



Original article

Association Between Sinonasal Anatomical Variations on CT and Chronic Rhinosinusitis: A Retrospective Cross-Sectional Study

Abdulbaset Eldeep^{1*}, Seham Albadri¹, Fatma Soof¹, Halima Mohamed¹, Hassan Alramash²

Department of Radiology, School of Medical Sciences, Libyan Academy for Postgraduate Studies, Ajdabiya, Libya

Department of Physics, Faculty of Science, University of Ajdabiya, Libya

Email. a.aldeep@academya.edu.ly

Abstract

Chronic rhinosinusitis (CRS) is a common inflammatory disease that may be associated with anatomical variations of the paranasal sinuses. This retrospective cross-sectional study evaluated 95 adult patients who underwent multidetector CT to determine the prevalence of sinonasal anatomical variations and their association with CRS. Anatomical variations were identified in 80.0% of patients, with nasal septal deviation (34.7%) and middle concha bullosa (31.6%) being the most frequent findings. Radiological evidence of CRS was present in 49.5% of cases. Nasal septal deviation showed a significant association with CRS ($P = 0.002$), whereas no significant associations were found for the remaining anatomical variations. These findings suggest that nasal septal deviation may contribute to chronic rhinosinusitis, while multidetector CT remains the imaging modality of choice for evaluating sinonasal anatomy and supporting surgical planning.

Keywords: Chronic rhinosinusitis; Computed tomography; Paranasal sinuses; Anatomical variations; Nasal septal deviation; Concha bullosa.

Introduction

Chronic rhinosinusitis (CRS) is a common inflammatory disorder of the nose and paranasal sinuses characterized by persistent sinonasal symptoms lasting for at least 12 weeks. It affects approximately 5–12% of the adult population worldwide and is associated with impaired quality of life and increased healthcare utilization. The pathogenesis of CRS is multifactorial and involves complex interactions among microbial infection, allergy, environmental factors, immune dysregulation, and anatomical variations of the sinonasal cavity (1,3).

Anatomical variations of the sinonasal region are common findings on computed tomography (CT) and have long been considered potential predisposing factors for impaired drainage of the osteomeatal complex, resulting in obstruction of normal mucociliary clearance and chronic inflammation. Common anatomical variations include nasal septal deviation, concha bullosa, septal bullosa, Haller cells, Onodi cells, agger nasi cells, and frontal sinus hypoplasia (4–8). However, the relationship between these anatomical variations and chronic rhinosinusitis remains controversial, with previous studies reporting inconsistent findings (1,3,9,10).

Multidetector computed tomography (MDCT) is considered the imaging modality of choice for evaluating sinonasal anatomy because of its excellent spatial resolution and ability to accurately demonstrate both anatomical variations and inflammatory changes. In addition to confirming the extent of sinonasal disease, CT plays a crucial role in preoperative planning for functional endoscopic sinus surgery (FESS) by identifying important anatomical landmarks and potentially hazardous

variations that may increase the risk of surgical complications.(4,11,12)

Although numerous studies have investigated the prevalence of sinonasal anatomical variations and their association with chronic rhinosinusitis, the reported findings remain inconsistent across different populations. Furthermore, data from North African countries, particularly Libya, are scarce, limiting the applicability of international evidence to local clinical practice.(1,3,10,13,14)

Therefore, this retrospective cross-sectional study aimed to determine the prevalence of sinonasal anatomical variations detected on multidetector CT and to evaluate their association with radiological evidence of chronic rhinosinusitis among adult patients at Sebha Medical Center, Libya.

Methods

Study Design and Setting

A retrospective observational cross-sectional study was conducted at Sebha Medical Center, Sebha, Libya, to investigate the association between anatomical variations of the paranasal sinuses and chronic rhinosinusitis. The study included adult patients who underwent multidetector computed tomography (MDCT) of the paranasal sinuses over a 6-month period in 2025 for clinically suspected chronic sinonasal disease.

Study Population

A total of 95 consecutive adult patients who underwent CT examination of the paranasal sinuses during the study period were included. Patients with a history of previous functional endoscopic sinus surgery (FESS), maxillofacial

trauma, nonseasonal tumors, congenital craniofacial anomalies, or poor-quality CT images were excluded.

CT Acquisition Protocol

All examinations were performed using a 128-slice Philips multidetector CT scanner. Non-contrast CT images were acquired using a dedicated sinonasal protocol with 1-mm slice thickness in axial and coronal planes, extending from the frontal sinus roof to the hard palate. Images were reconstructed in multiple planes and reviewed using the institutional PACS workstation.

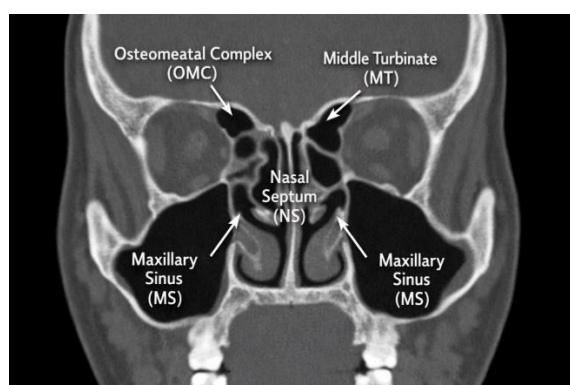


Figure 1. Coronal multidetector CT image showing normal sinonasal anatomy. The osteomeatal complex (OMC), middle turbinate (MT), nasal septum (NS), and maxillary sinus (MS) are identified.

Image Analysis

CT images were evaluated for the presence of anatomical variations, including nasal septal deviation, middle concha bullosa, inferior concha bullosa, septal bullosa, and frontal sinus aplasia/hypoplasia. Radiological features of chronic rhinosinusitis were assessed according to mucosal thickening, partial or complete sinus opacification, and other established CT criteria.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics were expressed as frequencies and percentages. Associations between anatomical variations and chronic rhinosinusitis were evaluated using Pearson's Chi-square test or Fisher's exact test, as appropriate. P-value < 0.05 was considered statistically significant.

Ethical Considerations

This retrospective study was conducted using anonymized CT imaging data retrieved from the institutional radiology archive. All patient identifiers were removed before data collection and analysis to ensure confidentiality. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

The study cohort comprised 95 patients referred for computed tomography evaluation of the paranasal sinuses. Sinonasal anatomical variations were identified in 76/95 patients (80.0%), whereas 19 patients (20.0%) exhibited completely normal anatomy. Mucosal abnormalities consistent with chronic rhinosinusitis (CRS) were documented in 47 cases (49.5%), while 48 cases (50.5%) showed no radiological evidence of sinusitis.

To evaluate the clinical significance of the detected anatomical variants, a Chi-square test was conducted to analyze the correlation between each specific variant and the presence of mucosal thickening or sinus opacification (Table 1).

Table 1: Distribution of Sinonasal Anatomical Variants and Their Statistical Correlation with Chronic Rhinosinusitis (n = 95)

Anatomical Variant	No. of Cases	Percentage (%)	P-value	Statistical Significance
Nasal septal deviation	33	34.7%	0.002	Highly Significant (P < 0.05)
Middle concha bullosa	30	31.6%	1.000	Not Significant (P > 0.05)
Nasal septal bullosa	5	5.3%	0.980	Not Significant (P > 0.05)
Unpneumatized frontal sinus	4	4.2%	0.624	Not Significant (P > 0.05)
Inferior concha bullosa	3	3.2%	0.985	Not Significant (P > 0.05)

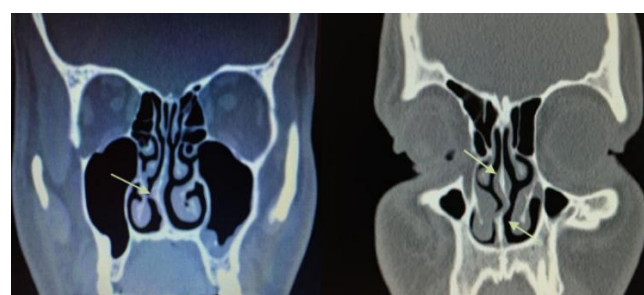


Figure 2. A: Deviated nasal septum to right side with nasal spur. B: Double nasal septum deviation, with the upper portion deviated to the left, and the lower portion to the right.

Nasal septal deviation was the most frequent anatomical variation (34.7%), followed by middle concha bullosa (31.6%), whereas inferior concha bullosa was the least common (3.2%). Some patients had more than one anatomical variation.

The statistical analysis revealed a highly significant correlation between nasal septal deviation and the occurrence of chronic rhinosinusitis ($P = 0.002$). Conversely, no statistically significant associations were found between sinusitis and other variations, including middle concha bullosa ($P = 1.000$), nasal septal bullosa ($P = 0.980$), unpneumatized frontal sinus ($P = 0.624$), or inferior concha bullosa ($P = 0.985$).

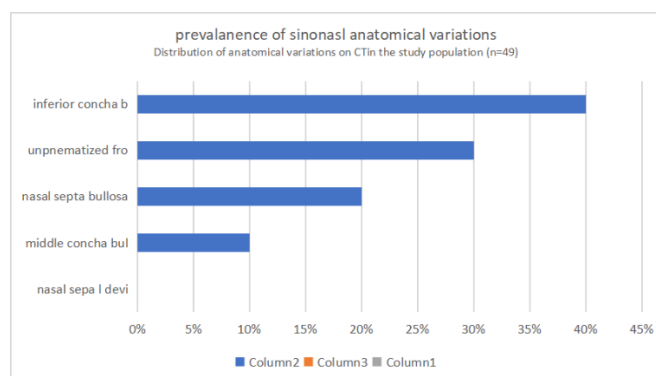


Figure 3. Prevalence of sinonasal anatomical variations detected by multidetector CT among the study population (n = 95).

Discussion

This retrospective study demonstrated a high prevalence of sinonasal anatomical variations (80.0%) among symptomatic patients undergoing CT evaluation of the paranasal sinuses. This finding is consistent with previous studies and systematic reviews reporting that anatomical variations are common in both healthy individuals and patients with chronic rhinosinusitis.(1,3) Nasal septal deviation was the most frequent anatomical variation, affecting 34.7% of the study population. A statistically significant association was observed between nasal septal deviation and chronic rhinosinusitis ($P = 0.002$), suggesting that septal deviation may contribute to impaired ventilation and obstruction of the osteomeatal complex, thereby promoting chronic mucosal inflammation. Similar findings have been reported in previous studies demonstrating an association between nasal septal deviation and increased maxillary sinus mucosal thickening.(9) Middle concha bullosa was the second most common anatomical variation (31.6%). However, despite its relatively high prevalence, no statistically significant association with chronic rhinosinusitis was identified ($P = 1.000$). These findings are consistent with previous reports suggesting that concha bullosa is a common anatomical variant that is not necessarily associated with sinonasal disease unless accompanied by significant obstruction or secondary inflammatory changes.(3,10)



Figure 4. Bilateral concha bullosa, more evident on the right side.

Other anatomical variations, including septal bullosa (5.3%), frontal sinus aplasia or hypoplasia (4.2%), and inferior concha bullosa (3.2%), were relatively uncommon. None of these variants demonstrated a statistically significant association with chronic rhinosinusitis, which agrees with previous reports indicating that these anatomical variations are generally incidental findings with limited clinical significance.(4) From a surgical perspective, multidetector CT remains indispensable for the preoperative evaluation of patients undergoing functional endoscopic sinus surgery (FESS). Accurate identification of anatomical variations facilitates surgical planning, improves orientation within the Sinonasal cavity, and reduces the risk of complications involving critical structures such as the skull base, orbit, and internal carotid artery.(4,11,12)

Limitations

The present study has several limitations. It was conducted at a single center with a relatively small sample size and employed a retrospective design, which may limit the generalizability of the findings. In addition, only radiological findings were evaluated without correlating them with endoscopic or postoperative outcomes. Therefore, larger prospective multicenter studies are recommended to further clarify the relationship between sinonasal anatomical variations and chronic rhinosinusitis.

Conclusion

Sinonasal anatomical variations are common CT findings in patients with chronic sinonasal symptoms. Among the evaluated anatomical variants, only nasal septal deviation demonstrated a significant association with chronic rhinosinusitis. Multidetector CT remains the imaging modality of choice for assessing sinonasal anatomy, identifying clinically relevant anatomical variations, and facilitating safe preoperative planning for functional endoscopic sinus surgery. Further multicenter



studies with larger sample sizes are recommended to validate these findings.

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