REVEALING SINONASAL ANOMALIES ON CT: INSIGHTS INTO SINUSITIS SYMPTOMS

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Abstract: Objective: This study aimed to ascertain the frequency of anatomical variants within the sinonasal region and their association with sinusitis symptoms.

Methods: Conducted between October 2023 and April 2024 at the Radiology Department of Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, the study enrolled 50 symptomatic sinusitis subjects aged 18-60 years for computed tomography (CT) scans of the paranasal sinuses. CT scans were examined for nasal septum, turbinates, uncinate process, ethmoid air cells, and other anatomical variations, correlating them with sinusitis symptoms.

Results: Among the 50 subjects, 34 were male and 16 were female, with a mean age of 42.68±18.22 years. The most prevalent anatomical variants were agger nasi cells (64%), deviated nasal septum (56%), and concha bullosa (46%). A statistically significant correlation was found between bilateral agger nasi cells and nasal obstruction ($p=0.017$, $\rho= -0.336$).

Conclusion: The sinonasal region's anatomy is intricate, and anatomical variations can impede sinus mucociliary drainage, leading to patient discomfort. Therefore, given the variability of sinonasal anatomy, CT of the paranasal sinuses is recommended for all patients to prevent surgical complications.

Keywords: Anatomical variations, CT scan, Facial pain, Nasal obstruction, Sinonasal region, Sinusitis, Rhinorrhea

INTRODUCTION:

The paranasal sinuses (PNS) are air-filled cavities located within the bones of the face and skull, including the maxillary, sphenoid, ethmoid, and frontal sinuses. These sinuses serve various functions such as reducing the weight of the head, humidifying inhaled air, and contributing to voice resonance. Anatomical variants within the sinonasal region are commonly observed on computed tomography (CT) scans. These variants include agger nasi cells, deviated nasal septum (DNS), infraorbital ethmoidal (Haller) cells, sphenoethmoidal (Onodi) cells, and concha bullosa (CB).

Agger nasi cells, situated anterior and inferolateral to the frontal recess, are among the most anterior ethmoidal air cells. Infraorbital ethmoidal cells extend beneath the medial floor of the orbit, adjacent to the ostium of the maxillary sinus. Posterior ethmoidal cells are positioned superolateral and posterior to the sphenoid sinus cavity, often in close proximity to the optic nerve (CN-II). DNS refers to any deviation of the nasal septum, while CB involves pneumatization of the middle turbinate, typically affecting the inferior bulbous part bilaterally.

Identification of these anatomical variants is crucial to avoid complications during surgical interventions. The sinonasal region exhibits significant anatomical variations that can obstruct the mucociliary drainage pathway of the ostiomeatal complex (OMC), including DNS, CB, paradoxical middle turbinate, variants of the uncinate process (UP), ethmoid bulla, and various ethmoidal air cells. The OMC plays a critical role in the spread and pathogenesis of rhinosinusitis. Episodes of rhinosinusitis disrupt ciliary movement, leading to mucus accumulation within the sinuses. Anatomical variants causing narrowing of the OMC may predispose individuals to recurrent infections and severe inflammatory changes in the sinonasal mucosa.

While the contribution of anatomical variants of the OMC to the etiology of sinonasal pathologies remains debated, comprehensive knowledge of these variants is essential before surgical interventions to prevent injury to adjacent vital structures such as the orbit and brain. CT of the paranasal sinuses (CT-PNS) and functional endoscopic sinus surgery (FESS) have emerged as preferred modalities for diagnosing and managing sinonasal morphology and pathologies.

Despite extensive literature on anatomical variations in the sinonasal region, there is a paucity of prospective data on these variations in symptomatic sinusitis patients, particularly within the local population of Vizianagaram. This study aimed to investigate the frequency of anatomical variations in symptomatic patients undergoing CT-PNS at Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, and to evaluate the correlation between these variants and sinusitis symptoms, including nasal obstruction, facial pain, and rhinorrhea.

OBJECTIVES:

1. Detect and characterize anatomical variations of the sinonasal region on CT scans.
2. Assess the association between anatomical variants and sinusitis symptoms, including nasal obstruction, facial pain, and rhinorrhea.

METHODS:

This cross-sectional study was conducted at the Radiology Department of Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram from the October 2023 to April 2024.The sampling technique used was non-probability convenience sampling, and the sample size was determined to be 50 participants using the OpenEpi version 3 calculator.

Participants included in the study were symptomatic sinusitis patients, regardless of gender, who presented with complaints of nasal obstruction, facial pain, and rhinorrhea. These participants were referred from the ENT Department of Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram.

INCLUSION CRITERIA:

1. Symptomatic subjects of sinusitis presenting with nasal obstruction, facial pain, and rhinorrhea.
2. Participants aged between 18 and 60 years.
3. Radiological evidence showing mucosal thickening greater than 1 mm.

EXCLUSION CRITERIA:

1. Subjects under the age of 18.
2. Mucosal thickening less than 1 mm.
3. Diagnosis of fungal sinusitis.
4. Presence of sinonasal polyposis.
5. Diagnosis of sinonasal malignancy.
6. Pregnant women.
7. History of previous sinus surgery.
8. History of facial trauma.

CT-SCAN PROTOCOL:

Participants who met the inclusion criteria were included in the study after obtaining written informed consent. Detailed histories, including age and symptoms, were recorded for all participants. CT scans of the paranasal sinuses (CT-PNS) were performed in the coronal plane, supplemented by axial views, using a GE Revolution 16-slice CT scanner.

For coronal images, participants were positioned prone with the hard palate as the reference point, ensuring the plane of section was perpendicular to it. Direct scans, 3 mm in thickness, were obtained from the anterior walls of the frontal sinuses to the posterior wall of the sphenoid sinus. For axial scans, participants were positioned supine, with the orbitomeatal line as the reference point. These scans were also 3 mm in thickness. The exposure settings for the CT scans were 120 kV and 80 mAs.

After CT scans were performed, anatomical variations in the sinonasal region were documented. The following anatomical variants were specifically studied:

a. **Nasal Septum:** Including septal deviation and the presence of bony spurs.

b. **Turbinates:** Examining for superior concha bullosa (CB), middle CB, paradoxical middle turbinate, turbinate hypoplasia, and secondary middle turbinate.

c. **Uncinate Process:** Assessing for deviation of the upper edge and pneumatization.

d. **Ethmoid Air Cells:** Including agger nasi cells, Haller cells, and Onodi cells.

e. **Other Variants:** Evaluating for hypoplasia of the maxillary sinus, presence of maxillary septa, hypoplastic frontal sinus, and asymmetry of the sphenoid sinus cavities.

DATA ANALYSIS:

The data collected from the CT reports were analysed to determine the frequency of each anatomical variant. The correlation between these anatomical variants and the symptoms of sinusitis (nasal obstruction, facial pain, and rhinorrhea) was assessed using appropriate statistical methods. The significance of the correlations was evaluated to understand the impact of anatomical variations on sinusitis symptoms. The results were interpreted to provide insights into the role of anatomical variants in the etiology and management of sinusitis.

STATISTICAL ANALYSIS:

Quantitative variables, such as age, were summarized using mean and standard deviation. Qualitative variables, including gender, symptoms, and anatomical variants, were described using frequencies and percentages. Data analysis was conducted using SPSS version 23.0. The chi-square test was utilized to determine the frequencies of anatomical variants, and Pearson correlation was used to assess the relationship between sinusitis symptoms and anatomical variants. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS:

The study included 50 participants, comprising 34 males and 16 females, with a mean age of 42.68 ± 18.22 years. The most common anatomical variants identified were agger nasi cells (64%), deviated nasal septum (DNS) (56%), concha bullosa (CB) (46%), Haller cells (10%), and Onodi cells (10%).

Figure 1: Distribution of Involved Sinuses

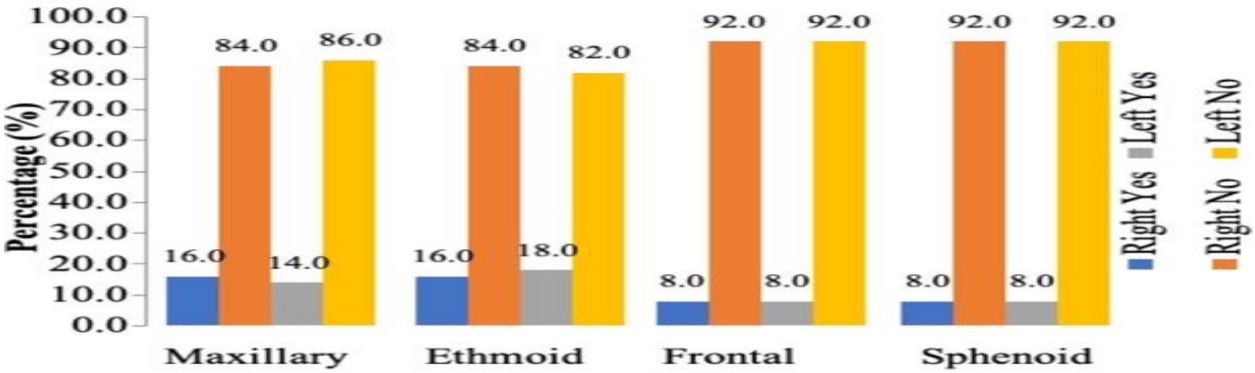

Table I: Correlation between Anatomical Variants and Sinusitis Symptoms

Variable	Nasal Obstruction	p-value	Facial Pain	p-value	Rhinorrhea	p-value
Septal Deviation	-0.075	0.603	-0.184	0.200	-0.242	0.091
Septal Bony Spur	0.062	0.667	-0.079	0.586	-0.124	0.932
Superior Concha Bullosa	0.229	0.110	-0.042	0.771	-0.048	0.743

Variable	Nasal Obstruction	p-value	Facial Pain	p-value	Rhinorrhea	p-value
Middle Concha Bullosa	0.229	0.110	-0.124	0.390	-0.174	0.227
Paradoxical Middle Concha	-0.089	0.538	-0.042	0.771	-0.048	0.743
Uncinate Process Deviation	-0.127	0.378	-0.060	0.678	-0.068	0.639
Uncinate Process Pneumatization	-0.089	0.538	-0.042	0.771	-0.048	0.743
Agger Nasi	-0.275	0.054	-0.240	0.094	-0.167	0.247
Haller Cells	-0.059	0.682	-0.098	0.497	-0.111	0.442
Onodi Cells	-0.208	0.147	-0.098	0.497	-0.111	0.442
Maxillary Septa	-0.089	0.538	-0.042	0.771	-0.048	0.743
Hypoplastic Frontal Sinus	-0.332	0.018	-0.202	0.159	-0.229	0.110
Asymmetry of Sphenoid Sinuses	-0.151	0.296	0.072	0.617	-0.145	0.313

*p-value significant at ≤ 0.05; ρ = Pearson correlation coefficient

Table II: Correlation between Anatomical Variants with Involved Sinus and Nasal Obstruction

Variable	Nasal Obstruction Right	p-value	Nasal Obstruction Left	p-value
Maxillary-sinusitis	0.214	0.136	0.262	0.066
Ethmoid-sinusitis	0.092	0.524	0.172	0.233
Frontal-sinusitis	0.144	0.317	0.309 *	0.029
Sphenoid-sinusitis	0.309 *	0.029	0.309 *	0.029
Agger Nasi	-0.305 *	0.031	-0.336 *	0.017
Onodi	-0.208	0.147	-0.208	0.147
Concha Bullosa (CB)	0.050	0.732	0.127	0.378
Haller Cells	-0.020	0.892	-0.059	0.682
DNS convexity towards	0.134	0.355	-0.117	0.420
DNS with Spur	0.172	0.233	-0.009	0.953

*p-value significant at ≤ 0.05; ρ = Pearson correlation coefficient

Significant positive correlations were found between right-sided nasal obstruction and sphenoid sinusitis (r = 0.309, p = 0.029). Significant negative correlations were observed between right-sided nasal obstruction and agger nasi cells (r = -0.305, p = 0.031), as well as between left-sided nasal obstruction and agger nasi cells (r = -0.336, p = 0.017).

Table III: Correlation between Anatomical Variants and Facial Pain

Variable	Facial Pain Right	p-value	Facial Pain Left	p-value
Maxillary-sinusitis	0.475 *	<0.001	0.306 *	0.031
Ethmoid-sinusitis	0.072	0.617	0.246	0.086
Frontal-sinusitis	0.185	0.199	0.457 *	0.001
Sphenoid-sinusitis	0.457 *	0.001	0.457 *	0.001
Agger Nasi	-0.255	0.074	-0.272	0.056
Onodi	-0.098	0.497	-0.098	0.497
Concha Bullosa (CB)	-0.044	0.760	-0.090	0.533
Haller Cells	-0.087	0.548	-0.098	0.497
DNS convexity towards	0.037	0.799	-0.193	0.179
DNS with Spur	0.054	0.711	-0.157	0.277

*p-value significant at ≤ 0.05; ρ = Pearson correlation coefficient

Table IV: Correlation between Anatomical Variants and Rhinorrhea

Variable	Rhinorrhea Right	p-value	Rhinorrhea Left	p-value
Maxillary-sinusitis	0.582 *	<0.001	0.442 *	0.001
Ethmoid-sinusitis	0.218	0.128	0.364 *	0.009
Frontal-sinusitis	0.393 *	0.005	0.393 *	0.005
Sphenoid-sinusitis	0.393 *	0.005	0.639 *	<0.001
Agger Nasi	-0.183	0.203	-0.200	0.164
Onodi	-0.111	0.442	-0.111	0.442
Concha Bullosa (CB)	-0.229	0.110	-0.136	0.346
Haller Cells	-0.098	0.497	-0.111	0.442
DNS convexity towards	0.000	>0.999	-0.218	0.128
DNS with Spur	0.017	0.905	-0.177	0.219

*p-value significant at ≤ 0.05; ρ = Pearson correlation coefficient

Significant positive correlations were found between right-sided rhinorrhea and maxillary sinusitis ($r = 0.582$, $p < 0.001$), and left-sided rhinorrhea and maxillary sinusitis ($r = 0.442$, $p = 0.001$). Rhinorrhea also significantly correlated with ethmoid, frontal, and sphenoid sinusitis on both sides.

DISCUSSION:

Functional endoscopic sinus surgery (FESS) has revolutionized the management of sinus disorders, offering minimally invasive procedures and shorter hospital stays. Despite the success of FESS, the presence of anatomical variants and the delicate proximity of the sinonasal region to vital structures pose risks of surgical complications. While some studies suggest that anatomical variants contribute to sinus mucosal disease, the literature remains controversial in this regard.

Several studies have reported varying frequencies of anatomical variants such as deviated nasal septum (DNS), concha bullosa (CB), agger nasi cells, Haller cells, and Onodi cells. Some researchers emphasize the surgical significance of these variants, highlighting the importance of pre-operative evaluation to minimize complications. However, other studies have found no significant correlation between anatomical variants and sinusitis symptoms.

For instance, one study reported a high frequency of DNS, CB, and agger nasi cells but found no correlation with sinusitis. Conversely, other studies have identified strong associations between certain anatomical variants and rhinosinusitis. The impact of these variants on sinus infections underscores the importance of CT imaging for evaluating the sinonasal region.

In our study, statistically significant correlations were observed between bilateral maxillary, frontal, and ethmoid sinusitis with rhinorrhea. However, we found no significant correlation between anatomical variants and sinusitis symptoms, except for a significant negative correlation between bilateral agger nasi cells and nasal obstruction. This suggests that while certain anatomical variations may predispose individuals to sinusitis, their role in symptom manifestation remains unclear.

Anatomical variations in the nasal cavity and paranasal sinuses are diverse and influenced by factors such as age, race, gender, geography, and ethnicity. While some variations may contribute to inflammatory sinus-mucosal diseases, a comprehensive understanding of these variants is crucial for diagnostic accuracy and reducing surgical complications in FESS and skull-base surgery. CT imaging plays a pivotal role in evaluating the extent and type of anatomical variations, providing guidance for ENT surgeons.

CT coronal sections showing few anatomical variants of paranasal sinuses with sinusitis

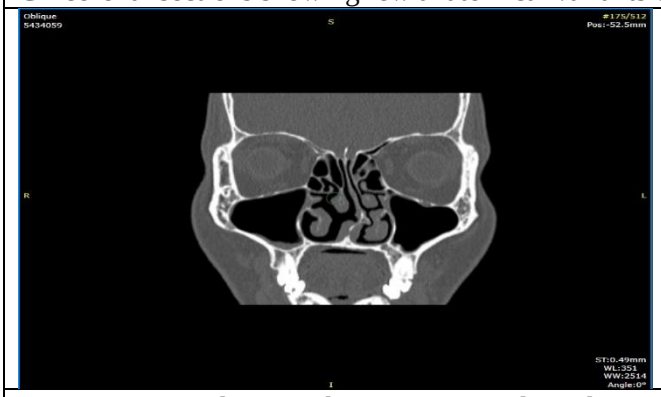

Fig 2: CT coronal image showing Deviated nasal septum towards left side with bony spur

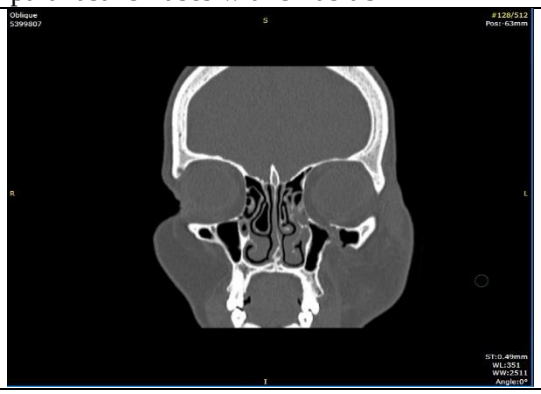

Fig 3: CT coronal image showing Lamella choncha on rightside

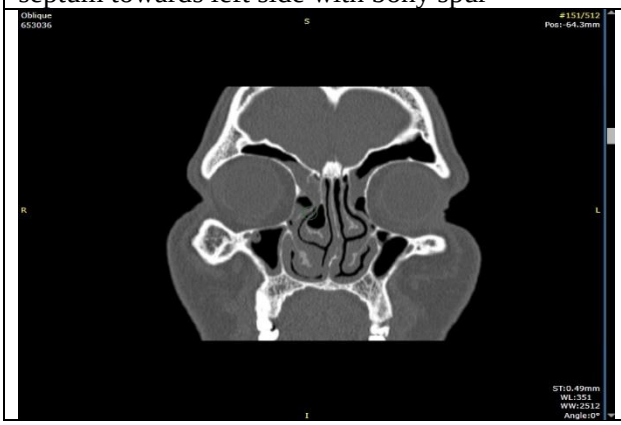

Fig4: CT coronal image showing Anterior ethmoidal sinusitis	Fig5: CT coronal image showing Maxillary sinusitis on right side
CT coronal sections showing few anatomical variants of paranasal sinuses with sinusitis	
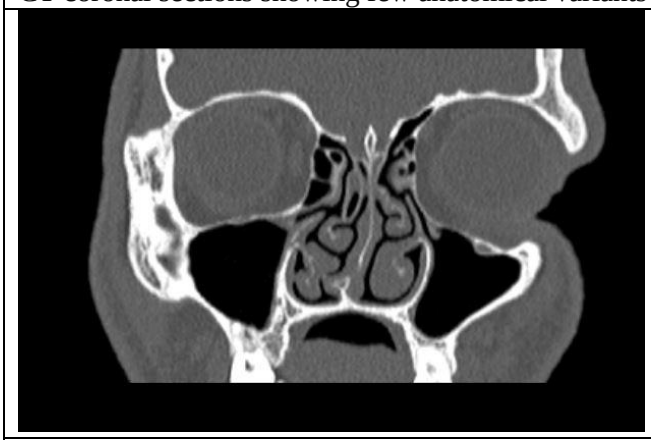	
Fig6: CT coronal image showing Bilateral paradoxical middile turbinate	Fig7: CT coronal image showing Onodi cell on left side
	
Fig8: CT coronal image showing Bilateral haller cells	Fig9: CT coronal image showing Septal pneumatization

LIMITATIONS:

This study is limited by its single-center design, warranting larger population sizes and multicentre approaches for more robust and generalized results. Further research is needed to validate our findings and explore the relationship between anatomical variants and sinusitis symptoms across diverse populations.

CONCLUSION:

In the conclusion, we summarize the main findings of the study and their implications, providing a comprehensive overview of the relationship between anatomical variants and sinusitis symptoms. We highlight the significance of understanding these variants in the context of sinusitis management and surgical interventions.

1. **Variability of Anatomical Variants**: We emphasize the diversity of anatomical variants in the nasal cavity and paranasal sinuses, noting that while some variants are common and widely observed, their impact on sinusitis symptoms remains uncertain. This underscores the complexity of the sinonasal region and the need for thorough evaluation.
2. **Correlation with Sinusitis Symptoms**: We discuss the significant correlations identified in the study, particularly between sinusitis involving specific sinuses (maxillary, frontal, and ethmoid) and the symptom of rhinorrhea. However, we also note the absence of significant associations between most anatomical variants and sinusitis symptoms, except for a negative correlation with agger nasi cells and nasal obstruction.
3. **Clinical Implications**: We elucidate the implications of these findings for clinical practice, suggesting that routine analysis of CT scans for anatomical variants may have limited value unless surgical intervention is planned. However, we emphasize the importance of awareness regarding specific variants, especially for patients undergoing surgical procedures such as functional endoscopic sinus surgery (FESS) or skull-base surgery.

4. **Risk of Complications**: We highlight the importance of identifying anatomical variants to mitigate the risk of operative complications, particularly in surgical settings where precise knowledge of sinonasal anatomy is crucial for safe and successful outcomes.

In terms of competing interests, the authors affirm that they have no conflicts to declare, underscoring their commitment to transparency and ethical conduct in research and publication practices.

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