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Original Research Article

A RETROSPECTIVE STUDY ON THE IMPACT OF ANATOMICAL VARIATIONS ON OSTEOMEATAL OBSTRUCTION IN CHRONIC RHINOSINUSITIS

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ABSTRACT

Background: Chronic rhinosinusitis (CRS) is a multifactorial inflammatory disorder affecting the nasal cavity and paranasal sinuses. The osteomeatal complex (OMC) plays an important role in sinus ventilation and drainage. OMC obstruction has traditionally been linked to sinonasal anatomical variations, though recent studies suggest these variations may not significantly contribute to obstruction. The aim is to evaluate the impact of sinonasal anatomical variations on osteomeatal complex obstruction in patients with chronic rhinosinusitis using computed tomography (CT) and diagnostic nasal endoscopy (DNE). **Materials and Methods:** This retrospective observational study included 214 patients diagnosed with CRS who underwent CT scan of the paranasal sinuses and DNE over a three-year period. Sinonasal anatomical variations and OMC obstruction were assessed and correlated. Statistical analysis was performed using Chi-square test and binary logistic regression, with $p < 0.05$ considered statistically significant. **Result:** The most common anatomical variation identified on CT and DNE was deviated nasal septum. OMC obstruction was present in several patients but not in all cases. Most anatomical variations, including concha bullosa, agger nasi cells, and uncinate process variations, showed no statistically significant association with OMC obstruction. Only left-sided paradoxical middle turbinate showed a significant correlation ($p < 0.05$). The presence of multiple anatomical variations also did not significantly influence OMC obstruction. **Conclusion:** Osteomeatal complex obstruction is not consistently present in all patients with chronic rhinosinusitis, and sinonasal anatomical variations alone are not significant predictors of CRS. These findings support the multifactorial nature of CRS, with inflammatory and functional factors playing an important role in disease pathogenesis.

INTRODUCTION

Chronic rhinosinusitis (CRS) is a persistent inflammatory condition affecting the lining of the nasal cavity and paranasal sinuses in which the symptoms will last over 12 weeks. Due to its prevalence, the effect it has on patients' quality of life and the pressure it exerted on healthcare systems CRS is becoming a critical health burden globally. Our understanding of CRS has evolved from viewing it mainly as an infection to recognizing it as a more complex condition. It involves various anatomical, physiological, and immunological interactions, which show the diversity of the disease.[1] The osteomeatal complex (OMC) being the main drainage route for the front group of paranasal sinuses - the maxillary, frontal, and anterior ethmoidal sinuses has a crucial role in pathophysiology of CRS. Traditional ideas, especially those presented by Messerklinger, suggest that blockage at the OMC disturbs the mucociliary clearance. This leads to the buildup of secretions, infections, and ongoing inflammation.[2] This understanding is basis for functional endoscopic sinus surgery (FESS), which aims to restore normal ventilation and drainage of the sinuses.[3]

Sinonasal anatomical variations contribute to OMC blockage. Common variations include a deviated nasal septum, concha bullosa, paradoxical middle turbinate, enlarged ethmoidal bulla, agger nasi cells,

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and issues with the uncinate process. These structural changes alter the drainage pathway thereby making individuals more prone to poor sinus ventilation and inflammation. Computed tomography (CT) and Diagnostic Nasal Endoscopy have shown that many patients with CRS have such variations, indicating a possible link to disease development.[4]

However, the precise role of these anatomical variations is still under discussion. Some studies have found significant links between certain variations and OMC blockage, while others have not shown any consistent or causal relationship.[5] Additionally, many variations are also found in people without symptoms, suggesting their presence alone may not be enough to cause the disease. This leads to the idea that these anatomical factors might be more of a risk factor than being a direct cause. Recent research on CRS has highlighted the significance of mucosal inflammation, especially eosinophilic and Type 2 inflammatory pathways. In such cases, OMC blockage may result from mucosal swelling instead of just structural issues.

This changing view emphasizes the need to distinguish between structural blockages and functional problems when evaluating CRS.[6] Computed tomography and diagnostic nasal endoscopy (DNE) are key tools in examining CRS. CT imaging offers a detailed look at the bony structure and sinus involvement, while endoscopy provides direct insights into the condition of the mucosa and factors affecting sinus drainage.[7]

The current study aims to explore the link between sinonasal anatomical variations and OMC blockage in patients with chronic rhinosinusitis through combined radiological and endoscopic evaluations. By investigating this relationship, the study hopes to shed light on the role of structural factors in the development of CRS and enhance our understanding of the disease.

MATERIALS AND METHODS

This retrospective observational study was conducted to evaluate the role of sinonasal anatomical variations in osteomeatal complex (OMC) obstruction among patients diagnosed with chronic rhinosinusitis (CRS). The study was carried out at a tertiary care hospital using records from the Department of Otorhinolaryngology over a period of three years from January 2023 to December 2025. Institutional Ethics Committee approval was obtained prior to the commencement of the study. A total of 214 patients clinically diagnosed with CRS were included. All patients had undergone computed tomography (CT) scan of the paranasal sinuses and diagnostic nasal endoscopy (DNE) as part of routine evaluation.

Patients aged more than 18 years with symptoms of CRS persisting for more than 12 weeks and who had undergone both CT scan and DNE were included in the study. Patients with previous sinonasal surgery, sinonasal tumors or mass lesions, acute rhinosinusitis, facial trauma affecting sinonasal anatomy, or incomplete clinical, endoscopic, or radiological records were excluded.

Patient records were retrospectively reviewed, and relevant clinical, endoscopic, and radiological findings were collected. CT scans including axial and coronal sections were evaluated for sinonasal anatomical variations such as deviated nasal septum, concha bullosa, paradoxical middle turbinate, agger nasi cells, uncinate process variations, and inferior turbinate hypertrophy. The OMC was assessed radiologically for evidence of obstruction based on mucosal thickening, sinus opacification, or obstruction of sinus ostia. DNE findings including middle turbinate hypertrophy, enlarged ethmoidal bulla, uncinate process variations, and inferior turbinate hypertrophy were also analyzed. Correlation between CT and DNE findings was performed to assess the presence, type, and side of anatomical variations and their association with OMC obstruction. The effect of multiple coexisting anatomical variations on OMC obstruction was also evaluated.

Data were expressed as mean ± standard deviation, frequency, and percentage. Independent sample t-test was used for comparison of continuous variables, while categorical variables were analyzed using Pearson chi-square test. Binary logistic regression analysis was performed to identify independent predictors of OMC obstruction, and results were expressed as odds ratios with 95% confidence intervals. The influence of multiple coexisting anatomical variations was assessed using a composite variation score and compared with OMC obstruction using chi-square test. A p value less than 0.05 was considered statistically significant. Statistical analysis was performed using IBM-SPSS version 21.0 (IBM-SPSS Science Inc., Chicago, IL).

RESULTS

A total of 214 patients with chronic rhinosinusitis were included in the study. The most common age group was 21–30 years with 54 patients (25.2%), followed by 31–40 years in 46 patients (21.5%) and 41–50 years in 45 patients (21.0%). Male patients constituted 117 (54.7%) cases, while female patients constituted 97 (45.3%) cases. Nasal obstruction was the most common presenting symptom seen in 210 patients (98.1%), followed by headache in 159 patients (74.3%), nasal discharge in 118 patients (55.1%), and facial pain in 26 patients (12.1%) [Table 1].

On diagnostic nasal endoscopy (DNE), deviated nasal septum (DNS) was present in 200 patients (93.5%). Middle turbinate hypertrophy was seen in 65 patients (30.4%) on the right side and 80 patients (37.4%) on the left side. Enlarged ethmoidal bulla was noted in 44 patients (20.6%) on the right side and 48 patients (22.4%) on the left side. Medialized uncinate process was present in 24 patients (11.2%)

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on the right side and 54 patients (25.2%) on the left side. Inferior turbinate hypertrophy was present in 34 patients (15.9%) on the right side and 50 patients (23.4%) on the left side. On CT evaluation, DNS was present in 201 patients (93.9%). Concha bullosa was present in 80 patients (37.4%) on the right side and 79 patients (36.9%) on the left side. OMC obstruction was seen in 95 patients (44.4%) on the right side and 102 patients (47.7%) on the left side. Agger nasi cells were present in 18 patients (8.4%) on the right side and 28 patients (13.1%) on the left side. Paradoxical middle turbinate was present in 33 patients (15.4%) on the right side and 30 patients (14.0%) on the left side. Uncinate process variation was present in 12 patients (5.6%) on the right side and 28 patients (13.1%) on the left side [Table 2].

Table 1: Demographic and Clinical Profile of Study Participants

Variable	Category	Number of Patients	Percentage
Age Group	<20 years	27	12.6%
	21–30 years	54	25.2%
	31–40 years	46	21.5%
	41–50 years	45	21.0%
	51–60 years	26	12.1%
	>61 years	16	7.5%
Gender	Female	97	45.3%
	Male	117	54.7%
Nasal Obstruction		210	98.1%
Nasal Discharge		118	55.1%
Headache		159	74.3%
Facial Pain		26	12.1%

Table 2: Distribution of Sinonasal Anatomical Variations and OMC Obstruction

Variable	Side	Number of Patients	Percentage
DNE DNS		200	93.5%
DNE MTH	Right	65	30.4%
	Left	80	37.4%
DNE EB	Right	44	20.6%
	Left	48	22.4%
DNE UP Medialised	Right	24	11.2%
	Left	54	25.2%
DNE ITH	Right	34	15.9%
	Left	50	23.4%
CT DNS		201	93.9%
CT ITH	Right	63	29.4%
	Left	58	27.1%
CT Concha Bullosa	Right	80	37.4%
	Left	79	36.9%
CT OMC Obstruction	Right	95	44.4%
	Left	102	47.7%
CT Agger Nasi	Right	18	8.4%
	Left	28	13.1%
CT PMT	Right	33	15.4%
	Left	30	14.0%
CT UP Variation	Right	12	5.6%
	Left	28	13.1%

Table 3: Association Between Anatomical Variations and OMC Obstruction

Variable	Side	OMU Yes (n)	OMU Yes (%)	OMU No (n)	OMU No (%)	P value
CT DNS	Right	88	92.60%	113	95.00%	0.479
	Left	96	94.10%	105	93.80%	0.91
CT Concha Bullosa	Right	39	41.10%	41	34.50%	0.322
	Left	39	38.20%	40	35.70%	0.703
CT PMT	Right	12	12.60%	21	17.60%	0.313
	Left	6	5.90%	24	21.40%	0.001
CT Agger Nasi	Right	5	5.30%	13	10.90%	0.138
	Left	13	12.70%	15	13.40%	0.888
CT UP Variation	Right	4	4.20%	8	6.70%	0.427
	Left	16	15.70%	12	10.70%	0.281
ITH (DNE/CT)	Right (DNE)	18	18.90%	16	13.40%	0.274
	Left (CT)	27	26.50%	31	27.70%	0.843

Association analysis between anatomical variations and OMC obstruction showed no statistically significant correlation for most variations. CT DNS, concha bullosa, agger nasi cells, uncinate process variation, and inferior turbinate hypertrophy were not significantly associated with OMC obstruction on either side ($p > 0.05$). Left-sided paradoxical middle turbinate showed a statistically significant association with left-sided OMC obstruction (5.9% vs 21.4%, $p = 0.001$) [Table 3].

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Table 4: Binary Logistic Regression Analysis for OMC Obstruction (Right Side)

Variable	OR (Exp(B))	p value
CT DNS	0.628	0.424
CT Concha Bullosa (RT)	1.265	0.424
CT PMT (RT)	0.692	0.359
CT Agger Nasi (RT)	0.455	0.155
CT Uncinate Process Variation (RT)	0.607	0.437
CT ITH (RT)	1.012	0.97

Table 5: Binary Logistic Regression Analysis for OMC Obstruction (Left Side)

Variable	OR (Exp(B))	p value
CT DNS	0.929	0.903
CT Concha Bullosa (LT)	1.116	0.717
CT PMT (LT)	0.233	0.003
CT Agger Nasi (LT)	1.165	0.725
CT Uncinate Process Variation (LT)	1.466	0.372
CT ITH (LT)	0.93	0.82

Binary logistic regression analysis showed that none of the right-sided anatomical variations independently predicted OMC obstruction [Table 4]. Among left-sided variations, only left paradoxical middle turbinate showed significant association with OMC obstruction with an odds ratio of 0.233 (p = 0.003). Other anatomical variations did not show significant predictive value [Table 5].

Table 6: CT Anatomical Variations and Right OMC Obstruction

Number of Anatomical Variations		CT OMU RT				P value
		No		Yes		
		Count	Row N %	Count	Row N %	
Right	0	2	66.7%	1	33.3%	0.71
	1	34	54.0%	29	46.0%	
	2	57	52.8%	51	47.2%	
	3	21	63.6%	12	36.4%	
	4	5	71.4%	2	28.6%	

Table 7: CT Anatomical Variations and Left OMC Obstruction

Number of Anatomical Variations		CT OMU LT				P value
		No		Yes		
		Count	Row N %	Count	Row N %	
Left	0	3	100.0%	0	0.0%	0.116
	1	30	50.8%	29	49.2%	
	2	49	48.0%	53	52.0%	
	3	21	53.8%	18	46.2%	
	4	9	81.8%	2	18.2%	
Number of Anatomical Variations		**CT OMU RT**				**P value**
		No		**Yes**		
		Count	**Row N %**	**Count**	**Row N %**	
DNE R	0	62	70.5%	26	29.5%	0.001
	1	45	51.1%	43	48.9%	
	2	11	32.4%	23	67.6%	
	3	1	25.0%	3	75.0%	

Table 8: DNE Anatomical Variations and OMC Obstruction

Number of Anatomical Variations		CT OMU LT				P value
		No		Yes		
		Count	Row N %	Count	Row N %	
DNE L	0	29	59.2%	20	40.8%	0.393
	1	56	53.8%	48	46.2%	
	2	26	46.4%	30	53.6%	
	3	1	25.0%	3	75.0%	

Analysis of multiple coexisting anatomical variations on CT showed no statistically significant association with right-sided OMC obstruction (p = 0.71) or left-sided OMC obstruction (p = 0.116) [Table 6 and 7]. Increasing number of anatomical variations identified on DNE on the right side showed significant association with right-sided OMC obstruction (p = 0.001), while left-sided DNE variations showed no significant association with left-sided OMC obstruction (p = 0.393) [Table 8].

DISCUSSION

The present study evaluated the association between sinonasal anatomical variations and osteomeatal complex (OMC) obstruction in patients with chronic

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rhinosinusitis (CRS) using computed tomography (CT) and diagnostic nasal endoscopy (DNE). In the present study, OMC obstruction was not observed in all patients with CRS, indicating that CRS can occur even in the absence of definite osteomeatal obstruction. This finding supports the concept that CRS is a multifactorial disease and not solely dependent on mechanical obstruction of the sinus drainage pathways.

Deviated nasal septum was the most common anatomical variation identified on both CT and DNE. Other commonly observed variations included concha bullosa, paradoxical middle turbinate, agger nasi cells, uncinate process variations, and inferior turbinate hypertrophy. Despite the high prevalence of these variations, most did not show statistically significant association with OMC obstruction. Only left-sided paradoxical middle turbinate showed significant association with left-sided OMC obstruction. These findings suggest that although certain anatomical variations may contribute to localized narrowing of the osteomeatal complex, they may not independently play a major role in the pathogenesis of CRS.

The present study also assessed the effect of multiple coexisting anatomical variations on OMC obstruction. Increasing number of anatomical variations did not show significant association with OMC obstruction on CT analysis. This observation suggests that coexistence of multiple structural variations does not necessarily impair sinus drainage or predispose to obstruction. Logistic regression analysis also failed to identify most anatomical variations as independent predictors of OMC obstruction, further supporting the limited role of anatomical factors alone.

The findings of the present study are comparable with previous studies. Bolger et al. reported that sinonasal anatomical variations are frequently present in both symptomatic and asymptomatic individuals, indicating that these variations alone may not be sufficient to cause disease.[4] Jones also reported poor correlation between CT findings and clinical severity of CRS[5] . Wani et al. similarly observed that although OMC obstruction is commonly seen in CRS patients, inflammatory mucosal disease plays a more important role than anatomical abnormalities.[7]

The findings of the present study support the current understanding that CRS is predominantly an inflammatory disorder with multiple contributing factors. According to EPOS 2020 guidelines, inflammatory mechanisms, especially Type 2 inflammation, have a major role in the development and persistence of CRS, while anatomical variations may act only as secondary contributing factors[1]. Therefore, management of CRS should not rely solely on correction of anatomical variations. Comprehensive evaluation including clinical symptoms, endoscopic findings, radiological assessment, and inflammatory status is important for appropriate treatment planning.

CONCLUSION

Osteomeatal complex obstruction is not consistently present in all patients with chronic rhinosinusitis, and sinonasal anatomical variations alone are not significant predictors of CRS. These findings support the multifactorial nature of CRS, with inflammatory and functional factors playing an important role in disease pathogenesis.

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