Journal of Cardiovascular Disease Research
ISSN:0975-3583,0976-2833 VOL14,ISSUE01,2023

Original Research Article

A Computed Tomographic Analysis of Paranasal Sinus Bony Anatomic Variations

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Abstract

Introduction

This study aims to evaluate the presence and characteristics of anatomic variations and mucosal abnormalities of the paranasal sinus in patients with chronic rhinosinusitis by coronal plane Computed Tomography (CT) scan imaging.

Materials and Methods

This retrospective descriptive study constituted a study population of 100 patients with clinical evidence of chronic rhinosinusitis with or without nasal polyposis. All patients were evaluated with Computed Tomography (CT) imaging of Paranasal sinus coronal view. The study duration was from July 2011 to September 2014.

Result

The most common anatomic variation found was Deviated Nasal Septum (DNS) (74%) followed by Concha Bullosa (48%). Maxillary sinus was found to be the most commonly exposed to mucosal abnormalities. Patients with grade I, II and III polyposis had mean CT scan Lund-Mackay scores of 14, 17.2 and 22 respectively. Patients without polyposis had least mean CT scan score of 10.

Conclusion

Computed Tomography of the paranasal sinus has improved the visualization of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. Deviated nasal septum and concha bullosa were the most common variations in the nose and paranasal sinuses and are proposed to play a significant role in the causation of Chronic Rhino Sinusitis (CRS).

Keywords: Chronic Disease; Computed Tomography; Sinusitis; X-Ray

1. INTRODUCTION

The anatomy of paranasal sinuses is extremely variable and is in close proximity to important body parts such as optic nerve, carotid artery, and skull base. This is found to account for its complex relationship with Chronic Rhino Sinusitis (CRS). Therefore, recognition of anatomical variations and related structures is of vital importance for the sinus surgeon to avoid probable complications.[1]

Ventilation and drainage are responsible for the maintenance of normal physiology of sinuses and their mucus membranes; and this in turn depends upon the physiological condition of the sinus ostium.[2] Any anatomical abnormality that impedes sinus drainage can potentially cause (chronic) sinus inflammation leading to chronic rhinosinusitis (CRS). The presenting symptoms of CRS are nasal congestion, fatigue, headache, hyposmia or anosmia, and facial pain; these can be disabling and can significantly reduce Health-Related Quality of Life (HRQoL).[3] Among the anatomic variants, concha bullosa (especially the larger ones), and giant ethmoidal bulla occur in the vicinity of the maxillary sinus infundibulum, and agger nasi cells are close to the frontal sinus recess.[4] A CT scan of the same readily detects these variations and paves way for definitive management of these patients. However, it should be borne in mind that mere single detection of an anatomical variant does not establish the genesis of disease.[5]

2. METHODS

The present retrospective descriptive study was carried out in the Department of Otorhinolaryngology. A total of 100 Patients with clinical evidence of chronic rhinosinusitis with or without nasal polyposis were recruited and evaluated by CT scan PNS coronal view and x-ray PNS water's view as well. The duration of study was from July 2011 to September 2014.

The study included those patients who were clinically and/or radiologically diagnosed as having chronic rhinosinusitis in accordance with the American Academy of Otolaryngology and Head and Neck Surgery (AAO-HNS)

criteria and were refractory to optimal medical therapy for a minimum of 3 months. They were further subjected to CT scan of the paranasal sinus and were scored in accordance with the Lund-Mackay CT classification system.[6]

3. RESULTS

In this study of 100 patients, the study population ranged from 7 to 68 years of age. Majority of the patients belonged to 11-30 years of age (59%). The total number of male patients was 57 (57%) and females numbered 43 (43%).

Nasal discharge was the most common complaint (76% of patients) and followed by nasal obstruction in 73%, postnasal drip in 47% and headache in 36% among the entire patients. As many as 30% of patients presented with complaints of nasal polyp and 31% with sneezing. Epistaxis was present in 10%, around 25% of patients had ear discharge secondary to nasal pathology.

Radiological evaluation was done by coronal section C.T. Scanning of Paranasal sinuses. The most common anatomic variation found was Deviated Nasal Septum (DNS) (74%) followed by Concha Bullosa (48%). (Table I) In absolute percentage terms, the highest degree of variability pertained to the nasal septum (74%), followed by middle nasal concha (48%) in that order.

Maxillary sinuses were involved in 70 cases (70%), anterior ethmoid in 60 cases (60%), posterior ethmoid in 34 cases (34%), frontal sinus in 28 cases (28%) and sphenoid in 24 patients (24%). Involvement of the maxillary sinus was more with deviated nasal septum (p-value =0.0368) and with concha bullosa (p-value = 0.0181) whereas involvement of the frontal sinus was more in the presence of agger nasi cells (p-value = 0.0254). All the above associations were found to be statistically significant ($p<0.05$).

In our study, we found that patients with grade I, II and III of nasal polyposis had mean CT scan LM scores of 14,

Anatomical Variation	**No Of Patients**	**%**	**U/L**	**%**	**B/L**	**%**
DNS* **Spur**	74 20	74 20		-	-	-
Septum pneumatization	13	13	-	-	-	-
Concha bullosa	48	48	21	21	27	27
Paradoxical Middle Turbinate	18	18	7	7	11	11
Middle turbinate hypertrophied	21	21	7	7	14	14
Prominent bulla ethmoidalis	36	36	15	15	21	21
Agger nasi cells	30	30	12	12	17	17
Haller cells	11	11	10	10	1	1
Onodi cells	1	1	-	-	-	-
Uncinate process						
A)Medially bent	11	11	10	10	1	1
B)Laterally bent	10	10	7	7	3	3
C)Anteriorly Bent	-	-	-	-	-	-
D)Hypertrophied/edematous	18	18	5	5	13	13
Inferior turbinate hypertrophied	28	28	13	13	15	15

17.2 and 22 respectively. (Table II). Patients without polyposis had least mean CT scan score of 10.

OTHERS **Crista Galli Pneumatization** **Maxillary sinus septa**	16 8	16 8				

Table I: Various anatomic variations found in our study

*DNS- Deviated Nasal Septum

Table II. CT scoring in patients

Grade of polyposis	**Mean Score**
Grade I	14
Grade II	17.2
Grade III	22
Patients without polyposis	10

4. DISCUSSION

Anatomic variations in the region of the paranasal sinuses were found to be fairly common in our study. We evaluated the same among patients of chronic rhinosinusitis and assessed for its significance in the causation of CRS. Patients with CRS in our study most commonly presented with nasal discharge (76%) followed by nasal obstruction (73%), post nasal drip (47%) and headache (36%). This was in accordance with the results of *Mackay and Lund (1991)* and *Kirtane and Nayak (1991)*. In their studies, the most common clinical presentation observed were nasal discharge (74% & 78.1%) followed by headache and facial pain (72% & 68.7%) and nasal blockage (70% & 68.7% respectively).[7,8]

Nasal septum:
Deviation of the nasal septum was present when there was non alignment between septal cartilage, perpendicular ethmoidal lamina, and vomer. *Bolger et al. (1991), Zinreich et al. (1990)* and *Perez-Pinas et al. (2000)* observed deviated nasal septum in 18.8%, 28% & 55% patients respectively.[9,10,11]
In our study we reported the prevalence of nasal septal deviation among 74% of cases. This was the most common abnormality found in our study and its association with maxillary sinusitis was found in 56 cases; which was statistically significant ($p < 0.05$).

Concha Bullosa:
Messerklinger (1967), Zinreich et al. (1988), Goldman (1987), Bolger et al. (1991) and *Kaplanoglu et al. (2013)* observed concha bullosa in 34%, 33%, 80%, 53% & 30.8% patients respectively.[12,13,14,9,15] *I*n our study, concha bullosa was present in 48% of patients, out of whom 10.4% were the lamellar type (5 patients), 50% were the bulbous type (24 patients) and 39.6 % were true concha bullosa (19 out of 100 patients). Of the 5 patients with lamellar type of concha bullosa, only 1 had maxillary sinusitis (20%) but with bulbous and true concha bullosa, the involvement of maxillary sinus was in almost all patients, i.e. in 38 out of 43 patients (88.37%). This was the second most common variation found and it was statistically significant in association with maxillary sinusitis ($p < 0.05$). (Fig 1 & Fig 2).

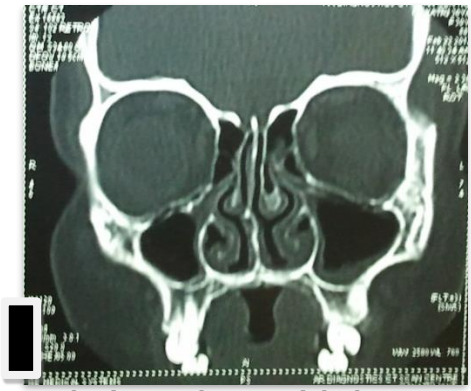

Fig. 1. CT scan showing severe DNS right along with mucosal thickening in right infundibular region and concha bullosa left side with mild mucosal thickening in left maxillary sinus and left infundibular region.

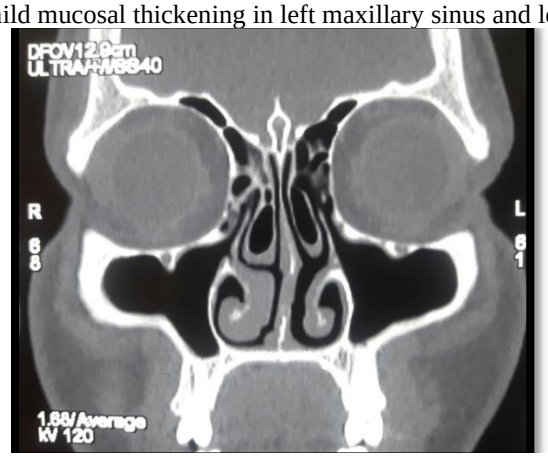

Fig. 2. CT scan showing severe DNS left with bilateral concha bullosa along with mucosal thickening in both infundibular region and bilateral ethmoid sinus.

Paradoxically curved middle turbinate

Bolger (1991) observed paradoxically curved middle turbinate in 26.1% and *Perez-Pinas (2000)* observed in 10%.[9,11] *Lloyd (1991)* reported that obtaining an accurate image of paradoxically curved middle turbinated was related to the level of the coronal CT scan.[16] However we reported paradoxically curved middle turbinate in 18 % of our patients. (Fig 3).

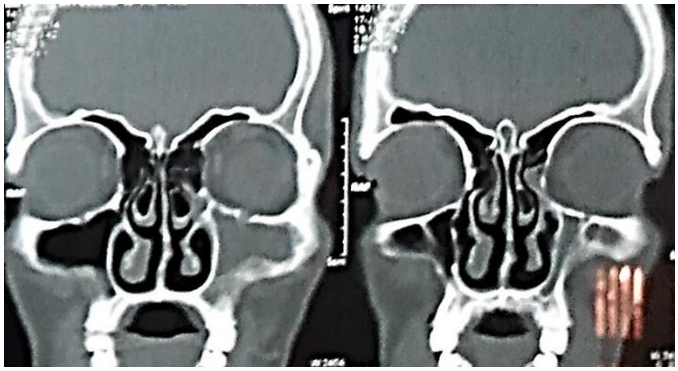

Fig. 3. CT scan showing paradoxical curvature of middle turbinate left side and bilateral concha bullosa with mild mucosal thickening in both ethmoid sinus and right maxillary sinus with incomplete septa and left maxillary sinus complete opacification.

Agger Nasi

Wormald considered these cells as the key to understanding the complex anatomical configuration of the frontal recess.[17] When present, these cells cause narrowing of the frontal recess by expanding superiorly and posteriorly and thus predisposing to frontal sinusitis. *Perez-Pinas et al. (2000)* reviewed 110 CT scans of patients suspected with inflammatory sinus pathology and found agger nasi in all cases studied.[11] *Bolger et al. (1991)* reported the same to be 98.5%, and *Zinreich SJ et al. (1990)* found these cells in nearly all patients, while *Lloyd et al. (1991)* described the same in 3% and *Kaplanoglu et al. (2013)* reported in 63% of patients. [9, 10, 16, 15]

This large difference in the reported incidence rates is attributable to the definition of agger nasi cells. If only large agger nasi cells are considered, then the reported incidence is low.

We reported agger nasi in 30 % in our study, out of whom 13 patients had frontal sinusitis. Its association with frontal sinusitis was found to be statistically significant ($p < 0.05$).

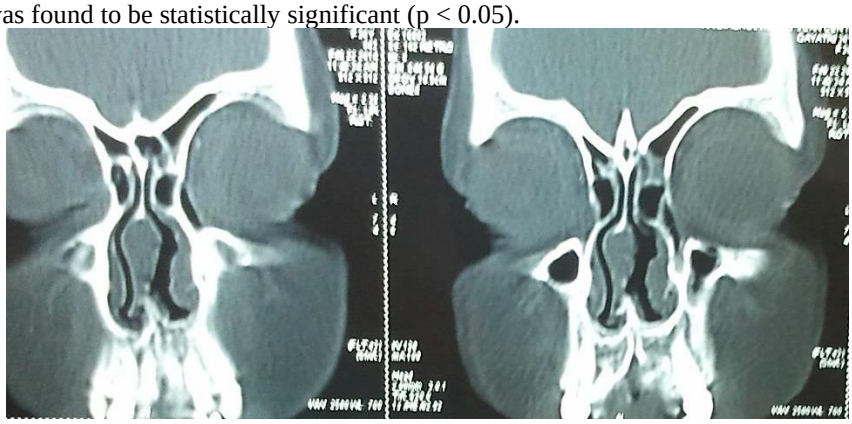

Fig. 4. CT scan showing prominent agger nasi bilaterally with mild mucosal thickening left frontal recess.

Uncinate process variations

Bolger et al. (1991) reported the incidence rate of pneumatization of the uncinate process to be between 0.4% and 2.5% of the population.[9] We did not observe pneumatization in any of the patients in our study**.**

In our study, we observed abnormal Uncinate process in 39 % of the cases; among whom it was hypertrophied/edematous in 18% and bent in 21%. Medially bent uncinate process was seen in 11 % cases while laterally bent uncinate process was seen in 10 % cases.

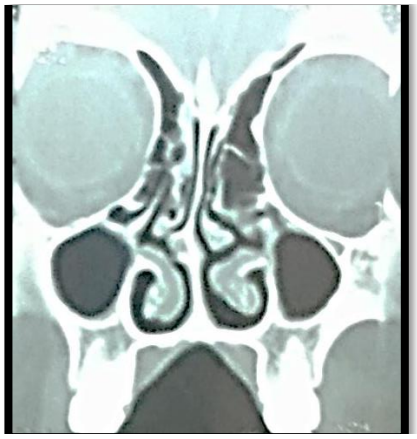

Fig. 5. CT scan showing horizontal uncinate process and enlarged ethmoid bulla left with mild mucosal thickening in ethmoid infundibulum.

Enlarged ethmoid bulla

A large ethmoidal bulla may contribute to sinus disease by obstructing the infundibulum or middle meatus or by being primarily diseased and filled with pus, cysts or polyps. *Dua et al. (2005)* in their study found over pneumatized ethmoid bulla in 4 patients unilaterally (8%) and 3 patients bilaterally (6%).[18] *Zinreich (1990)* reported the prevalence of this anatomical variant to be 8%.[10] We however found giant ethmoid bulla in a staggering 36% of patients.

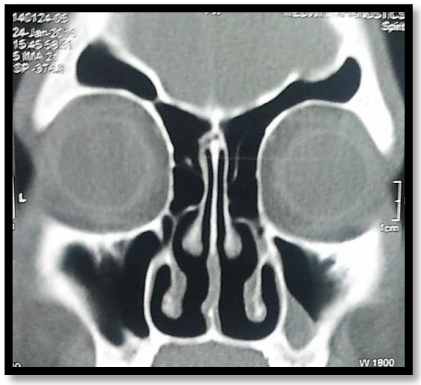

Fig. 6. CT scan showing enlarged ethmoid bulla with mild mucosal thickening in ethmoid infundibulum.

Haller cells

These cells are considered as a factor in recurrent maxillary sinusitis as they contribute to the narrowing of the infundibulum and the adjacent ostium of the maxillary sinus. *Zinreich (1990)* reported the Haller cells in 10%.[10] We reported Haller cells in 11% of patients.

Onodi cells

The prevalence of Onodi cells in CT studies varies from 8% to 13%.[17]

Onodi cells were found unilaterally only in 12 patients (13.6%) and bilaterally in 16 (18.2%) in their study by *Nitinavakarn et al.*[19] In their study by *Chaudhary et al. (2014)* this prevalence was 31%.[20] We found Onodi cells in a meagre 1 % of cases only.

Inferior Turbinate Variations

In our study, soft tissue hypertrophy of the inferior turbinate was seen in 27 % cases. We observed bony hypertrophy in just 1 patient and no pneumatization of the inferior turbinate in any of them.

Maxillary Sinus Variants

Maxillary sinus septation, duplication, rudimentation and complete agenesis are various anatomic variants of the maxillary sinus. We found septation of the maxillary sinus in 8% of cases.

Sphenoid Sinus Variants

In their study, *Perez- Pinas (2000)* found asymmetry between both loculi of the sphenoid sinus.[11] Similarly, we found asymmetry between both cavities of sphenoid sinus in our study.

Other Bony Anomalies

Anatomic anomalies that have not been implicated in the etiology of rhinosinusitis, such as pneumatization of the crista galli, the variations may also be frequently encountered on routine sinus CT examination of the PNS. In our series, Crista galli was found to be pneumatized in 30 cases (30%).

Mucosal Abnormalities

Mucosal abnormalities ranged from minimal mucosal thickening to total sinus opacification. Mucosal abnormalities were most frequently noted in the maxillary sinus (70%) followed by anterior ethmoid sinus in (60%) cases in our study. Results of various studies are shown in Table III.

Table III: Sites **Of Sinus Of Inflammation/ Infection Expressed In Percentage**

Sinus of infection/ inflammation	**Kennedy et al.[21]**	**Clement et al.[22]**	**Lloyd et al.[16]**	**Bolger et al[9]**	**Calhoun et al.[23]**	**Desothale et al.[24]**	**The present study**
Anterior ethmoid	78	35	63	78.2	84.3	74	60
Maxillary sinus	66	73	83	68.8	77.7	83	70
Frontal	34	19	57	30.5	38.6	39	28
Posterior ethmoid	31	13	60	32.3	36.6	38	34
Sphenoid sinus	16	13	49	22.3	25.4	22	24

In this study, it was found that the most common radiological pattern on CT scan was the *ostiomeatal pattern* followed by *anterior ethmoid* followed by the *posterior ethmoid sinuses*.

We found LM CT scoring of 14 in patients of chronic rhinosinusitis with grade I polyposis, a score of 17.2 in patients of chronic rhinosinusitis with grade II polyposis, a score of 22 in patients of chronic rhinosinusitis with grade III polyposis and a score of 10 in patients of chronic rhinosinusitis without polyposis. *Razmpa E et al. (2013)* in their study observed scores of 17.4, 16.9, 21.71 and 14.35 respectively. [25]

5. CONCLUSION

Chronic rhinosinusitis is a fairly common disease condition affecting most commonly the age group between 10-30 years, with male preponderance. The chief symptoms among all patients were nasal discharge, nasal obstruction, and headache.
CT scan imaging of PNS is an excellent tool for the precise evaluation of nasal cavity and its anatomical variations which are hypothesized to result in a diverse range of rhino and nasal conditions.
Single detection of an anatomical variant does not establish the genesis of disease; before the suggestion of a causal relationship between the anatomical variant & the sinus pathology, these conditions should be prudently considered in conjunction with the patient's clinical presentation.

Financial support: This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Conflict(s) of Interest: None

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