Panacea Journal of Medical Sciences 2024;14(2):567–572

Content available at: https://www.ipinnovative.com/open-access-journals

Panacea Journal of Medical Sciences

Journal homepage: http://www.pjms.in/

Original Research Article

Evaluation of the relationship between anatomical variations of the sinonasal cavity and chronic rhinosinusitis through ct scan at a tertiary care center in central India

Aprajita Awasthi[1]*, A Bose[1], Yamini Gupta[1], S Srivastava[1]

[1]*Dept. of Anatomy, Mahatma Gandhi Memorial Medical College, Indore, Madhya Pradesh, India*

ARTICLE INFO

Article history:
Received 28-04-2023
Accepted 08-09-2023
Available online 13-08-2024

Keywords:
Anatomical variations
Chronic rhinosinusitis
CT scan
Sinonasal cavity

ABSTRACT

Introduction: The correlation between Chronic Rhinosinusitis (CRS) and the sinonasal cavity is a subject of ongoing debate. Further in-depth research is needed to understand their role in the pathogenicity and chronicity of CRS.

Aims: The primary objective of this study is to systematically investigate potential associations between anatomical variations within the sinonasal cavity and the prevalence of chronic rhinosinusitis in the population of Central India.

Materials and Methods: In this study, 100 cases, aged 18 to 42 years, presenting clinical features of CRS unresponsive to medical management for 8 weeks or more, underwent CT scans of the paranasal sinus region as part of routine medical assessment. The control cohort consisted of 100 individuals who had undergone CT scans of the paranasal sinus region for non-chronic rhinosinusitis (CRS) related reasons and did not manifest any symptoms associated with CRS. Subsequently, the gathered data underwent calculation and rigorous statistical analysis.

Results: Agger nasi cells were the most prevalent anatomical variation, found in 68.5% of the study population, followed by a deviated nasal septum (64%), Concha bullosa (57%), Paradoxical middle turbinate (20.5%), Pneumatized uncinate process (1.5%), and Haller cells (15%). The frequency of occurrence of these variations between the CRS group and the control group was not statistically significant ($p > 0.05$). Therefore, no discernible relationship exists between the presence of anatomical variations examined in the study and the pathogenesis and chronicity of CRS.

Conclusion: While these anatomical variations may not directly indicate the presence or severity of CRS, they could serve as early indicators. This underscores the importance of lifestyle modifications to counteract the disease at its nascent stage. This study, along with similar research, holds valuable insights for ENT surgeons and radiologists, aiding in the prevention of damage to these variations during sinusitis surgery. Further detailed studies are warranted to enhance our understanding of the role of these variations in the etiopathogenesis of CRS.

1. Introduction

Respiratory epithelium extends through the apertures of paranasal sinuses to line their cavities, a feature that unfortunately facilitates the spread of infections.[1,2] The invagination of the nasal mucosa into the lateral nasal wall, frontal, ethmoid, maxilla, and the sphenoid bones leads to the development of paranasal sinuses during fetal development. This unique development explains the considerable anatomical variations. Chronic rhinosinusitis (CRS) stands as a prevalent modern ailment, exhibiting a rising prevalence on a global scale.[3] Chronic sinusitis

* *Corresponding author*.
E-mail address: aprajitaawasthi@gmail.com (A. Awasthi).

https://doi.org/10.18231/j.pjms.2024.102

is characterized by symptoms persisting beyond an 8-week duration.[4] Diagnosis of chronic rhinosinusitis in individuals aligns with criteria outlined by the Task Force on Rhinosinusitis.[5–8] Rhinosinusitis occurs when the lining of the sinuses gets infected or irritated, becomes swollen, and creates extra mucus. The contribution of anatomical variants to the development of sinusitis is a topic of debate. Some theories suggest that these variants have the potential to alter and compress components of the osteomeatal complex, resulting in an obstruction of mucus drainage from the paranasal sinuses[4,5,9,10] Notably, various variations are considered normal in the middle meatus, and it is essential to differentiate them from pathological ones. In certain cases, these variations may be the primary factor contributing to recurrent sinus disease. The prevalence and significance of these variations are under debate among investigators because they have been encountered equally in sinusitis patients as well as in patients who did not have sinusitis.[6,11] The more common variations taken up in the study include Concha Bullosa (CB): The pneumatization of the thin plate of the middle turbinate bone by the extension of the anterior or posterior ethmoidal air cells[6,11] as shown in Figures 1, 2, 3, 4 and 5.

Pneumatized Uncinate process (PUP): is defined by aeration of air cells into the uncinate process. The uncinate process projects from the ethmoid bone to the ethmoid process of inferior nasal concha.

Infraorbital ethmoid cells/Haller cells (HC): Bolger et al[9,12] defined Haller cells as any air cells located beneath the ethmoidal bulla, lamina papyracea, or orbital floor. Typically, the ethmoidal air cells extend downward to the ethmoidal bulla, reaching into the floor of the orbit.

Agger nasi cells (AN): Positioned anterolateral and inferior to the frontal recess, and above the attachment of the middle turbinate, Agger nasi air cells are the most anterior ethmoidal air cells (Figure 3). Situated within the lacrimal bone, they have lateral relations with the orbit, lacrimal sac, and nasolacrimal duct.

Nasal septal deviation or Deviated nasal septum (DNS): The structures that make up the nasal septum are aligned to form a straight wall. The nasal septum extends from the cribriform plate superiorly to the hard palate inferiorly. Acute bowing and deviation of the septum occur most commonly at the junction of the nasal cartilage and vomer (Figures 4 and 5). Considering the typical anatomy of the paranasal sinuses and the osteomeatal unit (including the middle meatus, frontal recess, and infundibulum), any deviation from normal anatomy hindering sinus drainage has the potential to trigger chronic sinus inflammation.

The Intricacies and variations in the anatomy of the nose and paranasal sinuses may pose challenges during surgery. The role of these anatomical variations in the pathogenesis of rhinosinusitis, the most prevalent disease in the region, remains uncertain[10,13]

The presence of anatomical variations has been studied in great detail by many authors in different populations, but their relationship with CRS is under debate. Computed Tomography (CT) scan demonstrates the extent of disease, significant anatomical variations that may predispose to rhinosinusitis and the nearby vital structures so that iatrogenic damage can be avoided.[11,14]

The aims of this study were to find the probable relationship between Anatomical variations of Sino-nasal cavity and CRS and their role in causing its chronicity to identify and to compare the percentage calculation of these Anatomical variations and to study the laterality and gender differences in the variations in patients with CRS in population of Central India. This knowledge will be useful for future endoscopic surgeons in order to understand the pathogenesis of sinusitis and therefore avoid iatrogenic injury due to these common anatomical variations.

2. Materials and Methods

The research was undertaken following ethical clearance from the Ethical Society, and written informed consent was obtained from all participants in both English and Hindi, presented in a clear and understandable language. The study included 100 CT PNS cases, aged 18 to 42 years, collected from the Radiologist, mainly referred from the ENT department at MGM Medical College and associated hospital—tertiary care centers in the MP region (Central India). These cases exhibited clinical features of CRS unresponsive to medical management for 8 weeks or more and underwent CT scans of the paranasal sinus region as part of routine medical treatment. Clinical features of CRS, such as facial pressure or pain, nasal discharge, nasal congestion, fatigue, headache, postnasal drip, and/or loss of sense of smell, were assessed for symptomatology.

Inclusion criteria encompassed adult patients (both genders) aged 18 to 42 years, regardless of socio-economic status, with a clinical diagnosis of CRS advised for CT scans as part of routine management, displaying CT scan findings of 4 mm or more mucosal thickening in any of the paranasal sinuses, as diagnosed by the radiologist.

Exclusion criteria included patients with a history of previous sinus surgery, benign tumors of sino-nasal mucosa or facial trauma, facial disturbances, mucosal polyps (massive or recurrent), other expansive lesions, craniofacial anomalies, those unwilling to undergo necessary investigations, and those with fungal rhinosinusitis (mycetoma), genetic diseases, or a history of endoscopic sinus surgery.

The control group comprised 100 patients aged 18 to 42 years who had undergone CT scans of the paranasal sinus region for reasons other than CRS, such as trauma or headache evaluation, and did not exhibit any signs of CRS. The CT scans, obtained with a 64 Slice Multidetector CT machine, covered the region from the roof of the frontal

sinus to the hard palate, with 5 mm slice thickness. Coronal sections were performed with patients in the prone position, and the presence of anatomical variations was documented and correlated with chronic inflammation with consultation from a Rhinologist.

Statistical analysis involved tabulating and analyzing the data using SPSS version 21 and MS Excel software. Numerical data were expressed as mean, while categorical data were expressed as numbers and percentages. Unpaired t-tests and Chi-square tests were utilized for comparing independent groups of numerical and categorical data, respectively, with significance set at $P < 0.05$.

Figure 1: Coronal CT showing bilateral concha bullosa (stars)

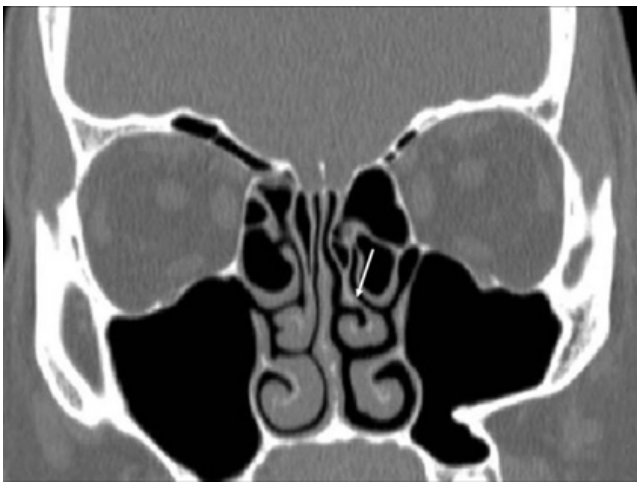

Figure 2: Coronal CT showing left sided paradoxical middle turbinate (arrow)

3. Observations and Results

We took 100 CRS cases in which 41 were females and 59 were males. The age group taken in the present study was 18 to 42 years with mean age 29.1 ± 8.06 (SD) years. Maximum percentage of variations were found in the age

Figure 3: Coronal CT showing bilateral agger nasi cells (arrows)

Figure 4: Coronal CT showing nasal septal Deviation on the left side (arrow)

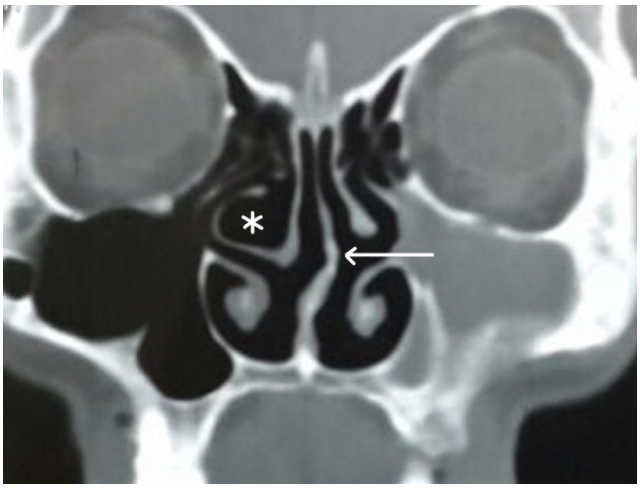

Figure 5: Coronal CT showing right sided concha bullosa (star) and left sided nasal septal deviation (arrow)

Table 1: Relationshipbetween anatomical variations of sino-nasal cavity with chronic rhinosinusitis

Parameter	Total N=200	Cases N=100	Controls N=100	p Value	Significance
DNS	64%	69%	59%	0.1421	Ns
CB	57%	48%	66%	0.01	**
PMT	20.50%	19%	22%	0.6014	Ns
PUP	1.50%	3%	0%	-	-
AN	68.50%	65%	72%	0.289	Ns
HC	15%	14%	16%	0.6938	Ns

Ns- Not Significant, ** Highlysignificant

Table 2: Distribution of anatomicalvariations among cases and control according to gender

Sino-nasal Variations	Female		Male		Total
	Cases (n=41)	Controls (n=27)	Cases (n=59)	Controls (n= 73)	Cases+ Controls
DNS%	73.2	55.6	66.1	60.3	64
CB%	46.3	66.7	49.2	65.8	57
PMT%	17.1	22.2	20.3	21.9	20.5
PUP%	2.4	0	3.4	0	1.5
AN%	51.2	74.1	74.6	71.2	68.5
HC%	12.2	11.1	15.3	17.8	15

Table 3: Distributionof laterality of anatomical variations among cases and controls

Variation	Laterality	Cases % (N=100)	Controls % (N=100)	Mean of Case + Control %
DNS	R	34	34	34
	L	35	25	30
	B/L	15	32	23.5
CB%	R	15	16	15.5
	L	18	18	18
	B/L	4	1	2.5
PMT	R	9	11	10
	L	6	10	8
	B/L	2	0	1
PUP	R	1	0	0.5
	L	0	0	0
	B/L	56	71	63.5
AN	R	6	1	3.5
	L	3	0	1.5
	B/L	8	9	8.5
HC	R	3	2	2.5
	L	3	5	4

group of 18 to 22 years that was 29% in cases and 25% in controls. Of the total 200 participants including 100 cases of CRS and 100 asymptomatic subjects (Table 1), it was found that the Agger nasi cells were the most common anatomical variation present in 68.5% of the study population. The occurrence of other variations in the study population were as Deviated nasal septum 64%, Concha bullosa 57%, Paradoxical middle turbinate 20.5%, Pneumatized uncinate process 1.5% and Haller cells 15%.

It is found that there is no significant relationship between various anatomical variations taken up in the study with chronic rhinosinusitis. Although the difference in the occurrence of Concha bullosa is significantly more in controls than in cases (p value=0.01), it does not points towards its association with Chronic Rhinosinusitis.

According to Table 2, which shows distribution of anatomical variations in male and female, DNS to be more common in female patients of CRS (73.2%), where as Agger Nasi cells (74.6%) were more common in male cases. Haller cells were more common in both cases and controls in men (15.3% and 17.8%). No significant difference (p value > 0.05) was found in the distribution of anatomical variations among males and females. The distribution of these variations also showed non-significant differences

among different age groups.

4. Discussion

In our investigation, we examined CT scans for various sino-nasal anatomical variations in 100 CRS patients, correlating them with radiologic evidence of sinus mucosal disease. The incidence of these variations was then correlated with the presence of unilateral or bilateral sinusitis, and our findings were compared with existing literature data. The conclusion drawn is that these normal anatomical variations can predict the occurrence of chronic rhinosinusitis. CT scans, the preferred imaging modality for paranasal sinusitis, offer detailed anatomical information about the sinuses and adjacent soft tissue.[15]

In our investigation, the 18 to 22 years age group exhibited the highest percentage of anatomical variations—29% among cases and 25% among controls. Elsherif et al[16] found a notable increase in patients with anatomical variations in the 40-60 years age group ($p<0.05$), coupled with a significant decrease in those above 60 years (<0.05). The rationale behind the prevalence of anatomical variations in younger patients may be attributed to the typical development of these variants during facial growth in puberty and the completion of paranasal sinus pneumatization, involving the formation of air cells such as those in the mastoid and ethmoid bones. Consequently, individuals with one or more of these anatomical variations may develop inflammatory paranasal sinus disease (sinusitis) at an earlier age compared to those without such variants. A broader age group analysis could provide a more detailed understanding of the age distribution of anatomical variations in the sino-nasal cavity.

While tabulating anatomical variations among total subjects (both cases and controls), we found no significant difference in the laterality of these anatomical variations, except for the Agger nasi cells, which tended to occur bilaterally (63.5%), and Paradoxical Middle Turbinate, which showed an inclination towards unilateral presentation (18%). The significance of the difference in these results has not been discussed so far. Thus, this study could serve as a reference for further investigations, particularly during endoscopic surgeries of the paranasal sinuses. It can assist surgeons by providing a general idea of how these variations present themselves, whether more likely on one side or both sides.

Upon evaluating gender differences, DNS was more common in female CRS patients (73.2%), while Agger Nasi cells were more common in male cases (74.6%). Haller cells were more common in both male cases and controls (15.3% and 17.8%), but these results were not significant ($p>0.05$). These results align with studies by Elsherif et al,[16] Stalmen et al and Babusa et al, demonstrating a high incidence of anatomic variations in female patients, but with insignificant differences compared to male patients.

Studies by Ozgur et al, Kanjvi, and Sarafaraz concluded that DNS was the most common variation, similar to our findings. In the above studies, Concha Bullosa was more common in cases than controls but not statistically significant. Awasthi A et al study found a significant prevalence of Concha Bullosa in the control group compared to cases of chronic rhinosinusitis (CRS), and Deviated Nasal Septum (DNS) was more associated with the opposite side where Concha Bullosa was present.[17] The occurrence of Concha Bullosa showed a significant correlation with mucosal thickening, aligning with findings from studies by Nouraei et al, Riello et al., Perez et al.,[2,18,19] and Roman et al.

In our investigation, the incidence of Agger Nasi (AN) cells was 65% in cases and 72% in the control group, a difference that was not statistically significant. Bolger and Mawn[20] reported a 98.5% rate of AN cells in paranasal CT, consistent with results from other studies.[21] These variations in findings may be attributed to differences in diagnostic methods and the ease of AN cell detection through CT scans.

In Azila's study, the prevalence of Haller cell (HC) was reported at 51%.[10] However, in our investigation, the rates were 14% among chronic rhinosinusitis (CRS) cases and 16% in the control group, demonstrating no statistical significance. Therefore, it can be inferred that HC is not implicated in the etiology of CRS.

Pneumatization of the Uncinate Process (PUP) is a rare sinonasal anatomical variation, with reported rates ranging from 0.4% to 9% in previous studies.[22,23] In our study, PUP was identified in 3% of cases and was absent in the control group, consistent with existing literature. Some authors propose that PUP may lead to functional blockage of the osteomeatal complex, acting as a predisposing factor for sinusitis in the anterior ethmoid and frontal cells, disrupting sinus ventilation at the infundibular region. However, in our study, this difference was not statistically significant. Similarly, Azila et al.[24] observed an equal distribution of PUP among CRS patients and controls (3.3%).

5. Conclusion

While these anatomical variations may not directly indicate the presence or severity of CRS, they could serve as early indicators. This underscores the importance of lifestyle modifications to counteract the disease at its nascent stage. This study, along with similar research, holds valuable insights for ENT surgeons and radiologists, aiding in the prevention of damage to these variations during sinusitis surgery. Further detailed studies are warranted to enhance our understanding of the role of these variations in the etiopathogenesis of CRS.

Scope for further research: Similar study can be conducted in other regions and a comparison can be drawn

for better understanding.

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Acknowledgement

None.

References

1. Dwivedi A, Singh KK. CT of the paranasal sinuses: normal anatomy, variants and pathology. *J Optoelectron Biomedicaln Mater*. 2010;2(4):281–9.
2. Pérez-Piñas I, Sabaté J, Carmona A, Catalina-Herrera CJ, Jiménez-Castellanos J. Anatomical variations in the human paranasal sinus region studied by CT. *J Anat*. 2000;197(2):221–7.
3. Slavin RG, Spector SL, Bernstein IL, Kaliner MA, Kennedy DW, Virant FS, et al. The diagnosis and management of sinusitis: A practice parameter update. *J Allergy Clin Immunol*. 2005;116(6):13–47.
4. Scribano E, Ascenti G, Cascio F, Racchiusa S, Salamone I. Computerized tomography in the evaluation of anatomic variations of the ostiomeatal complex. *Radiol Med (Torino)*. 1993;86(3):195–9.
5. Laine FJ, Smoker WR. The osteomeatal unit and endoscopic surgery: anatomy, variations, and imaging findings in inflammatory diseases. *AJR Am J Roentgenol*. 1992;159(4):849–57.
6. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. *Laryngoscope*. 1991;101(1 Pt 1):56–64.
7. Benninger MS, Ferguson BJ, Hadley JA, Hamilos DL, Jacobs M, Kennedy DW, et al. Adult chronic rhinosinusitis: Definitions, diagnosis, epidemiology, and pathophysiology. *Otolaryngol Head Neck Surg*. 2003;129(3):1–32.
8. Hopkins C, Brown JP, Slack R, Lund V, Brown P. The Lund-Mackay staging system for chronic rhinosinusitis: How is it used and what does it predict? *Otolaryngol Head Neck Surg*. 2007;137(4):555–61.
9. Madani S. Association Between Anatomical Variations of the sinonasal Region and Chronic Rhinosinusitis: A Prospective Case Series Study. *Scientific J Fac Med Niš*. 2013;30(2):73–7.
10. Azila A, Irfan M, Rohaizan Y, Shamim AK. The Prevalence of Anatomical Variations in Osteomeatal Unit in Patients with Chronic Rhinosinusitis. *Med J Malaysia*. 2011;66(3):191–4.
11. Berjis N, Hashemi SM, Rogha M, Biron MA, Setareh M. Some anatomical variation of paranasal sinuses using sinus endoscopic approach on "cadaver" in Isfahan. *Adv Biomed Res*. 2014;3:51. doi:10.4103/2277-9175.125774.
12. Danese M, Duvoisin B, Agrifoglio A, Cherpillod J, Krayenbuhl M. Influence of nasosinusal anatomic variants on recurrent, persistent or chronic sinusitis. X-ray computed tomographic evaluation in 112 patients. *J Radiol*. 1997;78(9):651–7.
13. Kennedy DW, Zinreich SJ. The functional endoscopic approach to inflammatory sinus disease: Current perspectives and technique modifications. *Am J Rhinol*. 1988;2(3):89–96.
14. Stammberger HR, Posawetz W. Functional endoscopic sinus surgery. Concept, indications and results of the Messerklinger technique. *Eur Arch Otorhinolaryngol*. 1990;247(2):63–76.
15. Lanzieri C. The sinonasal cavity . In: Haaga JR, Boll D, editors. Computed Tomography & Magnetic Resonance Imaging of The Whole. Toronto: Mosby; 1994. p. 471–93.
16. Elsherif MH. Some Anatomic Variations of the Paranasal Sinuses in patients with chronic sinusitis: a correlative CT study to age & Sex. *AAMJ*. 2006;4(3):42–5.
17. Awasthi A, Jehan M, Bose A. Association Of Chronic Rhino Sinusitis With Concha Bullosa And Deviated Nasal Septum. *IOSR J Dent Med Sci*. 2016;15(10):50–7.
18. Nouraei SA, Elisay AR, Dimarco A, Abdi R, Majidi H, Madani SA, et al. Variations in paranasal sinus anatomy: implications for the pathophysiology of chronic rhinosinusitis and safety of endoscopic sinus surgery. *J Otolaryngol Head Neck Surg*. 2009;38(1):32–7.
19. Riello AP, Boasquevisque EM. Anatomical Variants of the Ostiomeatal Complex: Tomographic Findings in 200 Patients. *Radiol Bras*. 2008;41(3):149–54.
20. Bolger WE, Mawn CB. Analysis of the suprabullar and retrobullar recesses for endoscopic sinus surgery. *Ann Otol Rhinol Laryngol Suppl*. 2001;186:3–14. doi:10.1177/00034894011100s501.
21. Navarro JAC. The nasal cavity and paranasal sinuses: surgical anatomy. Heidelberg: Springer; 2001.
22. Fadda GL, Rosso S, Aversa S, Petrelli A, Ondolo C, Succo G, et al. Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. *Acta Otorhinolaryngol Ital*. 2012;32(4):244–51.
23. Zinreich SJ, Mattox DE, Kennedy DW, Chisholm HL, Diffley DM, Rosenbaum AE, et al. Concha bullosa: CT evaluation. *J Comput Assist Tomogr*. 1988;12(5):778–84.
24. Kim HJ, Cho JM, Lee J, Tae K, Kahng H, Sung K, et al. The relationship between anatomic variations of paranasal sinuses and chronic sinusitis in children. *Acta Otolaryngol*. 2006;126(10):1067–72.

Author biography

Aprajita Awasthi, Assistant Professor

A Bose, Professor

Yamini Gupta, Professor and HOD

S Srivastava, Ex-Professor and HOD

Cite this article: Awasthi A, Bose A, Gupta Y, Srivastava S. Evaluation of the relationship between anatomical variations of the sinonasal cavity and chronic rhinosinusitis through ct scan at a tertiary care center in central India. *Panacea J Med Sci* 2024;14(2):567-572.