Original Article

Prevalence of Normal Anatomical Variations in the Region of Paranasal Sinuses in Patients with Chronic Rhinosinusitis

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Abstract

Background: Knowledge of the anatomical relationships and the anatomical variations in paranasal sinus region is critical for surgeons performing endoscopic sinus surgery. It helps surgeons to avoid the potential complications of sinus surgery and to improve success of management strategies. **Objective:** The objective of this study was to show how prevalent are the anatomic variations in the region of the paranasal sinuses and nasal cavity in patients with chronic rhinosinusitis. **Materials and Methods:** A cross-sectional study was conducted from January 2018 to July 2018 at Al-Hilla general teaching hospital. We collected data of 75 patients (who have met the clinical criteria of chronic rhinosinusitis) subjected to computed tomography (CT) of the paranasal sinuses. CT was performed using SIEMENS SOMATOM Definition AS and Philips machines. Direct coronal scans (1 mm in thickness) were made, from the anterior wall of the frontal sinus to the posterior wall of the sphenoid sinus with axial and sagittal reconstruction images. Results: Anatomical variations found in 69 patients of a total 75 patients with age range from 18 to 60 years with 92%. Among these, nasal septal deviation was the most common (seen in 54/75 patients = 72%) followed by the Agger nasi cells in 52 patients (69%), concha bullosa in 31 patients (41.3%), Haller cells in 28 patients (37%), and Onodi cells in 18 patients (24%). **Conclusion:** Sinonasal anatomical variations are common findings in patients with chronic rhinosinusitis. Providing information on these anatomical variations will improve the success of endoscopic sinus surgery.

Keywords: Anatomical variations, chronic rhinosinusitis, concha bullosa, nasal septal deviation

Introduction

The paranasal sinuses are air-filled spaces. They are named for the bones in which they are located: maxillary sinus, sphenoid sinus, ethmoid sinus, and frontal sinus.

The paranasal sinuses have several functions such as they reduce the weight of the head, air humidification, and aiding in voice resonance so that when they become filled with fluid, the quality of the voice is markedly changed.[1]

The region of the paranasal sinuses is subject to marked variation between individuals and between the two sides in the same individual. Some variations may cause recurrent disease.[2]

It is important to recognize the so-called "critical" variations that may cause complications during surgery, for example, damage to the optic nerve or internal carotid artery, or leakage of cerebrospinal fluid.

Materials and Methods

Study design

This cross-sectional study was reviewed and approved by the Ethical Committee in Babil Health Directorate-Iraq and verbal consents were obtained from all patients. The study conducted from January 2018 to July 2018 in Al-Hilla general teaching hospital, Babylon province, Iraq, at the computed tomography (CT) unit of the diagnostic radiology department. We collected data of 75 patients referred for Al-Hilla teaching hospital for CT evaluation of paranasal sinuses.

Inclusion criteria

Those patients have met the clinical criteria of chronic rhinosinusitis and their results of CT scan consistent with

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rhinosinusitis were included in our study with a verbal consent taken from patients to be included in the study.

These criteria are two or more of the following symptoms for >12 weeks: facial pain or fullness, nasal obstruction, nasal discharge (anterior and/or posterior), and abnormal sense of smell (hyposmia or anosmia).

The following groups were excluded from the study:

- Patients with rhinosinusitis symptoms of <12 weeks duration
- Patients <18 years of age due to the development stages of the paranasal sinuses
- Patients with an altered normal nasal anatomy.
  - Patients having facial trauma
  - Patients with previous sinonasal surgery
  - Patients with sinonasal neoplasm.

CT was performed using SIEMENS SOMATOM Definition AS and Philips machines.

Direct coronal scans (1 mm in thickness) were made [Figure 1], from the anterior wall of the frontal sinus to the posterior wall of the sphenoid sinus with axial and sagittal reconstruction images.

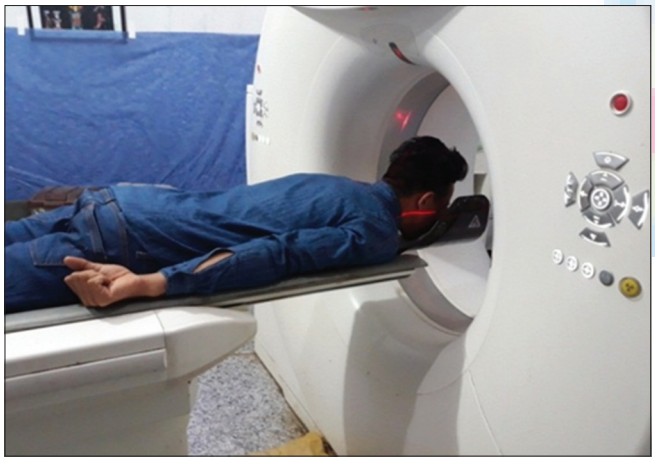

Figure 1: Positioning of a patient in computed tomography. Device for coronal imaging of paranasal sinuses

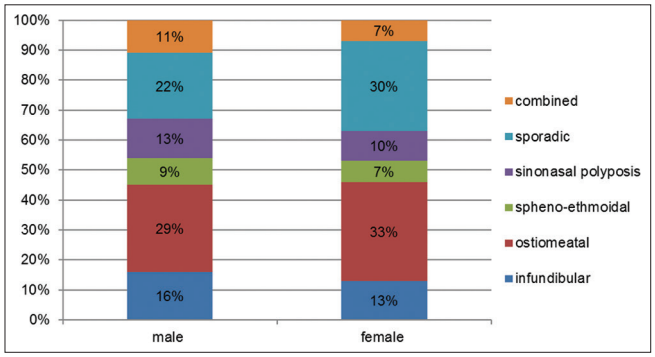

Figure 3: Diagram shows the distribution of patients according to pattern of chronic rhinosinusitis and sex

Radiological investigation of anatomical variations was performed using both a soft-tissue window and a bone-window. Selected scans were chosen for photographic presentation

There were 75 patients (45 males and 30 females).

Interpretation of CT images is done by academic radiologists during reporting of outpatients in our CT unit.

Patients' age and sex in addition to the normal anatomical variants were recorded in a data collection form and the patients grouped according to the pattern of chronic rhinosinusitis.

1. Infundibular pattern (Type I): characterized by obstruction of the maxillary infundibulum resulting in isolated maxillary sinusitis
2. Ostiomeatal unit (OMU) pattern (Type II): characterized by middle meatus obstruction resulting in ipsilateral sinusitis affecting the frontal, anterior ethmoid, and the maxillary antrum

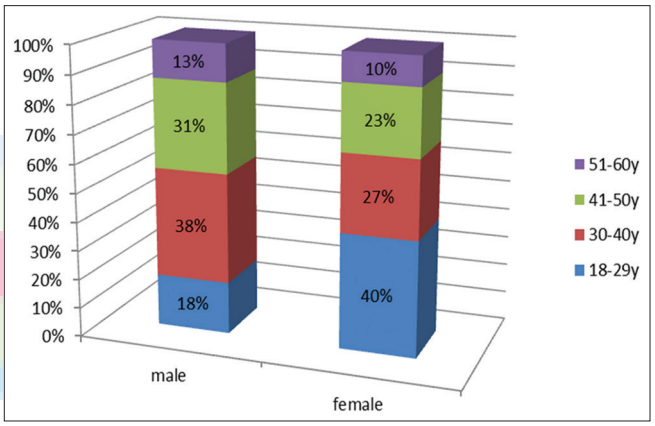

Figure 2: Diagram shows the distribution of patients according to age and gender

Figure 4: Coronal computed tomography image of paranasal sinuses of 18-year-old female with obstruction of the ostium of maxillary sinus and inflammatory mucosal thickening of right. Maxillary sinus and nasal cavity (infundibular pattern of chronic rhinosinusitis)

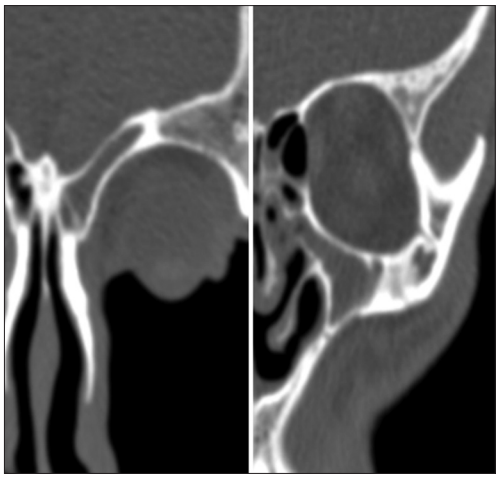

Figure 5: Coronal computed tomography images of two sections of 32-year-old male with ostiomeatal unit pattern of chronic rhinosinusitis with opacification of the maxillary, frontal, and anterior ethmoid sinuse

Figure 6: Coronal computed tomography image of paranasal sinuses of 26-year-old male with sphenoethmoidal pattern of chronic rhinosinusitis. Inflammatory process involving the sphenoid and posterior ethmoid cell

Figure 7: Coronal computed tomography image of paranasal sinuses. Soft tissue window – 60-year-old male with sinonasal polyposis

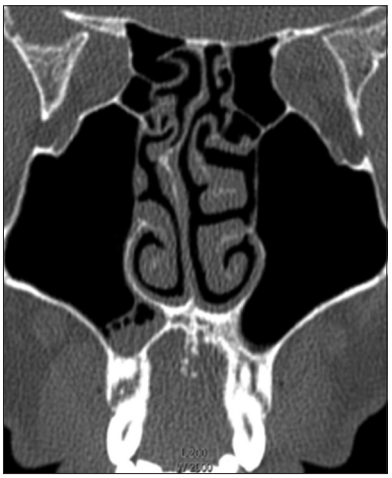

Figure 8: Coronal computed tomography image of paranasal sinuses: 54-year-old male with Sporadic pattern of chronic rhinosinusitis. Focal inflammatory process involving the right. Maxillary sinus with no obstruction of the sinus ostium or ostiomeatal unit

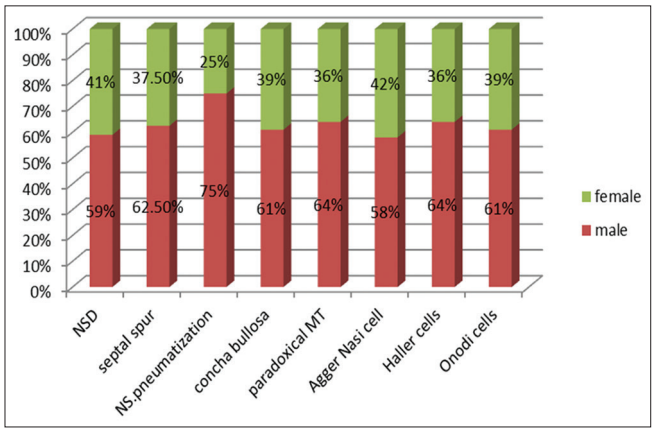

Figure 9: Distribution of anatomical variation in males and females

Figure 10: Coronal computed tomography image of paranasal sinuses. of 31-year-old male with nasal septal deviation to the right side with sinonasal polyposis

3. Sphenoethmoidal recess pattern (Type III): obstruction results in posterior ethmoid and sphenoid sinusitis
4. Sinonasal polyposis pattern (Type IV): sinonasal polyps

Figure 11: Coronal computed tomography image of paranasal sinuses of 50-year-old female with nasal septal deviation to the left side associated with inflammatory process involving the ipsilateral maxillary and anterior ethmoid sinuses (ostiomeatal unit pattern of chronic rhinosinusitis)

Figure 12: Coronal computed tomography image of paranasal sinuses. of 38-year-old male with septal spur directed to the right side

Figure 13: Coronal computed tomography image of paranasal sinuses of 54-year-old female with left. Concha Bullosa involved by inflammatory process

Figure 14: Coronal computed tomography image of paranasal Sinuses of 30-year-old male with bilateral paradoxical curve of middle turbinate

are evident, with opacification of various sinuses

5 Sporadic or unclassifiable pattern (Type V): this pattern includes: retention cysts, mucoceles, or mild mucosal thickening without obstruction.[3]

Frequency distributions of collected data were calculated. The relationship of the patient characteristic with finding is analyzed using Chi-square test. A value of $P < 0.05$ was considered to detect statistical significance.

Results

A total sample size of this study was 75 patients with chronic rhinosinusitis attending the CT unit for evaluation of paranasal sinuses.

Regarding the age of patients, the range was from 18 to 60 years. Of a total of 75 patients, males formed 45/75 patients with 60%, whereas female number was 30/75 patients with 40%; M:F =1.5:1 [Figure 2].

Anatomical variations found in 69 patients out of a total 75 patients with a percentage of 92%. Among these, nasal septal deviation was the most common (seen in 54/75 patients = 72%) followed by the Agger nasi cells in 52 patients (69%), concha bullosa in 31 patients (41.3%), Haller cells in 28 patients (37%), and Onodi cells in 18 patients (24%).

Distribution of patients according to the pattern of chronic rhinosinusitis

A total of 23 patients in our study have OMU pattern of chronic rhinosinusitis and this represents 30.66% of the total patients.

Totally 19 patients (25.3%) have unclassified pattern, 11 patients (14.66%) have infundibular pattern, 9 patients (12%) have sinonasal polyposis pattern, 6 patients (8%) have sphenoethmoidal pattern, and 7 patients (9.3%) have a combined pattern [Figures 3-8].

Figure 15: Coronal computed tomography image of paranasal sinuses of 27-year-old male with bilateral Agger nasi cells. These cells have a close relation to the frontal recess

Figure 16: Sagittal reconstruction computed tomography image of paranasal sinuses of 19-year-old female with Agger nasi cell causing narrowing of frontal recess and inflammatory process involving the frontal sinus

Figure 17: Coronal computed tomography image of paranasal sinuses of 35-year-old male. Bilateral Haller cells with inflammatory process involving the right. One causing obstruction of the right infundibulum and inflammatory process of right maxillary sinus

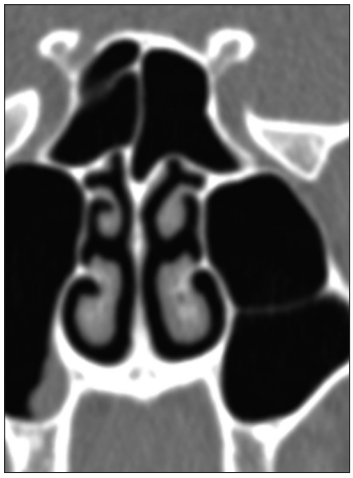

Figure 18: Coronal computed tomography image of paranasal sinuses of 40-year-old female with right Onodi cell

The prevalence of each anatomical variation

The most common AV observed was deviated nasal septum, 54 patients (72%), followed by the Agger nasi cells, 52 (69%), concha bullosa 31 patients (41.3%), Haller cells, 28 (37%), and Onodi cells, 18 (24%).

Anatomical variation related to Nasal Septum

Nasal septal deviations (NSDs) present in 54 patients in our study (72% of total patients with chronic rhinosinusitis). Of these 54 patients, 32 males and 22 females [Figure 9].

In 24 patients (44.5%), the nasal septum is deviated to the right side and in 26 patients (48%), it is deviated to the left side. Bilateral deviation was observed in 4 patients (7.5%).

Septal spurs observed in 24 patients (32% of total patients); in 16 patients of these (64%), the septal spur is right sided and in 8 patients (36%) it is left sided.

Of these 24 patients, 15 were male and 9 were female.

Anatomical variants related to nasal turbinates

In this study, pneumatization of MT observed in 46 patients out of a total of 75 (61.3%) including pneumatization of the lamellar and/or the bulbous parts.

In 12 patients, out of 46 with pneumatization (26%), it was right sided and in 13 patients (28%), it was on the left side and was bilateral in 21 patients (46%).

Concha Bullosa present in 31 patients (19 males and 12 females). About 41% of total patients with chronic rhinosinusitis including 7 patients in whom both bulbous and lamellar parts of middle turbinate are pneumatized.

Paradoxical curve of middle turbinate

Middle turbinates with paradoxical curve presented in 11 patients (15% of total patients with chronic rhinosinusitis).

Table 1: Distribution of cases according to gender of the patients

	Number of cases (%)
Males	45 (60)
Females	30 (40)
Total	75 (100)

Table 2: Total patient distributed according to sex and age group

Age group (years)	Male, *n* (%)	Female, *n* (%)	*P*
18-29	8 (18)	12 (40)	0.73
30-40	17 (38)	8 (27)	
41-50	14 (31)	7 (23)	
51-60	6 (13)	3 (10)	
Total	45 (100)	30 (100)	

Table 3: Distribution of cases according to the pattern of chronic rhinosinusitis

Pattern of CRS	Number of cases (%)
Infundibular pattern	11 (14.67)
Ostiomeatal pattern	23 (30.67)
Sphenoethmoidal pattern	6 (8)
Sinonasal polyposis pattern	9 (12)
Sporadic (unclassified) pattern	19 (25.33)
Combined pattern	7 (9.33)
Total	75 (100)

CRS: Chronic rhinosinusitis

Table 4: Distribution of cases in males and females according to the pattern of chronic rhinosinusitis

Pattern of CRS	Male, *n* (%)	Female, *n* (%)	*P*
Infundibular pattern	7 (16)	4 (13)	0.8
Ostiomeatal pattern	13 (29)	10 (33)	
Sphenoethmoidal pattern	4 (9)	2 (7)	
Sinonasal polyposis pattern	6 (13)	3 (10)	
Sporadic (unclassified) pattern	10 (22)	9 (30)	
Combined pattern	5 (11)	2 (7)	
Total	45	30	

CRS: Chronic rhinosinusitis

Table 5: Distribution of each anatomical variant according to gender

Anatomical variant	Total (*n*)	Male, *n* (%)	Female, *n* (%)	*P*
NSD	54	32 (59)	22 (41)	0.1
Septal spur	24	15 (62.5)	9 (37.5)	0.9
NS. pneumatization	8	6 (75)	2 (25)	0.5
Concha bullosa	31	19 (61)	12 (39)	0.7
Paradoxical MT	11	7 (64)	4 (36)	0.9
Agger Nasi cells	52	30 (58)	22 (42)	0.2
Haller cells	28	18 (64)	10 (36)	0.4
Onodi cells	18	11 (61)	7 (39)	0.9

NSD: Nasal septal deviation, MT: Middle turbinate

In 2 patients (18%), it is right sided and in 5 patients (46%), it is on the left side and was bilateral in 4 patients (36%). Of these 11 patients, 7 were male and 4 female.

Anatomical variants related to ethmoid air cells

The reported prevalence of the Agger nasi cell in the previous literature varies from 10% to 98.5%. In this study, the prevalence of Agger nasi cells was 69% being seen in 52 patients out of a total of 75. In most of the cases (46 patients), AN cells were bilateral (88%), Of these 52 patients, 30 were male and 22 were female.

Regarding Haller cells, the prevalence of Haller cells is remarkably variable, ranging from 2% to 70.3%. In our study, Haller cells observed in 28 patients out of a total of 75 and this represents 37% of chronic rhinosinusitis (CRS) patients.

They were observed on the right side in 6 of the cases (21%), on the left side in 10 of the cases (36%) and were bilateral in 12 of the cases (43%).

In most of our cases (in 25 cases), a single Haller cell seen and only in 3 cases, 2 cells observed on the same side. Of these 28 patients, 18 were male and 10 were female.

Regarding Onodi cells, these air cells were observed in 18 patients out of a total of 75 with CRS (24%). Right side Onodi cells seen in four cases (22%), left sided Onodi cells seen in 10 cases (46%) and bilateral Onodi cells seen in 4 cases (22%). Of these 18 patients with Onodi cells, 11 were male and 7 females.

Discussion

In our study, anatomical variants observed in most of CRS patients (69 out of a total of 75 patients = 92%) [Tables 1-5]. Paranasal variants were found in 99.8% of the patients in a study conducted by Dasar and Gokce.[4] and in 89% of patients in a study conducted by Jagannathan *et al*.[5]

Regarding NSD, we considered deviation as any asymmetric curvature of septum [Figures 10 and 11]. In our study, NSD observed in 54/75 patients (72%) [Table 6].

Deviation of nasal septum was reported in other studies at different rates as the following: 80% of patients as reported by Perez *et al*.[6], and 38% as reported by Asruddin *et al*.[7] Dissimilar rates of nasal septum deviation were also reported worldwide by several authors.[8-11] Low figures in some studies may be related to the fact that they followed the strict criteria of definition of DNS >4 mm.

Regarding septal spurs [Figure 12], they observed in 24 patients (32% of total patients) [Table 7] and reported in 13.6% by Pérez-Piñas *et al*.[6]

Concha bullosa [Figure 13] (pneumatized middle turbinate) has been implicated as a possible etiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on paranasal sinus ventilation and mucociliary clearance in the middle meatus region as quoted by Tonai and Baba.[12] In

Table 6: Distribution of cases according to the presence of nasal septal deviation

	Number of cases (%)
Cases with NSD	54 (72)
Cases with No NSD	21 (28)
Total	75 (100)
Distribution in cases with NSD	
Convexity to right side	24 (44.5)
Convexity to left side	26 (48)
Bilateral convexity	4 (7.5)
Total	54 (100)

NSD: Nasal septal deviation

Table 7: Distribution of cases according to the presence of nasal septal spurs

	Number of cases (%)
Cases with septal spurs	24 (32)
Cases with no septal spurs	51 (68)
Total	75 (100)
Distribution in cases with septal spurs	
Right side	16 (67)
Left side	8 (33)
Total	24 (100)

Table 8: Distribution of cases of middle turbinate pneumatization according to side and type

	Number of cases (%)
Distribution of cases according to type	
No pneumatization	29 (39)
Pneumatization of lamellar part	15 (20)
Concha Bullosa	31 (41)
Total	75 (100)
Distribution of cases according to side	
Pneumatization of right MT	12 (26)
Pneumatization of right MT	13 (28)
Bilateral pneumatization	21 (46)
Total	46 (100)

MT: Middle turbinate

Table 9: Distribution of cases of paradoxical curve of middle turbinate

	Number of cases (%)
Cases with paradoxical curve	11 (15)
Cases with normal curve	64 (85)
Total	75 (100)
Distribution in cases with paradoxical curve according to side	
Right side	2 (18)
Left side	5 (46)
Bilateral	4 (36)
Total	11 (100)

Table 10: Distribution of cases of Agger Nasi cells

	Number of cases (%)
Cases with ANC	52 (69)
Cases with no ANC	23 (31)
Total	75 (100)
Distribution in cases of ANC according to side	
Unilateral	6 (12)
Bilateral	46 (88)
Total	52 (100)

ANC: Agger Nasi cells

Table 11: Distribution of cases of Haller cells

	Number of cases (%)
Cases with Haller cells	28 (37)
Cases without Haller cells	47 (63)
Total	75 (100)
Distribution in cases with Haller cells according to side	
Right side	6 (21)
Left side	10 (36)
Bilateral	12 (43)
Total	28 (100)

our study, Concha bullosa was observed in 31 patients (41%) [Table 8] which is slightly less as compared to the reported incidence of 53.6% by Bolger *et al*.,[8] but is almost equal to the reported incidence of 42.6% by Maru and Gupta,[11] and it is higher than the reported incidence of 28% by Asruddin *et al*.,[7] 24% by Lloyd *et al*.[10]

The middle turbinate may be paradoxically curved [Figure 14], that is, bent in the reverse direction. This may lead to impingement of the middle meatus and thus to sinusitis (36). It was found in 11 patients (15%) [Table 9]. The incidence is almost similar to that of 12% by Asruddin *et al*.[7] and 15% by Lloyd *et al*.[10] It is less than that reported by Bolger *et al*.(27%).[8]

Regarding Agger Nasi cells [Figures 15 and 16], they were observed in 52 patients (69%) [Table 10]. This is less as compared to 98.5% reported by Bolger *et al*.[8] and 88.5% by Maru and Gupta,[11] but Asruddin *et al*.[7] reported a result of 48% and by Dua *et al*. a result of 40%.[9] In anatomic dissections, Messerklinger encountered the Agger nasi cells in 10%–15% of the specimens, Davis in 65% of specimens and Mosher in 40% of specimens as quoted by Bolger *et al*.[8]

Haller's cells [Figure 17] are ethmoid air cells grow into the floor of orbit and (if large) may narrow the adjacent ostium of the maxillary sinus, especially if they become infected.[9] In our study, Haller's cells were seen in 28/75 (37%) [Table 11]. This is almost equal to the result of 36% reported by Maru and Gupta[11] and it is slightly less than the result of 45.9% reported by Bolger *et al*.[8] By Asruddin *et al*., it was reported as 28%,[7] and by Lloyd *et al*. as 15%.[10]

Results of this study revealed that Onodi cells [Figure 18] were found in 18 patients in our study (24%) [Table 12]. In

Table 12: Distribution of cases of Onodi cells

	Number of cases (%)
Cases with Onodi cells	18 (24)
Cases without Onodi cells	57 (76)
Total	75 (100)
Distribution of cases with Onodi cells according to side	
Right side	4 (22)
Left side	10 (46)
Bilateral	4 (22)
Total	18 (100)

the series of Earwaker (1993), this type of posterior ethmoidal cells is present in 24% of cases. It is higher than that reported by Shpilberg *et al*. (12%).[2] Onodi cell was observed in 38% by Nandita *et al*.[13]

Conclusion

Sinonasal anatomical variations are common findings in patients with chronic rhinosinusitis and the radiologist should be familiar with these variations No statistically significant difference was found between males and females and between age groups regarding the prevalence of these variations providing information on these anatomical variations will improve the success of endoscopic sinus surgery. Sinonasal anatomical variations should be looked for and mentioned in the CT report of CRS patients (many of which will have endoscopic sinus surgery) to give an idea for the ENT surgeon to avoid the unwanted complications like injury to optic nerve or ICA or to avoid recurrence of symptoms if certain anatomical variations are not treated adequately.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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