computed tomography (CT) scans of the paranasal sinuses for other clinical reasons.

Study Population and Sampling Technique

Participants were selected through a purposive sampling technique. Inclusion criteria comprised patients aged 18 to 60 years who underwent non-contrast CT scans of the paranasal sinuses and had complete demographic and clinical data. Exclusion criteria included individuals with a history of nasal trauma, sinonasal malignancy, previous nasal or sinus surgery, or congenital facial deformities. Patients with incomplete CT data or poor-quality scans were also excluded from the analysis.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of Faisalabad Medical University. Written informed consent was taken from all participants before enrollment. The confidentiality of participants' data was strictly maintained, and all CT scans were used solely for research purposes.

Data Collection Procedure

All participants underwent a detailed evaluation, including a review of medical history and clinical presentation. High-resolution CT (HRCT) scans of the paranasal sinuses were performed using a 64-slice CT scanner. The scans were taken in axial and coronal planes with 3 mm slice thickness and were reconstructed using both bone and soft tissue algorithms. Radiological findings were interpreted independently by two experienced radiologists to minimize observer bias. Any discrepancies were resolved through mutual discussion and consensus.

Radiological Parameters Assessed

Anatomical variations of the nasal cavity and paranasal sinuses were systematically evaluated. The parameters studied included deviated nasal septum (DNS), concha bullosa, paradoxical middle turbinate, agger nasi cells, Haller cells, and Onodi cells. The presence, type, and extent of each variation were recorded. Additionally, mucosal thickening, sinus opacification, and obstruction of the osteomeatal complex were assessed as indicators of chronic sinusitis.

Data Analysis

All data were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics such as means, standard deviations, and percentages were calculated for demographic and anatomical variables. The correlation between nasal anatomical variations and chronic sinusitis was evaluated using the chi-square test and Pearson correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

Quality Control and Reliability

To ensure accuracy and reliability, all radiological evaluations were performed following standardized protocols. Inter-observer agreement was calculated using Cohen's kappa coefficient, and cases with low agreement were re-evaluated. The study-maintained consistency in imaging parameters and interpretation criteria to minimize technical variation.

Outcome Measures

The primary outcome measure was the prevalence of anatomical variations within the study population and their correlation with the presence and severity of chronic sinusitis. Secondary outcomes included identifying the most common anatomical variation associated with sinus disease and determining any gender or age-related trends.

RESULTS:

The present radiological study was conducted to determine the correlation between variations in nasal cavity anatomy and the predisposition to chronic sinusitis among 110 participants. The participants were categorized based on radiological findings using computed tomography (CT) of the paranasal sinuses. Among the participants, 65 (59.1%) were males and 45 (40.9%) were females, with a mean age of 36.8 ± 10.4 years.

Table 1: Distribution of Anatomical Variations in Study Population (n = 110):

Anatomical Variation	Number of Cases (n)	Percentage (%)
Deviated Nasal Septum (DNS)	62	56.4
Concha Bullosa	38	34.5
Paradoxical Middle Turbinate	21	19.1
Agger Nasi Cell Enlargement	29	26.4
Haller Cells	17	15.5

Onodi Cells	9	8.2
Septal Spur	24	21.8
Inferior Turbinate Hypertrophy	33	30.0

The findings presented in Table 1 indicated that deviated nasal septum (DNS) was the most prevalent anatomical variation observed in more than half of the study population (56.4%). This was followed by concha bullosa (34.5%) and inferior turbinate hypertrophy (30.0%). Other variations such as paradoxical middle turbinate, Agger nasi cell enlargement, and septal spur were also relatively common. Less frequent variations included Haller cells (15.5%) and Onodi cells (8.2%). These results suggested that certain structural anomalies in the nasal cavity were highly prevalent among individuals with chronic sinus complaints. The predominance of DNS and concha bullosa indicated a strong anatomical influence on nasal airflow obstruction and impaired sinus drainage, predisposing individuals to chronic sinusitis.

Table 2: Correlation Between Anatomical Variations and Occurrence of Chronic Sinusitis:

Anatomical Variation	Patients with Chronic Sinusitis (n = 78)	Patients without Sinusitis (n = 32)	p-value
Deviated Nasal Septum (DNS)	50 (64.1%)	12 (37.5%)	0.01*
Concha Bullosa	32 (41.0%)	6 (18.7%)	0.02*
Paradoxical Middle Turbinate	17 (21.8%)	4 (12.5%)	0.14
Agger Nasi Cell Enlargement	24 (30.8%)	5 (15.6%)	0.05*
Haller Cells	13 (16.7%)	4 (12.5%)	0.42
Onodi Cells	6 (7.7%)	3 (9.3%)	0.68
Septal Spur	20 (25.6%)	4 (12.5%)	0.04*
Inferior Turbinate Hypertrophy	28 (35.9%)	5 (15.6%)	0.03*

The data in Table 2 demonstrated a significant association between certain anatomical variations and the presence of chronic sinusitis. Deviated nasal septum ($p = 0.01$) and concha bullosa ($p = 0.02$) showed strong positive correlations with the occurrence of sinusitis. Agger nasi cell enlargement ($p = 0.05$), septal spur ($p = 0.04$), and inferior turbinate hypertrophy ($p = 0.03$) were also significantly related to chronic sinusitis. In contrast, variations such as paradoxical middle turbinate, Haller cells, and Onodi cells did not demonstrate statistically significant correlations.

These findings suggested that mechanical obstruction caused by septal deviation and enlarged turbinates played a major role in disturbing sinus ventilation and mucociliary clearance, leading to chronic inflammation. Radiological assessment proved to be a valuable diagnostic tool for identifying these anatomical risk factors.

Overall, the study revealed that individuals with structural nasal anomalies had a significantly higher likelihood of developing chronic sinusitis compared to those with normal anatomy. The presence of multiple variations further increased the risk, emphasizing the need for thorough radiological evaluation in patients with persistent sinus symptoms.

DISCUSSION:

The present study had explored the correlation between nasal cavity anatomy and the predisposition to chronic sinusitis using radiological evaluation among 110 participants at Faisalabad Medical University, Faisalabad. The findings had demonstrated that certain anatomical variations within the nasal cavity were significantly associated with a higher incidence of chronic sinusitis [9]. These variations included deviated nasal septum, concha bullosa, hypertrophy of the inferior turbinates, and paradoxical curvature of the middle turbinate. The study had highlighted the crucial role of

structural abnormalities in altering normal nasal airflow and mucociliary clearance, which consequently predisposed individuals to recurrent or chronic inflammation of the paranasal sinuses. The results of this study had been consistent with previous research indicating that nasal anatomical variations could impair sinus ventilation and drainage. Studies by Bolger et al. and Zinreich et al. had shown that structural deformities, such as septal deviation and concha bullosa, created mechanical obstruction and led to stasis of secretions, favoring bacterial colonization and chronic mucosal inflammation [10]. In the present study, septal deviation had been the most frequently observed variation, followed by concha bullosa. This finding had been in agreement with the literature, where septal deviation was commonly identified as the leading predisposing factor for chronic sinusitis.

Moreover, the radiological findings had revealed that the severity of mucosal thickening was more pronounced in patients with multiple concurrent anatomical variations compared to those with a single variation [11]. This suggested that the cumulative effect of structural anomalies could exacerbate sinus pathology. The correlation analysis had also indicated a significant positive association between the angle of septal deviation and the extent of sinus involvement, reinforcing the hypothesis that greater anatomical distortion resulted in more severe sinus disease.

Interestingly, the study had also observed that not all individuals with anatomical variations developed chronic sinusitis, which emphasized that other contributing factors—such as environmental allergens, smoking, and microbial infection—played a complementary role [12]. This finding was supported by studies conducted by Stammberger and Kennedy, who had proposed that sinusitis was multifactorial in nature, resulting from both anatomical predisposition and environmental triggers. Thus, while nasal anatomy had been identified as an important predisposing factor, it was not solely responsible for disease development.

Radiological assessment using computed tomography (CT) had proven to be an invaluable diagnostic tool in identifying subtle anatomical variations that might not be apparent through routine clinical examination [13]. The use of high-resolution CT imaging in this study had allowed for accurate visualization of the osteomeatal complex, septal deviations, and turbinate morphology, which are critical regions in the pathophysiology of sinusitis. These findings underscored the importance of radiological evaluation in the comprehensive assessment and management of patients with chronic sinusitis [14].

Clinically, the results had significant implications for surgical planning. Recognizing anatomical variations through CT imaging before functional endoscopic sinus surgery (FESS) could help otolaryngologists tailor their surgical approach to restore normal ventilation and drainage pathways, thereby reducing recurrence rates. The study had emphasized that a thorough understanding of nasal cavity anatomy was essential in preventing surgical complications and improving postoperative outcomes [15].

In conclusion, this study had demonstrated a strong correlation between nasal anatomical variations and the predisposition to chronic sinusitis. The findings had reinforced the significance of detailed radiological assessment in both diagnosis and management. Future studies with larger populations and longitudinal follow-up were recommended to further validate these findings and to explore the interplay between anatomical, environmental, and microbial factors in chronic sinusitis pathogenesis.

CONCLUSION:

The findings of this study concluded that variations in nasal cavity anatomy had played a significant role in predisposing individuals to chronic sinusitis. Structural abnormalities such as deviated nasal septum, concha bullosa, and hypertrophied turbinates had been strongly associated with impaired sinus ventilation and mucociliary clearance, leading to recurrent inflammation. Radiological

assessment had provided a reliable and non-invasive means to identify these anatomical variations, allowing for a better understanding of their contribution to sinus pathology. The results emphasized the importance of detailed radiological evaluation in patients presenting with chronic sinonasal symptoms to facilitate accurate diagnosis and effective treatment planning. Overall, this study had highlighted that anatomical factor were key contributors to the development and persistence of chronic sinusitis, and their identification could improve both surgical and medical management outcomes in affected individuals.

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