Original Article
DOI: https://doi.org/10.70749/ijbr.v3i7.1741

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Frequency of Anatomical Variations of Osteomeatal Complex among Patients with Chronic Rhinosinusitis

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ARTICLE INFO

Keywords: Anatomical Variation, Chronic rhinosinusitis, Osteomeatal complex.

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Declaration
Authors' Contribution: All authors equally contributed to the study and approved the final manuscript.

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 11-05-2025 Revised: 24-06-2025
Accepted: 02-07-2025 Published: 10-07-2025

ABSTRACT

Objectives: To determine the frequency of anatomical variations of osteomeatal complex in patients presenting with chronic rhinosinusitis. **Study design:** Descriptive cross-sectional study. **Date and place of study:** Department of Diagnostic Radiology, Combined Military Hospital, Multan, from Nov, 2024 to Apr, 2025. **Methods:** A total of 125 patients aged 18–65 years, clinically diagnosed with chronic rhinosinusitis (persistent symptoms lasting at least 12 weeks despite medication), and referred for CT scans of the paranasal sinuses were included in this study. A consultant radiologist identified anatomical variations of the osteomeatal complex. Descriptive statistics was applied to present the frequency and types of these variations. **Results:** The mean age of patients was 35.4 ± 11.2 years (range: 18–65 years). There were 59% males and 41% females. Anatomical variations of the osteomeatal complex were found in 112 (89.6%) patients. Most frequent variations were deviated nasal septum 82 (65.6%), concha bullosa 71 (56.8%), agger nasi cells 49 (39.2%), haller cells 34 (27.2%), pneumatized uncinate process 28 (22.4%), uncinate process deviation 25 (20%) and paradoxical middle turbinate 15 (12%). **Conclusion:** Anatomical variations of the osteomeatal complex are highly prevalent in patients diagnosed with chronic rhinosinusitis, with deviated nasal septum and concha bullosa being the most frequent variations observed in our population.

INTRODUCTION

Chronic rhinosinusitis (CRS) is defined as inflammation of the nasal and paranasal sinuses that lasts for more than 12 weeks, despite attempts at medical treatment. CRS is characterized by symptoms such as nasal obstruction, nasal discharge, facial pain/pressure, and reduction/loss of smell. The condition may be associated with mucosal thickening, sinus opacification, and in some cases, changes in adjacent bone.[1] The prevalence of CRS is reported to be 5% to 12%, exerting a significant impact on both economy and quality of life of these patients.[2]

The etiology of CRS is multifactorial including anatomical obstructions, infections, allergies, immune dysfunction, and biofilm formation. In rare cases genetic factors like primary ciliary dyskinesia, mucopolysaccharidosis, and cystic fibrosis may also contribute to its development. However, central to its pathogenesis are anatomical variations particularly in the osteomeatal complex (OMC), which causes impaired mucociliary clearance and sinus ventilation. Additionally, factors like environmental triggers and bacterial biofilms, also complicate this pathophysiology by perpetuating inflammatory responses and disrupting sinonasal drainage and airflow.[3,4]

The OMC, located in the middle meatus, serves as the anatomical gateway for drainage and ventilation of the frontal, maxillary, and anterior ethmoid sinuses. Obstruction in this narrow region becomes the cause of impaired mucociliary clearance, leading to secretion stasis, infection, and chronic inflammation. This obstruction may be caused by mucosal inflammation or anatomical variations such as, deviated nasal septum (DNS) , concha bullosa (CB), agger nasi cells (ANC), haller cells (HC), pneumatized uncinate process (PUP), paradoxical middle turbinate (PMT), uncinate process deviation (UPD) and others. These variations are crucial for diagnosing CRS and planning effective interventional strategies, especially in patients unresponsive to medical therapy requiring functional endoscopic sinus surgery (FESS).[5]

High-resolution computed tomography (CT) is the gold standard for the assessment of sinonasal anatomy and identification of anatomical variations in CRS. The technique provides detailed visualization of the OMC and reveals bony structures and mucosal abnormalities, essential for diagnosis and surgical planning. The combination of CT findings and nasal endoscopy, guide the management, especially for patients requiring FESS. [6,7]

It is important to note that prevalence and clinical impact of these anatomical variations have been observed in numerous studies conducted in Western and some Asian

populations; however, these findings vary across regions, highlighting the need for region-specific studies to guide clinical decision-making. Moreover, contribution of these variations to disease manifestation is inconsistent and shows varying degrees of clinical correlation.[8]

As the anatomical variations like septal deviation, concha bullosa, and paradoxical middle turbinate can narrow the osteomeatal complex and impair sinus drainage, predisposing to chronic sinusitis, surgical intervention is the recommended treatment to clear chronically infected sinuses and maintain ventilation and drainage. Identification of these variations is crucial not only for understanding the etiology of CRS but also for preventing surgical complications such as injury to vital structures like the orbit and skull base and performing a successful FESS procedure.[9,10]

Limited data exists on anatomical variations in OMC related to CRS in South Asian populations, especially Pakistan. As geographic, ethnic, and genetic differences may influence sinonasal anatomy and factors like pollution, poor healthcare access, and low awareness in developing nations may affect CRS presentation, understanding anatomical predispositions in our local population is important for early diagnosis and management of CRS. This research was therefore planned to determine the frequency of anatomical variations of the OMC among patients with CRS reporting at our hospital. These findings will provide valuable insights related to OMC variations in CRS and help our local surgeons performing FESS in these patients.

METHODOLOGY

This descriptive cross-sectional study was conducted at the Department of Diagnostic Radiology, Combined Military Hospital, Multan, from Nov-2024 to Apr-2025, over a period of six months following the ethical approval from the institutional review board.

The sample size was calculated as per following details:

Frequency of Paradoxical Middle Turbinate in CRS patients = *7.02%.*[11]

With confidence interval= 95% and margin of error= 5%, the estimated sample size was 101 patients. We, however, took a sample size of 125 patients to improve the power of study statistics.

A total of 125 patients aged 18–65 years, clinically diagnosed with CRS (defined by persistent symptoms lasting at least 12 weeks despite medication), and referred for CT scans of the paranasal sinuses were included in this study through consecutive sampling.

All participants provided informed consent before their enrollment.

Patients with a history of facial trauma, having any prior sinonasal surgery, with nasal polyposis, sinonasal malignancy or any congenital anomalies were excluded to avoid any confounding anatomical distortions. Any patient with poor quality of CT scan was also excluded.

All the demographic data, including age, gender, and duration of disease, were taken and recorded for each patient. A systematic assessment of OMC variations in CRS patients was conducted to provide valuable and meaningful insight into the overall prevalence and frequency of each variation.

CT scans were performed (using a Toshiba 160-slice Multi-Detector CT scanner) and detailed evaluation was done with high-resolution 0.5mm scans reconstructed into 1mm sections in axial, coronal, and sagittal planes. A consultant radiologist then analyzed and identified anatomical variations of the OMC, including DNS, CB, ANC, HC, PUP, PMT, UPD and any other variations. The bilateral or unilateral presence of each anatomical variation was also recorded. Additionally, the total number of variations per patient was noted to assess the presence of multiple occurrences of these changes in these patients suffering from CRS and diagnosed with OMC variations.

Data analysis was conducted using SPSS version 25. Descriptive statistics was applied where quantitative variables, including age and disease duration, were summarized as mean ± standard deviation, while qualitative variables, such as gender and types of OMC variations, were presented as frequencies and percentages. Additionally, bilateral and unilateral involvement and the distribution of patients based on the number of anatomical variations were also presented in frequencies and percentages.

RESULTS

The mean age was 35.4 ± 11.2 years (range: 18–65 years). There were 59% males and 41% females. The details of demographics and duration of disease are shown in Table 1.

Table 1

Demographics and Duration of Disease (n =125)

Variables		Value
Age (Mean± SD) years		35.18±10.01
Gender	Male n (%)	73 (58.4)
	Female n (%)	52 (41.6)
Duration of symptoms (Mean± SD) months		28.98±9.32

Anatomical variations of the OMC were reported in 112 (89.6%) patients where most frequent variations were DNS (65.6%), CB (56.8%), ANC (39.2%), HC 34 (27.2%), PUP (22.4%), UPD (20%) and PMT (12%), as shown in Table 2.

Table 2

*Anatomical Variations (*n=125)

Anatomical variations observed in patients with OMC	n (%)
DNS	82 (65.6)
CB	71 (56.8)
ANC	49 (39.2)
HC	34 (27.2)
PUP	28 (22.4)
UPD	25 (20)
PMT	15 (12)
No Variations	13 (10.4)

The bilateral and unilateral distribution of anatomical variations showed that DNS had the highest bilateral occurrence (76.8%), followed by CB (62.0%) and ANC (57.1%) as shown in Table 3.

Table 3
Bilateral and Unilateral Distribution of OMC Variations (n=112)

Anatomical variations	Bilateral n (%)	Unilateral n (%)
DNS (n=82)	63 (76.8)	19 (23.2)
CB (n=71)	44 (62)	27 (38)
ANC (n=49)	28 (57.1)	21 (42.9)
HC (n=34)	17 (50)	17 (50)
PUP (n=28)	13 (46.43)	15 (53.57)
UPD (n=25)	6 (24)	19 (76)
PMT (n=15)	5 (33.33)	10 (66.67)

The analysis found that majority of patients 101 patients (80.8%) presented with multiple anatomical variations as shown in Table 4.

Table 4
Number of Patients with Multiple Variations (n = 125)

Number of variations	Patient n (%)
0 Variations (normal anatomy)	13 (10.4)
1 Variation	11 (8.8)
2 Variations	36 (28.8)
3 Variations	46 (36.8)
4 Variations	17 (13.6)
5 Variations	2 (1.6)
6 Variations	0 (0)
7 Variations	0 (0)

DISCUSSION

There was a higher percentage of males (59%) compared to the females (41%) in our study. Anatomical variations of the OMC were reported in 112 (89.6%) patients where most frequent variations were DNS 65.6%, CB (56.8%), ANC (39.2%), HC (27.2%), PUP (22.4%), UPD (20%) and PMT (12%). The bilateral and unilateral distribution of anatomical variations showed that DNS had the highest bilateral occurrence (76.8%), followed by CB (62.0%) and ANC (57.1%). The analysis also showed that that majority of patients (80.8%) presented with multiple anatomical variations.

Anatomical variations in CRS have been studied in numerous research works with varying outcomes in international, South Asian and some Pakistani studies. The importance of evaluating these variations in CRS patients was reinforced by Papadopoulou AM et al., who conducted a review including 30 studies (6999 patients) on the association between anatomical variations and the sinus pathology. The results demonstrated statistically significant correlations between anatomical variations and increased sinus disease risk; however, some studies showed no significant association. The researchers emphasized the need for further research and comprehensive CT assessment in CRS patients undergoing endoscopic surgery.[13]

The above review reinforced the importance of regional data on this topic.

In an Indian cohort, Sonone J et al. evaluated the CRS patients using CT scans and found that ANC (91.23%) was most frequent variation. The other variations reported were HC (22.81%), CB (10.53%) and PMT (7.02%).[11] In contrast to this study Nautiyal A et al., explored paranasal sinus anatomical variants using CT imaging in patients predisposed to CRS and surgical complications. There were 423 variations identified in 250 patients where most common were PMT (30.73%), followed by HC (22.91%), DNS (21.91%), and ANC (21.64%).[14] Gouripur K et al. also aimed to analyze sinonasal anatomical variations in Indian population with CRS and having frontal sinus discharge using nasal endoscopy and CT scans. Among 50 patients investigated, common variations included ANC (96%), and DNS (70%). These findings highlighted the importance of thorough preoperative assessment for safe endoscopic sinus surgery.[15] Baisakhiya N et al. investigated 118 patients diagnosed with CRS in Bangladesh. CT scan revealed DNS (70.4%), ANC (49.2%), CB (30.5%), and HC (12.7%) as the most frequent OMC variations.[16]

Qureshi MF and Usmani A made a CT evaluation in 50 symptomatic sinusitis patients in Pakistan. The common anatomical variants included were ANC (64%), DNS (56%), and CB (46%). A significant correlation was also identified in this study with most common variation of bilateral ANC and nasal obstruction (p=0.017) providing good insights for the clinicians.[17]

Data for Pakistani population was further strengthened in a recently published study by Jawad A. et al. who analyzed CT scans of 95 patients undergoing FESS, with the aim to identify anatomical variations in sinonasal disease. The most commonly found variations were DNS (43%) and CB (27%). The study also emphasized on the importance of CT scan findings in detecting anatomical obstructions in order to optimize surgical planning for CRS patients.[18]

The results of these studies are aligned with our findings and point towards the frequently observed anatomical variations of OMC in patients diagnosed with CRS that must be assessed using CT imaging.

CONCLUSION

Anatomical variations of the OMC are highly prevalent in patients diagnosed with CRS, with DNS, CB and ANC, being the most commonly observed variations in our population that contribute to impaired sinus drainage and ventilation. Evaluation of these patients using CT imaging is therefore important in the diagnostic assessment and tailored management strategies.

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