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A Study on Anatomical Variations of Nasal Cavity Using CT Scan Images among South Indian Population

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KEYWORDS

Chronic rhinosinusitis, Paranasal sinuses, Nasal septum, Computerized tomographic scan, Anatomical variations, Maxillary sinus

ABSTRACT:

Introduction

Sinonasal diseases are global health problems that are frequently seen in rhinological practice. Chronic rhinosinusitis (CRS) is one of the leading causes of morbidity in the developing countries. Computerized tomographic imaging (CT) of the paranasal region has become an indispensable tool for the endoscopic sinonasal surgery. The present study was planned with two objectives: 1) To identify the distribution of anatomical variations in the sinonasal region for CRS group and control group using CT scan. 2) To find the association between anatomical variations in the sinonasal region and CRS among the study groups.

Materials & methods

The study was carried out among 800 participants (cases, i.e., patients with CRS n=400 and controls n=400) representing the south Indian population. Each sub group comprised of 200 males and 200 females. The data collection was done from the CT images, which scanned the anatomical variations of the sinonasal region.

Results

There was a higher incidence of bilateral CRS in maxillary sinuses 150 (74.6%) in males and unilateral maxillary sinusitis 40 (19.9%) in females of the cases group. Among the males of the cases group, the absence of patency in osteomeatal complex and frontal sinus drainage pathway, was seen among 76 (37.8%) and 68 (33.8%) participants, respectively.

Higher bilateral presence ofconcha bullosa, accessory septa within the maxillary sinus and onodi cell

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was seen among the males and females of the cases group. Among the anatomical variations in the sinonasal region, significant association ($p<0.01$)in the accessory septa within maxillary sinus, was seen among the female participants of the study group. The estimated risk for the CRS in cases and control groups, with OR (odds ratio),were optic nerve protrusion (OR=2.168, 95% CI=1.172-4.010) for the males. Among all the anatomical variations seen in the females, accessory septa within the maxillary sinus were statistically significant ($p<0.01$)with odds ratio (OR=2.556, 95% CI =1.309-4.988).

Conclusion

The study findings show marked variations in the sinonasal region, and suggest a cautious preoperative assessment while approaching the cranial regions during surgical interventions.

Introduction

Sinonasal diseases are health problems that are frequently seen in rhinological practice. Chronic rhinosinusitis (CRS) is the inflammation of the respiratory mucosa, lining the nasal cavity and paranasal sinuses. It is one of the leading causes of morbidity in the developing countries. CRS is aggravated by presence of anatomical variations in the sinonasal region. Computerized tomography(CT) scan technique is the gold standard imaging tool to assess the severity of the sinus disease [1,2].

The nasal septum frames the midline wall of the nasal cavity and gives an inflexible epiphyseal stage for the development of nasal cavity. Extensive pneumatization of the middle concha leads to the formation of concha bullosa that interferes with the normal ventilation and drainage patterns[3,4,5].

Paranasal sinuses located within the respective skull bones are named as frontal, ethmoid, sphenoidal and maxillary sinuses. The paranasal sinuses open into the lateral nasal wall by a small ostium[3,4]. The maxillary sinus is the largest of the paranasal sinuses. They are pneumatic air filled pyramidal spaces situated within the maxilla. The base of the sinus is contributed by the lateral wall of the nasal cavity. There is a narrow ostium located on the superior aspect of the medial wall, above the sinus floor. This ostia location of maxillary sinus is unfavorable for the sinus drainage[5,6,7].

In the coronal plane, frontal sinus drainage pathway (FSDP) appears as an hour-glass shaped configuration. The surgeons and the radiologists must be aware of these complicated FSDP anatomy, and be skilled in evaluating the assessment of the surgical planning [8].

Osteomeatal complex(OMC), which is located in the middle meatus, comprises of ethmoid infundibulum, maxillary sinus ostia, hiatus semilunaris, and uncinate process. The largest middle ethmoid air cell is termed the bulla ethmoidalis.OMC forms the common drainage pathway for secretions from the maxillary, frontal, middle, and anterior group of ethmoid sinuses.OMC is the key location that maintains the physiological function of the paranasal sinuses. Many authors opined the presence of anatomical variations produce ostial blockade and improper drainage from the OMC, and perpetuates the risk for CRS [9].

Sinusitis is described as an inflammation of the paranasal sinuses and its lining respiratory mucosa. The etiology can be either an allergy trigger, viral or bacterial infections [10]. When the infection spreads to the nasal regions it is termed as rhinosinusitis. Sinusitis can be classified into acute, subacute, chronic, and recurrent stages. It can have either an infected or non-infected pattern [9,10,11]. Chronic rhinosinusitis (CRS) is the inflammation of the paranasal sinuses lasting for at least eight weeks, despite attempts of medical treatment. CRS is repeated bouts of acute infection or persistent chronic inflammation of the sinuses [11,12].

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CT scan is the most precise imaging technique to demonstrate the paranasal sinuses. It displays bone, soft tissue, and air in their three dimensional orientation. Spiral CT scan provides excellent surgical orientation in axial, coronal, and sagittal sections. It enables the scanner to optimally evaluate the size of the orbital, maxillofacial bony structures, intracranial soft tissues and the OMC region [13]. The CT images clearly delineate the mucosal thickening, sinus opacity, bone sclerosis and disease extent during CRS. In addition, CT scan defines the underlying anatomic abnormalities that predispose to sinusitis. It also identifies the key neurovascular structures like orbital contents, optic nerve and carotid artery in the diseased areas, a course of action that is essential for surgical planning [13,14]. The appearance of bony details at wide window settings correlates exactly with the true measurements of the air spaces and the thickness of soft tissue diseases and bone [14,15,16].

A fundamental knowledge of the sinus anatomy is crucial for the preoperative surgery planning. The anatomical variations related to CRS are nasal spurs, concha bullosa, onodi cells, accessory septa within maxillary sinuses.

The aim of the study is to evaluate an association between the anatomical variations of paranasal sinuses and chronic rhinosinusitis using CT scan. The objectives of the present study are

- To find the distribution of anatomical variations in the nasal cavity and paranasal sinus regions, for chronic rhinosinusitis cases and the control group using CT scan.
- To find the association between anatomical variations in the nasal cavity and paranasal sinuses and chronic rhinosinusitis in the cases and the control group.

Materials and methods

A descriptive, observational case control study was carried out on patients who were referred for a CT scan from the department of Radio diagnosis and imaging, Karuna medical college.

Ethical clearance certificate was obtained from the medical institution.

This research study comprises of 800 patients. They are segregated according to their diagnosis into 400 patients under the cases group and 400 patients under the controls group. Out of each group, 200 were males and 200 were females. The patients are selected between the ages of 18-65 years.

The cases group comprises of patients, who are clinically diagnosed as chronic rhino sinusitis and not responding to medical treatment for more than 2 weeks. They are referred from department of ear, nose and throat for radiological assessment. The control groups are selected from the patients of non-CRS cases, neurological, ophthalmological and neck pathologies.

Distributions of the anatomical variations such as nasal spur, concha bullosa, maxillary accessory septa, onodi cell, were studied gender wise, among the cases and control group.

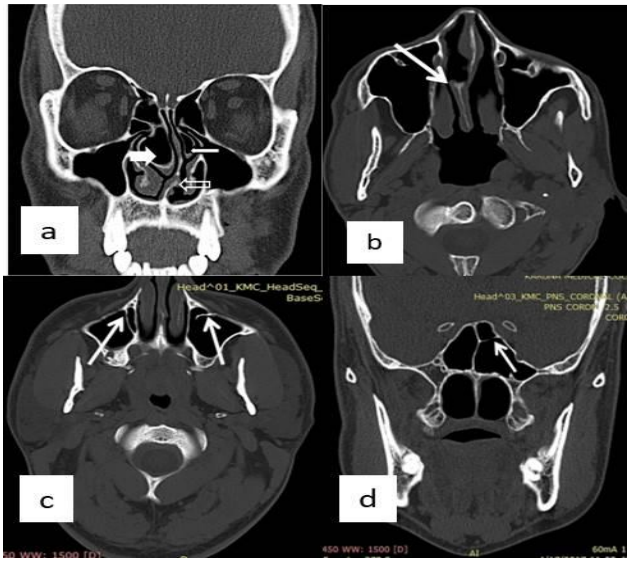

Fig. 1 Anatomical variations of the nasal cavity using CT scan images

a) Coronal CT image of the nasal cavity showing the deviated nasal septum(white outlined arrow) and bilateral concha bullosa (white solid arrows). b) Axial CT scan showing the presence of nasal spur (white solid arrow).c) Axial reconstructed CT scan image showing the bilateral accessory septa located within the maxillary sinuses (white solid arrow). d) Coronal CT image of paranasal

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sinuses shows left onodi cell (white arrow).SIEMENS AG somatom spirit scanner machine was used.

Measurements of mucosal thickening of maxillary sinus in chronic rhino sinusitis

Measurements of the maxillary mucosa were made perpendicularly to the underlying bone and the maximum thickest area was recorded using radiant software length measurement tool. The mucosal thickness of maxillary sinus is graded into five types. (Lana et al., 2012, Carmelli et al.,2011) [17,18].The thickness of the lining mucosa is measured from the floor of the maxillary sinus till the summit of the mucosal thickening using radiant software as shown in figure 2. They are categorized into type I,II,III,IV,V.

Table. 1 Classification of grading of the mucosal thickening of maxillary sinus

Grades	Range
Type I	1 to 5 mm
Type II	6 to 10 mm
Type III	11 to 15 mm
Type IV	15 to 20mm
Type V	> 20mm

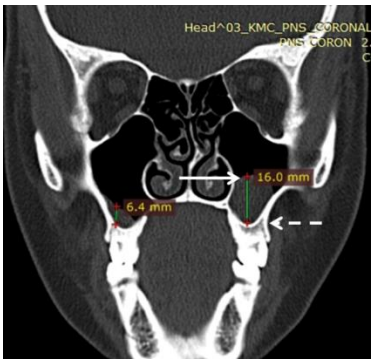

Fig. 2 Measurements of mucosal thickening (mm) on both right and left side of the maxillary sinus for the cases group suffering from chronic rhino sinusitis

Radiant software was used to measure the height of the mucosal thickening of the maxillary sinuses. The linear measurement extends from the floor of the maxillary sinus to the maximum height of the mucosal thickening within the sinus cavity. The mucosa appears radiopaque in CT image.

Data analysis will be done using descriptive statistics by implementing mean, percentage and standard deviation. Inferential statistics are applied by using chi-square test for qualitative variables, to test the significant association between the anatomical variations of paranasal sinuses and chronic sinusitis. Correlation test will be implemented to find an association, either positive or negative with p value > 0.05 to be considered insignificant, p value <0.05 will be considered significant, while p value <0.01 to be considered highly statistically significant. The association between chronic rhino sinusitis and prevalence of anatomical variations of paranasal sinuses were measured by implementing odds ratio with 95% confidence interval. Odds ratio is used to quantify the strength of the association between the anatomical variations and the outcome of the disease.

RESULTS

Chronic rhinosinusitis in the cases group

The occurrence of chronic rhinosinusitis (CRS) disease in the paranasal sinuses was assessed and represented as present or absent. Further, the presence of the disease pattern was evaluated as unilateral or bilateral occurrence. In addition, the patency of osteomeatal complex (OMC) and frontal sinus drainage pathway (FSDP) were assessed in the cases group.

CRS was identified by the mucosal thickening of the paranasal sinuses (PNS). The mucosal thickening was identified in the following sinuses namely, maxillary, sphenoidal, frontal, ethmoid, and two regions of concern, i.e., OMC and FSDP.

Table 2 shows a high incidence of bilateral CRS in maxillary sinuses 150 (74.6%) in males of the cases group. Higher incidence of unilateral maxillary sinusitis 40 (19.9%) was seen in females. In the present study, among the males of the cases group, CRS was seen in

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maxillary sinus (74.6%), ethmoid sinus (51.2%), sphenoidal sinus (43.8%) and frontal sinus (38.3%). While, among the females the distribution of CRS was in the following order: maxillary sinus (62.2%), ethmoid sinus (48.8%), sphenoidal sinus (35.8%) and frontal sinus (22.9%).

Presence of bilateral CRS was higher in males as compared to females. Bilateral inferior turbinate hypertrophy 159 (79.1%) was found more in females than the males of the cases group.

Among the males of the cases group, the absence of patency in OMC and FSDP, was 76 (37.8%) and 68 (33.8%), respectively. This shows that the incidence of absence of patency in OMC and FSDP is high.

Table. 2 Gender wise distribution of the mucosal thickening in the paranasal sinuses and nasal cavity of the cases group (n=200 + 200)

Location of thickening paranasal sinuses	Males n (%)			Females n (%)		
	Absent	Unilateral	Bilateral	Absent	Unilateral	Bilateral
Maxillary sinus	23 (11.9)	27 (13.4)	150 (74.6)	35 (17.4)	40 (19.9)	125 (62.7)
Sphenoid sinus	94 (46.8)	18 (9.4)	88 (43.8)	115 (57.2)	13 (7.0)	72 (35.8)
Frontal sinus	105 52.2)	18 (9.5)	77 (38.3)	125 (62.5)	29(14.6)	46 (22.9)
Ethmoid sinus	88 (43.8)	9 (5.0)	103 (51.2)	95 (47.3)	7(3.9)	98 (48.8)
Turbinate hypertrophy	37 (18.4)	26 (12.9)	137 (68.7)	26 (12.9)	15(8.0)	159 (79.1)
Regions of the nasal cavity						
OMC patency	76 (37.8)	25 (13.4)	99 (48.8)	58 (28.9)	39 (19.4)	103 (51.7)
FSDP	68 (33.8)	21 (11.0)	111 (55.2)	38 (18.9)	25 (12.4)	137 (68.7)

Data shown is frequency (n) with percentage in parenthesis (%). The data was assessed using SIEMANS AG scanner CT images. Abbreviations used: OMC-OsteoMeatalComplex; FSDP-frontal Sinus Drainage Pathway. Cases – patients with chronic rhinosinusitis.

Measurements of mucosal thickening in the maxillary sinus for the (cases group)

The mucosal thickening on the bilateral sides of the maxillary sinus was assessed for the presence of the CRS disease in both males and females of the cases group. The categorization was done based on the previous literature [17,18]. The mucosal thickening was graded as type 1 to type 5 according to the height of the respiratory mucosal lining as shown in Fig. 3 for males and in Fig. 4 for females.

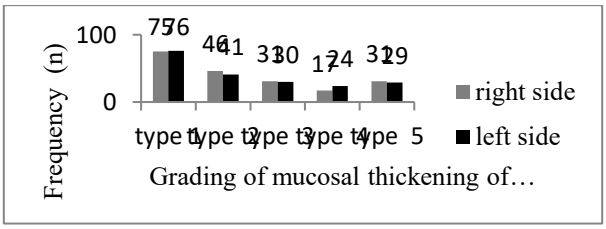

Fig. 3 Categorisation of the males in the cases group based on the mucosal thickening on the right and left side maxillary sinuses

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Categories: Type 1- 1-5 mm, type 2 -6 to 10 mm, type 3- 11 to 15 mm, type 4 - 15 to 20 mm and type 5 - >20 mm Data represented is frequency for the right and left side maxillary sinuses in males. The type of grading was plotted against x axis and frequency of the cases were plotted against the y axis. Cases – patients with chronic rhinosinusitis.

Among the males of the cases group, presence of type 1 mucosal thickening in the left maxillary sinus (n=76) followed by right side (n=75) was high. Type 2 was followed by type 5, type 3 and type 4 in the descending order (Fig. 3).

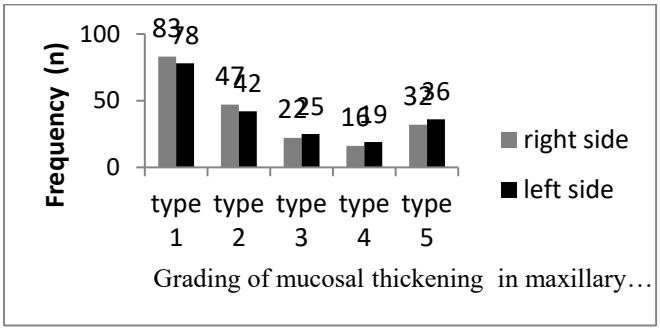

Fig. 4 Categorization of the female participants in the cases group based on the mucosal thickening on the right and left side maxillary sinuses

Categories: Type 1- 1-5 mm, type 2 -6 to 10 mm, type 3- 11 to 15 mm, type 4 - 15 to 20 mm and type 5 - >20 mm. Data represented is frequency of female participants with CRS for the right and left side maxillary sinuses. The type of grading was plotted against x axis and frequency of the cases were plotted against the y axis. Cases – patients with chronic rhinosinusitis.

Among the females of the cases group (Fig. 4), presence of type 1 mucosal thickening in the right maxillary sinus (n=83) followed by left side (n=78) was high. Type 2 was the most common, followed by type 5, type 3 and type 4 in the descending order.

Anatomical variations of the sinonasal region among the cases and control groups

The distribution of anatomical variations of sinonasal region was classified into absent or present. In case of the presence of the anatomical variations, the anatomical variation is further categorized as either unilateral or bilateral based on the occurrence. Distributions of the anatomical variations such as, nasal spur, concha bullosa, maxillary accessory septa, onodi cell, were studied gender wise, among the cases and control group.

Table3 shows that, among the males in the cases group, the bilateral presence of concha bullosa (22.3%), accessory septa within the maxillary sinus (35%), onodi cell (30%) were higher than that in the control group. However, in the control group, bilateral presence of nasal spur (21%) was higher than in the cases group.

Table. 3 Distribution of anatomical variations of paranasal sinuses identified using CT scan of the male participants of the study groups

Anatomical variations of paranasal sinus	Males (n = 400)					
	Cases n (%) (n=200)			Controls n (%) (n=200)		
	Absent	Unilateral	Bilateral	Absent	Unilateral	Bilateral
Nasal spur	151 (74.8)	25 (12.2)	24 (13.0)	145 (72.5)	13 (6.0)	42 (21.5)
Concha bullosa	127 (62.9)	28	45 (23.2)	142 (71.0)	23	35 (17.5)

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		(13.9)			(11.5)	
Accessory septa within maxillary sinus	101 (50.5)	29 (14.5)	70 (35.0)	141 (70.5)	16 (8.0)	43 (21.5)
Onodi cell	101 50.5)	39 (19.5)	60 (30.0)	171 (85.5)	7 (3.0)	22 (11.5)

The study groups were cases and controls. CT image was taken using Sieman AG Somatom scanner, to assess the anatomical variations of the paranasal sinuses. The data shown is frequency (n) with percentage in parenthesis (%). Abbreviations used: CT scan-Computerized Tomography scan. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronic rhinosinusitis.

Table 4 shows that, among the females of the cases group, the bilateral presence of concha bullosa (26.0%), accessory septa within the maxillary sinus (33.5%), onodi cell (29.5%) were higher than that in the control group. Unilateral occurrence of anatomical variations was higher in the cases than the control group.

Table. 4 Distribution of anatomical variations of paranasal sinuses identified using CT scan of female participants in the study groups

Anatomical variations of paranasal Sinus	Females (n = 400)					
	Casesn (%) (n =200)			Controls n (%) (n =200)		
	Absent	Unilateral	Bilateral	Absent	Unilateral	Bilateral
Nasal spur	169(84.0)	26 (13.0)	5(3.0)	190(95.0)	5 (2.5)	5 (2.5)
Concha bullosa	117 (59.0)	30 (15.0)	53(26.0)	136 (68.0)	16 (8.0)	48(24.0)
Accessory septa within maxillary sinus	110(55.0)	23(11.5)	67(33.5)	152(76.0)	10(5.0)	38(19.0)
Onodi cell	100 (50.0)	41 (20.5)	59(29.5)	161 (80.0)	11 (5.5)	28(14.5)

The study groups were cases and controls. CT image was taken using Sieman AG somatom scanner to assess the anatomical variations of the paranasal sinuses. The data shown is frequency (n) with percentage in parenthesis (%). Abbreviations used: CT scan-Computerized Tomography scan. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronicrhinosinusitis.

Genderwise distribution of the anatomical variations in the sinonasal region and their association with mucosal thickening among the study groups

Table 5 shows that, among the anatomical variations in the sinonasal region of the male participants of the study groups, none of the parameters showed any significance in the study population.

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Table. 5 Association between the anatomical variations of sinonasal region and the mucosal thickening among the male participants

Sl.No.	Anatomical variations of sinonasal region	Study groups	Mucosal thickening among males		p value
			Present	Absent	
1.	Nasal spur	Cases	138	13	0.577
		Controls	46	3	
2.	Concha bullosa	Cases	90	37	0.495
		Controls	55	18	
3.	Accessory septa within maxillary sinus	Cases	74	27	0.495
		Controls	71	28	
4.	Onodi cell	Cases	88	13	0.509
		Controls	83	16	

*The study groups were cases and controls. Abbreviations used: ICA- Internal Carotid Artery. ACP-Anterior Clinoid Process. The test used was Chi square test. Level of significance: p> 0.01** indicates highly significant, p<0.05*indicates significant, p>0.05 indicates non-significant. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronic rhinosinusitis.*

Distribution of anatomical variations in the sinonasal region, among the female participants of the study group, showed significant association in the accessory septa within maxillary sinus ($p<0.01$) (Table 6). None of the other parameters showed any significance in the study population.

Table. 6 Association between the anatomical variations of sinonasal region and the mucosal thickening among the female participants

Sl.No.	Anatomical variations of sinonasal region	Study groups	Mucosal thickening among females		p value
			Present	Absent	
1.	Nasal spur	Cases	160	9	0.622
		Controls	30	1	
2.	Concha bullosa	Cases	76	41	0.273
		Controls	60	23	
3.	Accessory septa within maxillary sinus	Cases	92	18	**0.005****
		Controls	60	30	
4.	Onodi cell	Cases	83	17	0.372

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	Controls	78	22

*The study groups were cases and controls. Abbreviations used: ICA- Internal Carotid Artery. ACP-Anterior Clinoid Process.The test used was Chi square test. p<0.01** indicates highly significant, p<0.05*indicates significant, p>0.05 indicates non-significant difference. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronic rhinosinusitis.*

Assessment of risk for chronic rhinosinusitis based on the anatomical variations and mucosal thickening of sinonasal region among the study groups

The present study focused on the anatomical variations and mucosal thickening of the sinonasal region to determine the risk of an individual for developing CRS. Odds ratio (OR) was used to estimate the risk for developing CRS. The OR was calculated for the anatomical variations and mucosal thickening in the sinonasal region for male (Table 7) and female (Table 8) participants in the study groups.

Table 7 shows that, among the anatomical variations of sinonasal region found in males, the OR calculated was the highest foronodi cell (OR=1.305, 95% CI=0.592-2.878). Chances of developing CRS are 1.305 times more with onodi cells. Hence, a male individual with onodi cell might be at a significant risk for developing CRS in the study population.

Among the male population, all the anatomical variations studied, except concha bullosa and nasal spurs, had an OR>1, suggesting these anatomical variations showed an increased risk of developing CRS.

Table. 7 Assessment of risk for development of CRS among male participants in the study groups based on the anatomical variations and mucosal thickening of sinonasal regions

Sl.No.	Anatomical variations of sinonasal region		Mucosal thickening among males		Odds ratio (OR)	95% Confidence Interval(CI)
			Present	Absent		
1	Nasal spur	Cases	138	13	0.692	0.189-2.538
		Controls	46	3		
2	Concha bullosa	Cases	90	37	0.796	0.413-1.533
		Controls	55	18		
3	Accessory septa within maxillary sinus	Cases	74	27	1.081*	0.581-2.011
		Controls	71	28		
4	Onodi cell	Cases	88	13	1.305*	0.592-2.878
		Controls	83	16		

*CT image, obtained from Sieman AG somatom scanner, was used to assess the anatomical variations. Odds ratio (OR) with 95% confidence interval (95% CI) was calculated.*Odds ratio > 1 was considered as risk. Abbreviations: ICA-Internal Carotid Artery,ACP-Anterior clinoid process. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronic rhinosinusitis.*

Table 8 shows that, among the anatomical variations of sinonasal region found in females, the OR calculated was the highest for accessory septa within maxillary sinus (OR=2.556, CI=1.309-4.988). Chances of developing CRS

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are 2.556 times more with the presence of accessory septa within maxillary sinus. Hence, a female individual with accessory septa within maxillary sinus might be a risk factor for developing CRS.

Among the female population, all the anatomical variations studied, except concha bullosa and nasal spurs, had an OR>1, suggesting these anatomical variations showed an increased risk of developing CRS.

Table. 8 Assessment of risk for development of CRS among female participants in the study groups based on the anatomical variations and mucosal thickening of sinonasal regions

Sl. No.	Anatomical variations of sinonasal region	Study groups	Mucosal thickening among females		Odds ratio (OR)	95% Confidence Interval (CI)
			Present	Absent		
1	Nasal spur	Cases	160	9	0.593	0.072-4.851
		Controls	30	1		
2	Concha bullosa	Cases	76	41	0.711	0.385-1.311
		Controls	60	23		
3	Accessory septa within maxillary sinus	Cases	92	18	**2.556***	1.309-4.988
		Controls	60	30		
4	Onodi cell	Cases	83	17	1.377*	0.681-2.785
		Controls	78	22		

*CT image, obtained from Sieman AG somatom scanner, was used to assess the anatomical variations. Odds ratio (OR) with 95% confidence interval (95% CI) was calculated.*Odds ratio > 1 was considered as risk. Abbreviations: ICA-Internal Carotid Artery,ACP-Anterior clinoid process. Cases – patients with chronic rhinosinusitis; Controls – healthy individuals without chronic rhinosinusitis*

DISCUSSION

The present study provided the following significant findings.

-Bilateral CRS of the maxillary sinus was more common among males of the cases group, whereas bilateral turbinate hypertrophy was more common among females of the cases group.

-The mucosal thickening of the left maxillary sinus was high among the males of the cases group, while right maxillary sinus showed more of mucosal thickening among the females of the cases group.

-Among the anatomical variations, left deviated nasal septum and intra sinus septa within maxillary sinus were more common in the cases group. This study re-emphasized that the nasal septum and variations in the osteo meatal complex forms a key factor for CRS.

Studies report that anatomical variations of paranasal sinuses and nasal cavity predispose to chronicity of rhinosinusitis [10,13]. The disease presents as symptomatic inflammation of the nasal and sinus mucosal lining extending more than 12 weeks, and is refractory to medical treatment. It progressively leads to recurrent nasal airway obstruction and worsens the morbidity of the patients [19,20].

There is apaucity in the knowledge regarding the presence of sinonasal anatomical variations, among the population from Kerala, South India. CT images of the sinonasal region showed varying degrees of mucosal thickening, and clogged drainage pathways with mucopurulent secretions.

In the present study, among both genders of the cases group, the prevalence of CRS was seen majorly in maxillary sinuses (44.3%) followed by ethmoid sinus, sphenoid sinus, frontal sinus. These findings were similar

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to those reported by Biswas *et al*., (2013), at Wardha [21], and Deosthale *et al*., (2014), at Nagpur [22]. Nath *et al*., (2017) in their study conducted at Trivandrum, demonstrated the gender wise presence of CRS as 48% and 52% among males and females, respectively [23].

Absence of the patency of drainage pathways directly reveals the extent of the chronicity of the CRS [24]. In the cases group of the present study, bilateral occurrence of inferior turbinate hypertrophy was found more among the females at 79.1%, than the males. Osteomeatal complex (OMC) forms the main mucosal draining pathway for the anterior group of sinuses. Considering OMC patency and frontal sinus drainage pathway (FSDP) patency, the absence of patency was higher among males at 37.8% and 33.8%, respectively.

Coronal images of sinonasal region were preferred for detecting the mucosal abnormalities [25]. In the present study, various degrees of maxillary mucosal thickening, ranging from minimal thickening to total sinus opacification were assessed. The current research showed an increased frequency of type 1 (1-5 mm) bilaterally, followed by type 2 (6-10 mm) on the right side among the males, and type 1 in the right maxillary sinus followed by left side among females of the cases group. The linear measurements of maxillary mucosal thickening done among the cases, i.e., patients suffering from CRS, done in a subset of the Indian population was a novelty of the present study.

In contrast to the present study, Shahbazian *et al*., (2010), in their study from Belgium, showed that 66% of the population had mucosal thickening of> 4 mm [26], and Carmelli *et al*., (2010), from Israel demonstrated 34% of the patients had > 5 mm of mucosal thickening in the maxillary sinuses [18].

Anatomical variations of the sinonasal region

The presence of anatomical variations like concha bullosa (CB), accessory septa within maxillary sinus, onodi cell were assessed from the CT scan images. The presence of anatomical variations in the paranasal sinuses among males and females were assessed for both the study groups. Findings similar to that of the present study were earlier reported by Deosthale *et al*., (2014), [22] and Biswas *et al*., (2013), [21]. Contrary to the present study, Bhandary *et al*., (2009), from Karnataka, demonstrated a higher frequency of concha bullosa [28].

The prevalence of onodi cells assessed in the present study was in concordance with that reported by Thimmappa *et al*.,(2014) [29]. Most of the anatomical variations of the cases group were found to have an association with the CRS disease [29,30].

Tomovic *et al*., (2012), in their cohort study, reported that the presence of onodi cells was 65.3%. Based on ethnicity, the studies from developed countries have documented the frequencies of onodi cells to be 83.3% among Asians, 73.1% among the whites, 57.0% among African Americans, and 62.7% among the Hispanics [14]. However, Daghighi *et al*., (2007), reported a higher prevalence of onodi cells than the present study [31].

Association between anatomical variations of sinonasal region and chronic rhinosinusitis

The present study calculated odds ratio (OR) to assess whether the frequencies of anatomical variations are the risk factors for CRS. Association between the anatomical variations of the sinonasal region, and the mucosal thickening, were assessed for both the genders, using Chi-square test.

In the present study, accessory septa within the maxillary sinus was significant ($p<0.001$) among the female participants of the cases and control group. Studies done by Reddy *et al*., (2018), showed the remaining anatomical variations to be statistically significant between the cases and control group [13,32].

The relationship between the anatomical variations of the sinonasal region and mucosal thickening of the paranasal sinuses were assessed by using OR among the genders of the two study groups. Considering all the anatomical variations among the males of the cases group, the estimated risk of developing CRS was 1.305 times [95% CI-0.592-2.878] in the presence of onodi cells with a significant positive relationship between the two. In addition, CB, and nasal spur, rest of the anatomical variations had a positive relationship with OR >1.

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Among the females of the cases group, accessory septa within the maxillary sinus had the highest estimated risk for CRS, OR =2.556 [95% CI-1.309-4.988]. Exclusively, the remaining anatomical variations, except CB and nasal spur, had OR >1.

Significance of the paranasal variations is documented to evaluate its prevalence and contribution for endonasal surgeries. FESS demands a meticulous assessment and a detailed description of both nasal and paranasal territories. Iatrogenic injuries can perpetuate post-operative complications such as, diplopia, visual blindness, cerebrospinal fluid (CSF) leak, intra-cranial hemorrhage, dural penetration, intra cerebral complications, etc.

CONCLUSION

Chronic rhinosinusitis (CRS) is one of the most prevalent, multifactorial upper respiratory diseases affecting all age groups. Detailed knowledge about the paranasal sinuses provides understanding about the upper limit of surgical dissection and further aids in road mapping the confident direction for the neurosurgeons. This is a preliminary study; further research can be done on diverse populations. The study findings show marked variations in the sinonasal region, and suggest a cautious preoperative assessment is necessary while approaching the cranial regions during surgical interventions. Apart from the cases group, the study investigated the normal population to provide information regarding the existence of the sinonasal variations. The findings support that, positive CT scan findings in both symptomatic and non-symptomatic patients should be meticulously assessed to create an awareness during endoscopic surgeries.

Among the females of the study group, the accessory septa within the maxillary sinus could be a risk factor for CRS. Except for a few anatomical variations (nasal spur and concha bullosa) most of the anatomical variations in the sinonasal region showed a significant relationship with CRS. Hence, the present study suggests that, the early identification of the sinonasal variations can help in reducing the propensity of the disease progress.

Limitations of the study

Few of the anatomical variations like concha bullosa, nasal spurs did not show correlation with the mucosal thickening of the nasal cavity.

Future scope of the study

This study forms a foundation for further research in analyzing the trigger factors that perpetuate CRS. Further research on the size, type and shape of the anatomical variations for the study group can be done to provide a paramount information for endoscopic surgeons.

CONFLICT OF INTEREST

No conflict of interest for the authors.

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