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A STUDY OF ANATOMICAL VARIATIONS OF PARANASAL SINUSES ON COMPUTED TOMOGRAPHY IN CHRONIC SINUSITIS

[*1]Marwa Khaleel Ibrahim and [2]Sura Saadi Hamzah

[1]Baghdad- Al-Karkh Health Directorate, Baghdad, Iraq.
[2]Baghdad- Al-Karkh Health Directorate, Baghdad, Iraq.

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***Corresponding Author: Marwa Khaleel Ibrahim**

Baghdad- Al-Karkh Health Directorate, Baghdad, Iraq.

ABSTRACT

Background: There is a wide range of anatomical variations affecting the nose, paranasal sinuses (PNS) best diagnosed by Computed Tomography (CT). These variations may cause impairment of mucociliary drainage of the PNS resulting in sinusitis. **Aims of the study**: Study the frequency and types of anatomical variants of PNS on Computed Tomography scan in clinically diagnosed chronic sinusitis patients. Study the association between these anatomical variants and chronic sinusitis. **Patients & Methods:** A cross sectional study was conducted in the department of Radiology in AL-Shaheed Ghazi Al. Hariri and Baghdad Teaching Hospitals in medical City-Baghdad, from August 2018 to February 2019. All the adult patients with clinical diagnosis of chronic rhino sinusitis for a period of more than 12 weeks, and with persistent chronic rhino sinusitis requiring surgical intervention were included in our study. Based on our inclusion and exclusion criteria a total of 115 patients were involved in the study (61 male & 54 female). **Results:** From 115 patients in our study, (73%) of them were have one or more anatomical variations of PNS. The most common anatomical variants seen were nasal septal deviation (50.43%) and concha bullosa (46.96%). Statistically significant correlations were found between nasal septal deviation and maxillary sinusitis (p value 0.001), concha bullosa and maxillary sinusitis (p value 0.017), Agger nasi cells and frontal sinusitis (p value 0.001), Haller cells and maxillary sinusitis (p value 0.003) and between Giant ethmoid bulla and anterior ethmoid sinusitis (p value 0.006). **Conclusion:** By using multislice CT scan we found statistically correlation between existence of some anatomical variations of paranasal sinuses and some pattern of sinusitis, which may lead to defect in the drainage of the sinus secretions and secondary infection. In addition precise knowledge of anatomic variations of the paranasal sinuses is important in chronic rhinosinusitis to prevent possible complications during surgery.

KEYWORDS: Anatomical, Variations, Paranasal Sinuses, Computed Tomography, Chronic Sinusitis.

INTRODUCTION

Chronic rhinosinusitis is a prevalent condition known to significantly impair health-related quality of life.[1] The persistence of symptoms and chronic nature of the disease are primarily attributed to the disruption of mucociliary clearance, often resulting from anatomical variations and underlying mucosal pathology.[2] In contemporary clinical practice, computed tomography (CT) of the paranasal sinuses (PNS) has emerged as the gold standard imaging modality for evaluating sinonasal diseases.[3] Compared to conventional radiography, sinus CT offers superior visualization of both soft tissue and bony structures, providing comprehensive anatomical and pathological details essential for accurate diagnosis and safe surgical planning.[4] The nasal cavity is divided by the septum and contains turbinates that facilitate air cell drainage through various recesses. Paranasal sinuses are air-filled cavities, with the sphenoid sinus near critical neurovascular structures. The maxillary sinuses are the largest, draining into the ostiomeatal complex and shaping the cheek contour.[5] Anatomical variations within the PNS are commonly observed and may predispose patients to chronic rhinosinusitis. Nasal septum deviation is among the most frequent, leading to lateral compression and displacement of the middle turbinate, thereby contributing to nasal obstruction.[6] Concha bullosa, a pneumatized middle turbinate, is implicated in recurrent sinusitis due to its interference with mucociliary clearance.[7] Agger nasi cells, situated anterior to the upper margin of the nasolacrimal duct and maxillary sinus infundibulum[8], can expand posteriorly and obstruct the frontal recess, contributing to chronic

frontal sinusitis and persistent frontoethmoid pain.[9] Haller cells, pneumatized ethmoid air cells along the medial roof of the maxillary sinus and inferior lamina papyracea, are another common variant[10], while Onodi cells—sphenoethmoidal air cells—are associated with a risk of optic nerve involvement due to their proximity.[11] A rare but clinically relevant variant, the paradoxical middle turbinate, may go undetected during endoscopic examination and is another potential contributor to nasal obstruction.[12] CT imaging is favored for its ability to delineate fine bony structures and adjacent anatomy in the PNS. Proper evaluation typically requires both axial and coronal views, with coronal sections being particularly useful for endoscopic surgical planning.[13] Axial scans, aligned with the plane of orbital CT, are valuable for assessing the optic nerve, optic canals, ethmoid air cells, and sphenoid sinuses[14], while coronal scans—obtained through head hyperextension—highlight the relationship between intracranial structures and the PNS, critical for preoperative assessment.[13] Radiation exposure during CT varies depending on scanner protocol, including kilovoltage (kV) and milliampere-second (mAs) settings, with reported lens doses ranging from 70.3 mGy at 475 mAs to as low as 4.7 mGy at 30 mAs.[15] Although MRI is more commonly employed for evaluating nasosinus malignancies before and after surgery, it lacks the resolution to assess bony anatomy and calcifications. CT remains the preferred modality for most sinonasal conditions. MRI is performed using a standard quadrature head coil, with axial and coronal sequences including T1- and T2-weighted images. Fast spin echo (FSE) has largely replaced conventional spin echo (CSE) techniques, and fat-suppressed T1-weighted images are often used for clearer delineation of pathology.[16] This study aims to assess the frequency and types of anatomical variations in the paranasal sinuses as seen on CT in patients clinically diagnosed with chronic rhinosinusitis and to explore their association with disease chronicity.

METHOD

This was a cross sectional study was performed on 115 patients at radiology department in AL-Shaheed Ghazi Al-Hariri and Baghdad Teaching Hospitals in Medical City- Baghdad, from August 2018 to February 2019, the study was formally started after getting the clearance from the institutional ethical committee. All the patients were referred from ENT outpatient clinic with clinical diagnosis of chronic rhinosinusitis for period of more than 12 weeks, patients with chronic sinusitis who have failed to response to medical therapy or conservative management and patients prepared to undergo FESS were also included in the study. Patients with acute and fungal sinusitis, patients with previous paranasal sinus surgery, with history of trauma, patients had benign and malignant neoplasm and patients with facial anomaly were excluded from the study. An informed written consent was obtained from all the study subjects. All patients were examined by multislice computed tomography of the paranasal sinuses by Somatom (Definition AS) 64 slices from Siemens-Germany and 64 slices CT scan (Bireliance 64: Philips medical system corporation, the Netherland). The patient was positioned supine without any preparation needed before examination. Then a scout view was taken for the skull in order to determine the area of interest by the radiographer from the frontal sinus to the alveolar ridge, then the examination was performed by using direct axial section and coronal reformat without I.V. contrast administration. The imaging protocol used in this study was: KV = 120 (fixed in the equipment), mAs = 100-200, slice thickness = 1mm, table increment = 0.2, the pitch = 0.6 - 0.8, window width = 2000, window level = 200 – 400, scan time of about 7 - 10 seconds. The examinations were reviewed by two radiologists. Statistical Analysis: The collected data where introduced to the Microsoft excel sheet and loaded into IBM/SPSS version 24 to be used in statistical analysis. The statistical inferences were presented using chi-square and Fischer exact test accordingly to find out the significance of the associations between related categories variables. P-value less than 0.05 was considered as discriminative point of significance.

RESULTS

In this cross-sectional study, the mean age of the patients was 32.79± 10.5 years old. And the total number of patients included in the study were 115 patients, 61(53%) of them were male and 54 (46.9%) were female. About three-fourths (73%) of the patients with chronic sinusitis had one or more anatomical variants of PNS. The most common type of variations in this study was deviated nasal septum seen in 58 cases (50.43%) followed by concha bullosa in 54 cases (46.96%). Agger nasi cells were reported in 16 cases (13.9%). Haller cells were found in 15 cases (13.04%). Paradoxical middle turbinate was observed in 9cases (7.83%). Giant ethmoid bulla was seen in 8 cases (6.96%). Variations of uncinte process were seen in 11.3% (deviations of uncinate process in 6.96% & pneumatization of uncinate process in 4.35%). Onodi cells were observed in 7 cases (6.09%). As shown in table 1.

Table 1: Distribution of anatomical variations among the study cases.

Anatomical variants	Frequency	Percentage
Deviated nasal septum	58	50.43%
Concha bullosa	54	46.96%
Agger nasi cells	16	13.91%
Haller cells	15	13.04%
Paradoxical middle turbinate	9	7.83%
Giant ethmoid bulla	8	6.96%
Uncinate process deviation	8	6.96%
Onodi cells	7	6.09%
Uncinate process pneumatization	5	4.35%

Maxillary sinus was the most commonly affected sinus seen in (68.7%), followed by anterior ethmoid seen in (51.3%), posterior ethmoid in (39.1%), frontal sinus in (36.5%), sephenoid sinus in (26.1%) and no sinus involvement (9.6%). As shown in table **2.**

Table 2: Involvement of paranasal sinuses among the study cases Sinus involved Frequency Percentage.

Sinus involved	Frequency	Percentage
Maxillary sinus	79	68.7%
Anterior ethmoid	59	51.3%
Posterior ethmoid	45	39.1%
Frontal sinus	42	36.5%
Sphenoid sinus	30	26.1%
No sinus involved on CT scan	11	9.6%

Statistically significant correlation was found between deviated nasal septum and maxillary sinusitis (p value 0.001). There was significant correlation between choncha bullosa and maxillary sinusitis (p value 0.017). There was significant correlation between Agger nasi cells and frontal sinusitis (p value 0.001). There was significant correlation between Giant ethmoid bulla and anterior ethmoid sinusitis (p value 0.006). There was significant correlation between Haller cells and maxillary sinusitis (p value 0.003). As shown in tables 3 and 4.

Table 3: Correlation between anatomical variations and sinusitis.

Anatomical variants		Maxillary sinusitis		Anterior ethmoid sinusitis		Posterior ethmoid sinusitis		Frontal sinusitis		Sphenoid sinusitis	
		79		59		45		42		30	
		N	%	N	%	N	%	N	%	N	%
DNS	Present 57	52	91.2%	27	47.4%	20	35.1%	17	29.8%	15	26.3%
	Absent 58	27	46.6%	32	55.2%	25	43.1%	25	43.1%	15	25.9%
P value		0.001*		0.403		0.379		0.139		0.956	
CB	Present 54	43	79.6%	31	57.4%	18	33.3%	15	27.8%	14	25.9%
	Absent 61	36	59.0%	28	45.9%	27	44.3%	27	44.3%	16	26.2%
P value		0.017*		0.218		0.231		0.067		0.970	
ANC	Present 16	14	87.5%	9	56.3%	6	37.5%	12	75.0%	2	12.5%
	Absent 99	65	65.7%	50	50.5%	39	39.4%	30	30.3%	28	28.3%
P value		0.081		0.670		0.885		0.001*		0.182	
PMT	Present 9	5	55.6%	3	33.3%	1	11.1%	1	11.1%	0	0.0%
	Absent 106	74	69.8%	56	52.8%	44	41.5%	41	38.7%	30	28.3%
P value		0.458		0.314		0.088		0.152		0.109	

***Significant at 0.05 level by Pearson's chi-square test**

Table (4): Correlation between anatomical variations and sinusitis.

Anatomical variants		Maxillary sinusitis		Anterior ethmoid sinusitis		Posterior ethmoid sinusitis		Frontal sinusitis		Sphenoid sinusitis	
		79		**59**		**45**		**42**		**30**	
		N	%	N	%	N	%	N	%	N	%
Up dev.	Present 8	6	75.0%	3	37.5%	2	25.0%	2	25.0%	1	12.5%
	Absent 107	73	68.2%	56	52.3%	43	40.2%	40	37.4%	29	27.1%
P value		1		0.483		0.479		0.708		0.678	
Up pnum.	Present 5	4	80.0%	4	80.0%	1	20.0%	3	60.0%	2	40.0%
	Absent 110	75	68.2%	55	50.0%	44	40.0%	39	35.5%	28	25.5%
P value		1		0.365		0.647		0.353		0.604	
Giant EB	Present 16	14	87.5%	9	56.3%	6	37.5%	12	75.0%	2	12.5%
	Absent 99	65	65.7%	50	50.5%	39	39.4%	30	30.3%	28	28.3%
P value		0.432		0.006*		1		0.708		0.109	
OC	Present 7	7	100.0%	4	57.1%	4	57.1%	2	28.6%	4	57.1%
	Absent 108	72	66.7%	55	50.9%	41	38.0%	40	37.0%	26	24.1%
P value		0.096		1		0.430		1		0.075	
HC	Present 15	15	100.0%	8	53.3%	4	26.7%	4	26.7%	4	26.7%
	Absent 100	64	64.0%	51	51.0%	41	41.0%	38	38.0%	26	26.0%
P value		0.003*		0.866		0.289		0.395		1	

***Significant at 0.05 level by Pearson's chi-square test**

Figure 1: CT scan shows bilateral paradoxical middle turbinate (Left picture), left sided agger nasi cell (right picture).

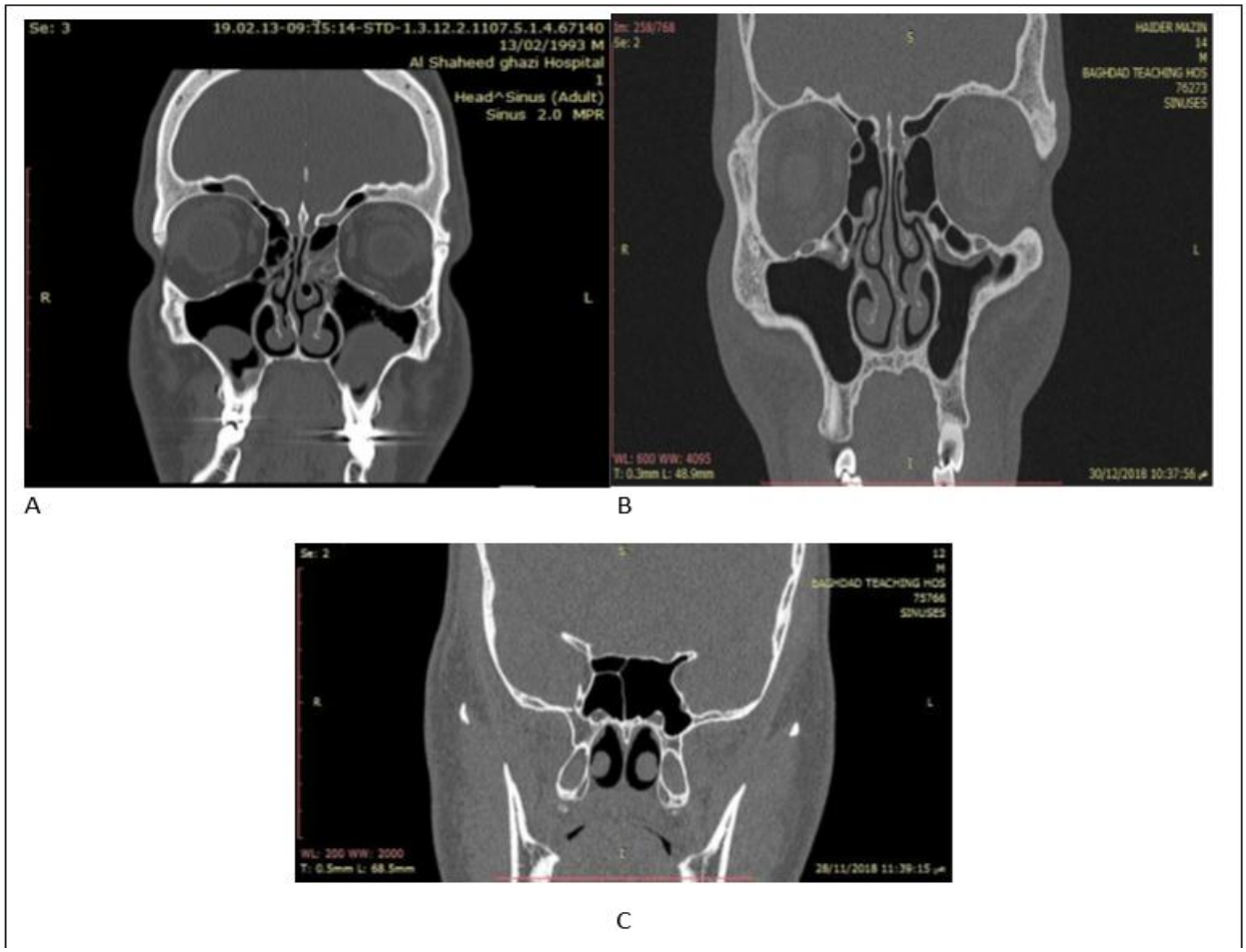

Figure 2: CT scan shows (A) right sided nasal septal deviation and left sided concha bullosa, (B) bilateral haller cells and left sided septal nasal deviation, (C) right sided onodi cell.

DISCUSSION

Anatomical variations in the paranasal sinuses (PNS), as demonstrated by multislice CT, play a crucial role in predisposing patients to chronic sinusitis and may also pose significant intraoperative challenges during endoscopic sinus surgery.[17] In this study involving 115 patients (61 males and 54 females) with clinically diagnosed chronic sinusitis, anatomical variations were identified in 73% of cases. This aligns with findings from Murthy et al., who reported a prevalence of 77%[18],

and Aramani et al., who reported even higher variation at 87% in the osteomeatal complex.[19] Among the sinuses involved, the maxillary sinus was the most frequently affected (68.7%), while the sphenoid sinus showed the lowest involvement (26.1%). These findings are consistent with Sethi et al., who found the maxillary sinus to be affected in 76% of cases.[20] Deviated nasal septum (DNS) was the most common anatomical variation noted (50.43%), closely matching findings by Dua et al. (44%).[21] A statistically significant correlation was observed between DNS and maxillary sinusitis (p=0.001), similar to reports by Jaura et al.[22] The second most common variant was concha bullosa (46.9%), a pneumatized middle turbinate associated with impaired mucociliary clearance and recurrent sinusitis. This incidence is comparable to previous studies by Murthy et al. (45.5%)[18], Stallmann et al. (44%)[23], and Maru et al. (42.6%).[24] A significant association was observed between concha bullosa and maxillary sinusitis (p=0.017), in agreement with studies by Senniappan S et al.[25], Prasad et al.[26] Agger nasi cells, the most anterior ethmoid air cells, were found in 13.9% of cases—close to Afzal A et al.'s 10% prevalence.[27] Their significant correlation with frontal sinusitis (p=0.001) was supported by findings from Fadda et al.[28], and Jaura et al.[22] However, Ameri et al.[29] associated these cells more with ethmoid sinusitis. Haller cells were present in 13% of cases, aligning with the 17.5% reported by Sethi et al.[20] These infraorbital ethmoid cells can obstruct the maxillary ostium and infundibulum[30], and a significant correlation with maxillary sinusitis was observed (p=0.003), as also reported by Kamdi P et al.[31] and Stackpole SA et al.[32], found no such link. Their proximity to the orbit poses surgical risks during ethmoidectomy. Paradoxical middle turbinate (PMT) was seen in 7.8% of patients, comparable to Perez et al. (10%).[33] No significant association with sinusitis was found, consistent with Fadda et al.[28], possibly due to the mild degree of turbinate curvature. Giant ethmoid bulla was found in 6.9% of patients and showed a significant association with anterior ethmoid sinusitis (p=0.006), supporting earlier findings by Fadda et al.[28] and Dasar and Gokce.[34] Deviated uncinate process (6.9%) and pneumatization (4.3%) had no significant correlation with sinusitis, consistent with Tuli et al.[35], although these variants remain surgically relevant due to potential complications.[36] Onodi cells, found in 6% of cases, had no significant link with sinusitis but pose surgical risks due to their proximity to the optic nerve and carotid artery.[18,19] Their presence, though uncommon, necessitates careful preoperative evaluation. CT remains the most reliable imaging modality for evaluating chronic sinusitis and anatomical variants, especially in the coronal plane due to its surgical relevance.[37]

CONCLUSION

The study found common nasal septal deviation and Conch bullosa anatomical variants in paranasal sinuses, which can lead to sinusitis and secondary infection, emphasizing the importance of accurate knowledge for chronic rhinosinusitis. Multislice CT scans should be used before FESS to prevent complications. Radiologists should focus on important variants causing drainage passage narrowing. Future studies should identify relationships between these variants.

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