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Anatomical Variations of the Osteomeatal Complex on Diagnostic Nasal Endoscopy and CT Imaging in Patients with Sinonasal Symptoms: A Hospital-Based Observational Study

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Abstract

Background: Background: Anatomical variants around the osteomeatal complex (OMC) influence ventilation and drainage of the anterior paranasal sinuses and can modify the clinical course of sinonasal inflammatory disease. ***Objectives***: To estimate the frequency and patterns of OMC-related anatomical variations in symptomatic patients and to compare detection of key variants and OMC obstruction on diagnostic nasal endoscopy (DNE) versus computed tomography (CT). ***Methods***: This hospital-based observational study included 100 patients with sinonasal symptoms evaluated with both DNE and non-contrast CT of the paranasal sinuses. OMC-related bony variations and signs of obstruction/mucosal disease were recorded using a standardized proforma and summarized descriptively. ***Results:*** The mean age was 34.6 ± 11.2 years (18–65 years); 58% were men. Nasal obstruction (72%) and postnasal drip/nasal discharge (61%) were most frequent. OMC variations were identified in 82% on CT and 76% on DNE; multiple co-existing variants were present in 54%. Deviated nasal septum (65% on CT; 60% on DNE) and concha bullosa (38% on CT; 34% on DNE) predominated. OMC obstruction was observed in 58% on CT and 52% on DNE, with maxillary sinus mucosal thickening as the most common radiological association. ***Conclusion***: OMC variations were common among symptomatic patients and often occurred in combination. CT was superior for deep or subtle bony variants, while DNE complemented imaging by characterizing mucosal inflammation and functional narrowing of the middle meatus.

Keywords: osteomeatal complex; diagnostic nasal endoscopy; CT paranasal sinuses; anatomical variation; sinonasal symptoms; chronic rhinosinusitis.

INTRODUCTION

The osteomeatal complex (OMC) represents the key functional corridor for aeration and mucociliary drainage of the maxillary sinus, anterior ethmoid cells, and frontal recess. Obstruction at this narrow region promotes stasis of secretions and sustained mucosal inflammation, underpinning a large proportion of chronic rhinosinusitis (CRS) presentations. The functional endoscopic sinus surgery paradigm emphasized restoring physiologic drainage by addressing disease in and around the OMC rather than undertaking radical mucosal clearance [1]. Consequently, precise anatomic assessment has become central to both diagnosis and safe surgical planning. Variations in the lateral nasal wall can also modify the proximity of surgical dissection to the lamina papyracea and skull base, where narrow recesses increase procedural risk. Multiplanar CT review provides a reliable map of these relationships and supports safer, anatomy-driven intervention [2,3]. Computed tomography (CT) of the paranasal sinuses provides high-resolution delineation of the bony boundaries of the OMC and adjacent cells, enabling recognition of clinically relevant variants and their relationships to the orbit and skull base [2,3]. Common variants include deviated nasal septum (DNS), concha bullosa, paradoxical middle turbinate, agger nasi cells, Haller cells, prominent ethmoidal bulla, and uncinate process deviations. These patterns can contribute to narrowing of the infundibulum and middle meatus, alter airflow dynamics, and predispose to contact points that amplify symptoms in selected patients [4,5]. At the same time, anatomical variants are prevalent in the general population and are not uniformly pathogenic, making side-specific correlation with mucosal disease essential [3,4]. Systematic syntheses and regional series demonstrate wide prevalence ranges across ethnic and clinical settings, reinforcing the value of institution-level prevalence data to contextualize imaging and endoscopic reports [4,6-9].

Diagnostic nasal endoscopy (DNE) complements CT by allowing direct visualization of the middle meatus, uncinate process, and mucosal status, including edema, discharge, and contact points that are not quantified by imaging alone [8,9]. However, endoscopy has limited access to deeper cells, particularly infraorbital ethmoid (Haller) cells, and subtle bony contour changes are better appreciated on CT [10,11]. A structured comparison of DNE and CT findings in symptomatic

patients can therefore guide rational investigation and highlight the relative utility of each modality in routine care. In resource-constrained workflows, such evidence helps prioritize endoscopy for inflammatory assessment and reserve CT for detailed anatomic mapping when clinically required [9-11]. The present study was undertaken to determine the prevalence and laterality of OMC-related anatomical variations on DNE and CT in patients presenting with sinonasal symptoms and to describe their association with OMC obstruction and mucosal disease.

MATERIALS AND METHODS

Study design and setting: A hospital-based observational (cross-sectional) study was conducted in the Department of Anatomy, Government Medical College, Jagtial, Telangana, India, over a 10-month period (March 2025 to December 2025). Patients were recruited from outpatient services where individuals with sinonasal complaints were referred for endoscopic evaluation and CT imaging as part of routine work-up.

Study population: Consecutive patients aged 18–65 years presenting with sinonasal symptoms (nasal obstruction, nasal discharge/postnasal drip, facial pain/pressure, or headache) were screened. A total of 100 eligible participants were included. Patients with a history of prior sinonasal surgery, maxillofacial trauma, sinonasal tumors, invasive fungal sinusitis, craniofacial anomalies, pregnancy, or inadequate CT images were excluded to avoid confounding structural distortion.

Diagnostic nasal endoscopy (DNE): A 0° rigid nasal endoscope was used after topical decongestion and local anesthesia. The nasal cavity was examined sequentially for septal deviation, middle turbinate morphology, visibility of concha bullosa, paradoxical curvature, ethmoidal bulla prominence, and uncinate process appearance. The middle meatus was assessed for edema, purulent discharge, and crowding/narrowing suggestive of functional OMC obstruction. Findings were documented separately for right and left sides using a standardized checklist; the approach mirrored methods described in endoscopy–CT correlation studies [8,9].

CT protocol and image review: Non-contrast CT of the paranasal sinuses was performed with thin-section acquisition and multiplanar reconstruction, emphasizing coronal and axial planes. Images were reviewed for OMC-related bony variants: DNS, concha bullosa, paradoxical middle turbinate, agger nasi cells, Haller cells, enlarged ethmoidal bulla, and uncinate process variations. OMC obstruction was defined radiologically by crowding or opacification at the infundibulum/hiatus semilunaris region with associated sinus mucosal disease. Mucosal thickening or opacification of the maxillary and anterior ethmoid sinuses was recorded as radiological involvement. CT assessment followed established imaging principles used for pre-endoscopic planning [2,3,10].

Outcome measures: Primary outcomes were the prevalence of OMC-related anatomical variations on CT and DNE and their laterality (unilateral/bilateral). Secondary outcomes included the frequency of OMC obstruction on CT and DNE and the pattern of associated mucosal disease. Multiplicity was defined as the presence of two or more anatomic variations in a single participant.

Statistical analysis: Data were entered into a spreadsheet and analyzed descriptively. Continuous variables were summarized as mean ± standard deviation (SD), while categorical variables were expressed as frequency and percentage. CT and DNE findings were compared qualitatively to describe areas of concordance and modality-specific detection, as reported in prior work [8,11,13].

Ethical considerations: Institutional approval was obtained before study initiation. Written informed consent was taken from each participant. DNE and CT were performed as part of clinical assessment, and identifiers were removed during analysis to maintain confidentiality.

RESULTS

A total of 100 patients with sinonasal symptoms were evaluated using both DNE and CT of the paranasal sinuses. The mean age was 34.6 ± 11.2 years (range: 18–65 years). Men constituted 58% of the cohort. Nasal obstruction was the predominant symptom (72%), followed by nasal discharge/postnasal drip (61%), facial pain/pressure (48%), and headache (44%). Baseline demographic characteristics and symptom distribution are summarized in Table 1.

Table 1. Demographic Profile and Presenting Symptoms of the Study Population (N = 100)

Variable	Value
Age (years), mean ± SD	34.6 ± 11.2
Age range (years)	18–65
Male sex, n (%)	58 (58.0)
Female sex, n (%)	42 (42.0)

Nasal obstruction, n (%)	72 (72.0)
Nasal discharge / postnasal drip, n (%)	61 (61.0)
Facial pain / pressure, n (%)	48 (48.0)
Headache, n (%)	44 (44.0)

OMC-related anatomical variations were identified in 82 patients (82%) on CT imaging, whereas 76 patients (76%) showed corresponding variations on DNE. DNS was the most frequent variant on both modalities (65% on CT; 60% on DNE). Concha bullosa (38% on CT; 34% on DNE), agger nasi cells (42% on CT; 28% on DNE), and enlarged ethmoidal bulla (30% on CT; 26% on DNE) were also common. Haller cells were detected in 18% on CT and were not reliably visualized on endoscopy. A side-by-side distribution of variants detected on CT and DNE is presented in Table 2.

Table 2. Prevalence of Osteomeatal Complex Anatomical Variations Detected on CT and DNE

Anatomical variation	**CT scan n (%)**	**DNE n (%)**
Deviated nasal septum (DNS)	65 (65.0)	60 (60.0)
Concha bullosa	38 (38.0)	34 (34.0)
Paradoxical middle turbinate	22 (22.0)	20 (20.0)
Enlarged ethmoidal bulla	30 (30.0)	26 (26.0)
Agger nasi cells	42 (42.0)	28 (28.0)
Uncinate process variation	27 (27.0)	24 (24.0)
Haller cells	18 (18.0)	—

With respect to distribution, unilateral OMC variations were observed in 46% of patients, while 36% demonstrated bilateral involvement; 18% had no identifiable anatomical variation. Multiplicity was prominent: 54% of participants had two or more anatomical variations, whereas 28% showed a single variation. Laterality and multiplicity patterns are detailed in Table 3.

Table 3. Laterality and Multiplicity of Osteomeatal Complex Variations (N = 100)

Pattern of variation	**n (%)**
Unilateral involvement	46 (46.0)
Bilateral involvement	36 (36.0)
No identifiable variation	18 (18.0)
Single anatomical variation	28 (28.0)
Multiple anatomical variations (≥2)	54 (54.0)

Evidence of OMC obstruction was identified in 58% on CT and 52% on DNE. Maxillary sinus mucosal thickening was the most frequent radiological accompaniment (62%), followed by anterior ethmoid involvement (49%). On endoscopy, middle meatal mucosal edema (55%) and middle meatal discharge (47%) were common inflammatory findings. Findings related to obstruction and mucosal disease are summarized in Table 4.

Table 4. Osteomeatal Complex Obstruction and Associated Mucosal Disease

Finding	**CT scan n (%)**	**DNE n (%)**
OMC obstruction	58 (58.0)	52 (52.0)
Maxillary sinus mucosal thickening	62 (62.0)	—
Anterior ethmoid sinus involvement	49 (49.0)	—
Middle meatal mucosal edema	—	55 (55.0)
Middle meatal discharge	—	47 (47.0)

Overall concordance between CT and DNE was high for readily visible structural variants such as DNS, concha bullosa, and paradoxical middle turbinate. CT demonstrated clear advantage for identifying agger nasi cells, Haller cells, and subtle uncinate process deviations. In contrast, DNE provided richer information on mucosal edema, discharge, and dynamic crowding of the middle meatus, supporting its role as a complementary bedside assessment.

DISCUSSION

This study demonstrates a high burden of OMC-related anatomical variations among patients presenting with sinonasal symptoms, with four out of five individuals showing at least one variation on CT. The predominance of DNS and concha bullosa aligns with the well-established observation that septoturbinal asymmetry is common in symptomatic CRS cohorts and is routinely encountered during preoperative CT mapping [2,3,5-8]. Beyond single variants, more than half of participants exhibited multiple co-existing changes, a pattern also highlighted in earlier Indian studies, supporting the view

that cumulative narrowing at the middle meatus often reflects several small anatomic contributions rather than one dominant lesion [6-9,13].

CT identified a broader spectrum of variants than DNE, particularly for agger nasi and Haller cells, which are situated in regions that are either partially concealed endoscopically or require angled scopes and extensive middle meatal dissection for confident visualization. This modality-specific advantage is consistent with CT-based anatomic mapping studies that emphasize the role of multiplanar imaging in detecting infraorbital and frontal recess-related cells that influence the infundibulum and frontal drainage pathways [2,3,10,11]. Recent work focusing on Haller cells underscores their potential relevance to chronic mucosal disease by contributing to infundibular constriction and altered ventilation at the ostiomeatal unit, strengthening the rationale for documenting this variant in symptomatic patients [14].

Conversely, DNE offered added clinical granularity by capturing mucosal edema, active discharge, and functional crowding of the middle meatus features that represent the inflammatory component of disease rather than fixed bony anatomy. Comparative studies have similarly noted that while CT provides a comprehensive structural map, endoscopy better reflects current mucosal activity and helps localize the source of secretions, thereby guiding targeted medical therapy or culture-directed management when indicated [8,9,13]. The observed rates of OMC obstruction on CT and endoscopy in the present cohort highlight this duality: CT indicates the anatomic and mucosal substrate of obstruction, whereas DNE depicts the accessible endoscopic correlate and the inflammatory milieu that influences symptom severity.

The clinical implication is a complementary workflow. CT remains essential when planning intervention, when deeper variants are suspected, or when symptom burden persists despite appropriate medical management [2,3]. DNE is valuable as an initial office-based assessment to document middle meatal inflammation, identify obvious structural crowding, and support clinical phenotyping of sinonasal disease [9,10]. Systematic reviews continue to emphasize that anatomical variants are common and not uniformly pathogenic; the interpretive value lies in relating a given variant to localized obstruction, endoscopic inflammation, and the pattern of sinus mucosal disease on CT [3,4,12]. Within this framework, the present findings add local data describing the distribution and detectability of OMC variants in a symptomatic hospital population and reinforce the pragmatic role of integrating endoscopic and radiological assessment.

Limitations

This single-center study enrolled only symptomatic patients and lacked an asymptomatic control group, limiting causal inference between variants and symptoms. CT and endoscopic severity scores were not applied, so gradient relationships were not evaluated. Interobserver agreement across modalities was not quantified. Analyses were descriptive and unadjusted for confounders such as allergic rhinitis, smoking, or occupational exposure. Seasonality and baseline medication use at presentation were not recorded

CONCLUSION

OMC-related anatomical variations were frequent in this hospital cohort with sinonasal symptoms, and combined variants were more common than isolated single changes. DNS and concha bullosa were the dominant patterns on both CT and DNE, while agger nasi and Haller cells were better characterized on CT. Evidence of OMC obstruction was identified in over half of patients, with maxillary and anterior ethmoid mucosal disease as the leading radiological associations. DNE provided complementary value by demonstrating middle meatal edema and discharge, supporting its role as a functional correlate to CT-based anatomic mapping. An integrated CT–DNE approach therefore offers a practical framework for comprehensive evaluation of symptomatic patients in routine practice.

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