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The correlation between nasal and paranasal sinus anatomical variations with severity of Chronic Rhino Sinusitis Based on CT Scan Examination at Dr. Zainoel Abidin Hospital Banda Aceh

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Abstract

Background: Chronic rhinosinusitis (CRS) is a persistent inflammation of the nasal mucosa and paranasal sinuses. Anatomical variations of the nasal and paranasal sinuses can obstruct and impair the drainage and ventilation functions of the sinus ostium, causing CRS.

Objective: To determine the correlation between nasal and paranasal sinus anatomical variations with the degree of severity of CRS based on a CT scan at Dr. Zainoel Abidin Hospital. Methods: An analytic observational study with a cross-sectional design from the results of CT scans of CRS patients in the period on October 2019-october 2022. The anatomical variations assessed were the degree of deviation of the nasal septum, type of bullous turbinate, paradoxical turbinate, hypertrophy of ethmoid bullae, Haller cells, deflection of uncinate process, type of superior insertion of the uncinate process, pneumatization of the uncinate process and frontal sinus cells to the degree of CRS using the Lund Mackay score. Data were analyzed using the Chi-Square test or Fisher's exact test.

Result: Analysis of 64 CT scans consisting of 128 sides of the nose found a significant relationship between anatomic variations and the degree of CRS, namely the degree of deviation of nasal septum, type of concha bullosa, ethmoid bulla hypertrophy and deflection of the uncinate process to the severity of maxillary sinusitis (p=0.023; p=0.024; p=0.039; p=0.029) and paradoxical medial concha for the severity of maxillary sinusitis, anterior and frontal ethmoiditis (p=0.018; p=0.013; p=0.000)

Conclusion: Anatomical variations of the nasal and paranasal sinuses are related to the severity of CRS.

Keywords: Chronic rhinosinusitis; Nasal and paranasal sinus; Anatomical variations; Computed tomography

1. Introduction

The European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS) 2020 states that chronic rhinosinusitis (CRS) is persistent inflammation of the nasal mucosa and paranasal sinuses which is characterized by the presence of two or more symptoms such as nasal congestion and nasal discharge as well as other symptoms, namely pain or pressure on the face and reduced or loss of smell for ≥ 12 weeks and also supported by signs of mucosal inflammation found from nasoendoscopy or radiological imaging because the clinical signs and symptoms that appear are inadequate because they often overlap with the clinical features of sinonasal benign tumors.[1]

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This case affects all age groups and the incidence continues to increase every year.[2] There were 55 cases of CRS in 2008 and there were 74 people in 2009 at Dr Zainoel Abidin Hospital Banda Aceh, In 2019, the number of cases increased, there were 111 people and in 2020 there were 97 people.[3,4] Various etiologies and predisposing factors play a role in the emergence of CRS, one of which is the anatomical variation of the nose and paranasal sinuses. The anatomical variations present in the lateral nasal wall have a role in causing obstruction of the ostiomeatal complex and disrupting drainage and ventilation functions, causing changes in the paranasal sinus mucosa. In addition, anatomical variations also have the potential for surgical safety and so need to be specifically assessed as part of the preoperative evaluation.[5-7] PERHATI-KL Clinical Practice Guideline states that a CT scan of SPN with axial, coronal, and sagittal sections which a thickness of 3 mm, soft tissue setting is done for diagnosis and preparation before action.[8]

An assessment using the Lund-Mackay score is recommended to assess the severity of chronic rhinosinusitis.[5,7] The Lund Mackay score is more widely accepted as a measure of severity and has been adopted by the Rhinosinusitis Task Force committee of the American Academy of Otolaryngology Head and Neck Surgery in 1996 due to its easy and clear assessment so that can be used without the need for special radiology training.[9,10]

Table 1 Lund Mackay Scoring System

Sinuses	Right Sinuses	Left Sinuses
Frontal	0-2	0-2
Ethmoid Anterior	0-2	0-2
Ethmoid Posterior	0-2	0-2
Maksilaris	0-2	0-2
Sfenoid	0-2	0-2
KOM	0 atau 2	0 atau 2

Sinuses : 0 : no abnormality; 1 : partial engagement ; 2 : total engagement; KOM (osteomatal complex) : 0 : no obstruction; 2 : obstruction

Total score maximum (24) of The Lund Mackay assessment measures different aspects of the subjective score, but these correlate with markers of disease severity, choice of action, and outcome after surgery.[10] Other studies have also shown that there is a relationship between Lund Mackay score and overall symptom score and disease severity.[11,12]

2. Material and methods

The research was an observational analytic study with a cross sectional design which has been conducted at Dr. Zainoel Abidin Banda Aceh. The research data collection used a consecutive sampling technique, which collected medical record data and CT scans of patients in the period of October 2019 to October 2022. The population in this study were patients with suspected CRS based on EPOS 2020 whose data were obtained from medical records starting from October 2019 to /d October 2022 and the name, age, gender were recorded. Evaluation of a non-contrast SPN CT scan was carried out with axial, coronal, and sagittal slices with a thickness of 1 mm windows 1000 HU. Patients with an impression of CRS with nasal polyps, history of nasal trauma, suspected malignancy and had a history of nasal surgery were grouped into the exclusion criteria.

Furthermore, CT scans that was appropriate to the inclusion criteria are assessed for anatomical variations of the nasal and paranasal sinuses (nasal septal deviation, bullous turbinates, paradoxical medial turbinates, hypertrophy of ethmoid bullae, Haller cells, variations in deflection of the uncinate process, insertion of the uncinate process, pneumatization of the uncinate process, -frontal sinus cells) as well as assessing the sinus score using the Lund Mackay score. In this study, we evaluated the variables of each anatomic and sinus variation on each side (dextra and left). Interpretation of the results was carried out using the Novarads 3D reconstruction multiplanar system application and filling out a check list sheet by the researcher and confirmed by a Radiologist Specialist doctor. Statistical analysis to determine the relationship between nasal anatomical variation of SPN and the severity of CRS used was the chi-square test. With a value if the p-value > 0.05 becomes the basis for decision making in this data analysis.

3. Results and discussion

The collection of research data on patients with CRS in the period October 2019 to October 2022 who met the study criteria obtained a total of 64 samples. The characteristics of the research sample are presented in Table 2.

Table 2 Characteristics of The Research Sample

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	27	42.2
Female	37	57.8
Age	29 (11-69)	

Based on Table 2, it was found that the dominance of the female sex (57.8%) with an average age of the study sample was 29 years. The results of this study are in line with previous research at RSUDZA Banda Aceh which found that the number of sufferers of CSR during 2019 was female (53.2%) more than male (46.8%) with the majority aged 30-39 years (37.8%).[3] The research conducted in Dr. Pirngadi hospital Medan also had more women (71.4%) than men (28.6%) with the highest age group being 40-49 years (24.5%).[13] However, from research by Amelia at Dr. Mohammad Hoesin hospital Palembang, there were more CSR cases in men (58.9) than women (41.1) and are mostly found at the age of 46-52 years (19.2%).[14] CRS cases can affect all gender and age groups and the incidence continues to increase every year.[2] The specific reasons for differences in the sex distribution in the incidence of CRS are not known certaintly, this is related to the assumption that women are more susceptible to infection and obstruction due to the small size of the sinus ostium. Hormonal factors also influence CRS, although they are not known for certain, several theories state that there are effects of estrogen, progesterone and placental growth hormone on the nasal mucosa and vascular changes that play a role in the incidence of rhinosinusitis. Based on the data above, the distribution of CSR sufferers is in adulthood, this is believed to be because at that age there are changes in lifestyle, eating patterns and tendencies for outdoor activities that allow for increased exposure to pollutants.[1,2,15] From 64 samples of this study, an evaluation of the variables of each anatomical variation on each side (dextra and left) was carried out, so that the number of samples became 128 samples. The characteristics of the anatomical variations are presented in Table 3.

Table 3 showed that the highest anatomical variation is the bullous bullosa (42.2%) with the most common type being the bulbous type (21.9%) followed by deviation of the nasal septum (36.7%) with the most dominant angulation being mild degrees (16.4%) and variations in processal deflection. uncinate (36.7%). In variations in the deflection of the uncinate process, the medial deflection is 21.9% and the lateral deflection is 14.8%.

Anatomical variations that are often found from each study are different. Nasal septal deviation is the most common variation found in patients with CRS followed by concha bullosa, uncinate process deflection, ethmoid bulla hypertrophy and other anatomical variations.[3,5,16-18] The prevalence of nasal septum deviation from several reported literature ranges from 26-97% and the prevalence of concha bullosa ranges from 15-80%.[18] A study by Kaygusuz A *et al* (2013) in Turkey on 99 CT Scan samples of the paranasal sinuses (65 cases and 34 controls) found septum deviation of 72 (72.7%), agger nasi 61 (61.6%) and concha bullosa 45 (45.4%).[16] A retrospective study by Sarkar PS *et al* (2016) in India, 500 CT scans of patients with CRS from March 2013 to June 2014, the most common anatomic variation was septal deviation nasi (75%) and konka bullosa (32.9%).[19] Qureshi MF and Usmani A (2021) at the Shifa Hospital Karachi Pakistan, from January to June 2020 obtained 50 samples with the highest anatomical variation, agger nasi cells (64%) followed by deviation nasal septum (56%) and concha bullosa (46%).[20] The differences in the prevalence of anatomical variations reported in this study and previous studies may be due to various factors such as differences in the characteristics of the study population, assessment criteria, and analytical methods used in every research.[21] As well as differences in the prevalence of septum deviation in different countries/races studied by Holton NE *et al* (2012), where in this study found significant differences in the size of the nasal septum-premaxillary complex between populations of European and African descent, which correlated with the magnitude of the deviation of the nasal septum in the European population. The same thing was reported by Post (1966), where the deviation of the nasal septum is more common in Europeans than other races. A study by Gray (1978) also reported differences in nasal septum deviation among populations from India and Australia as well as Europe and Africa.[22-24]

Table 3 Frequency variation of nasal and paranasal sinus anatomy

Anatomic variation	n	%
Septum Nasal Deviation	47	36.7
Mild	21	16.4
Moderate	18	14.1
Severe	8	6.2
Konka Bulosa	54	42.2
Lamellar	12	9.4
Bulbous	28	21.9
Ekstensif	14	10.9
Konka Media Paradoksal	9	7.0
Bulla Ethmoid Hypertrophy	37	28.9
Sel Haller	22	17.2
Prosesus Unsinatus Deflection	46	36.7
Lateral Deflection	19	14.8
Medial Deflection	27	21.9
Prosesus Unsinatus Pneumatization	5	3.9
Insertion Variation of Prosesus Unsinatus		
Type 1	44	34.4
Type 2	21	16.4
Type 3	17	13.3
Type 4	5	3.9
Type 5	8	6.3
Type 6	33	25.8
Sel Sinus Frontalis		
Sel anterior	55	28.6
Sel posterior	45	23.4
Sel medial	8	4.2

Table 5 found that 16 samples (34.0%) mild degree of nasal septal deviation had a score of 1 in the maxillary sinus. However, based on statistical analysis, it was found that there was a significant relationship between the degree of deviation of the nasal septum and the severity of maxillary sinusitis ($p<0.05$). Meanwhile, in the analysis of the relationship between the degree of deviation of the nasal septum and the scores of the anterior and frontal ethmoidal sinuses, the most distribution of mild degrees of septal deviation was 0 score for every sinus. From the results of statistical analysis, there was no relationship between the degree of deviation of the nasal septum and the severity of the anterior and frontal ethmoidal sinuses ($p>0.05$).

Table 4 Sinusitis frequency and sinus score from CT scan results

Sinusitis	Frequency (n)	Percentage (%)

Sinusitis maxillary		
Skor 0	53	41.4
Score 1	54	42.2
Score 2	21	16.4
Sinusitis ethmoidalis anterior		
Score 0	76	59.4
Score 1	33	25.8
Score 2	19	14.8
Sinusitis ethmoidalis posterior		
Score 0	101	78.9
Score 1	19	14.8
Score 2	8	6.3
Sinusitis sphenoidalis		
Score 0	109	85.2
Score 1	17	13.3
Score 2	2	1.6
Sinusitis frontalis		
Score 0	99	77.3
Score 1	19	14.8
Score 2	10	7.8
KOM (Osteomatal Complex)		
Score 0	79	41.1
Score 2	49	25.5

Lazim NM *et al* (2019) reported that the severity of nasal septal deviation angulation was significantly related to the degree of severity of CRS based on symptom scores and VAS.[25] Poorey and Gupta (2014) reported 67 CT scans of patients with CRS which were 56.7% had a degree of septal deviation moderate and were correlation between the degree of deviation of the nasal septum and changes in the maxillary sinus mucosa ($p < 0.05$), but did not correlate with changes in the mucosa of the ethmoidal, frontal and sphenoidal sinuses.[26] Yasan H (2015) also found a relationship between degrees of nasal septum deviation severity of maxillary sinusitis, anterior ethmoidalis and frontalis ($p=0.035$). This is not found in posterior ethmoidal sinusitis and sphenoidalis. Meanwhile, mild to moderate degrees of septal deviation did not play a role in the pathogenesis of chronic rhinosinusitis ($p=0.901$; $p=0.165$).[27]

Table 5 Analysis the relationship between the deviation degree of the nasal septum and the score of the maxillary sinus, anterior ethmoidalis and frontalis

Sinus Score	**Septum Nasal Deviation**			***p value****
	Mild	**Moderate**	**Severe**	

Maxillary				
0	3 (6.4)	8 (17.0)	2 (4.3)	0.023
1	16 (34.0)	5 (10.6)	3 (6.4)	
2	2 (4.3)	5 (10.6)	3 (6.4)	
Total	21 (44.7)	18 (38.3)	8 (17.0)	
Ethmoid anterior				
0	11 (23.4)	9 (19.1)	1 (2.1)	0.283
1	5 (10.6)	5 (10.6)	5 (10.6)	
2	5 (10.6)	4 (8.5)	2 (4.3)	
Total	21 (44.7)	18 (38.3)	8 (17.0)	
Frontalis				
0	17 (36.2)	16 (34.0)	5 (10.6)	0.506
1	2 (4.3)	1 (2.1)	2 (4.3)	
2	2 (4.3)	1 (2.1)	1 (2.1)	
Total	21 (44.7)	18 (38.3)	8 (17.0)	

*Fisher exact test

Javardrashid R *et al* (2014) evaluated 206 CT scans of the paranasal sinuses from patients who had CRS symptoms and no symptoms. The results of their study found a positive correlation between nasal septal deviation and the number of infected sinuses (Pearson's r=0.58, p< 0.001). From the study of Javardrashid R *et al* (2014) also obtained a cut-off value of the deviation of the nasal septum ≥ 3.5o which distinguished between the presence or absence of rhinosinusitis with a sensitivity value of 77.8% and a specificity of 76.5%.[28] From the study of Utami IL *et al* (2021) at Dr. Sardjito hospital Yogyakarta obtained 54 samples, of which 29 samples (53.7%) had mild nasal deviation, 22 samples (40.7%) had moderate deviation of the nasal septum, 2 samples (3.7%) normal category deviation of the septum, and 1 sample (1.9%) had severe nasal septum deviation . A total of 31 patients (57%) had multisinusitis, 20 patients (37%) had single sinusitis, and 3 patients (6%) had pansinusitis. The results of statistical analysis showed an insignificant relationship (sig. 0.569), very weak and negatively correlated (Spearman-s r = -0.081) between the deviation angle of the nasal septum and the number of paranasal sinuses with sinusitis.[29]

Table 6 showed that the bulbous which is type of concha bullosa was more dominant (21.9%) and from the results of statistical analysis found that there was a significant relationship between the type of concha bullosa and the severity of maxillary sinusitis (p <0.05), but this was not related to the severity of anterior ethmoidal sinusitis and frontalis (p>0.05). The concha bullous is a median turbinate that is partially or totally pneumatized. which occurs as a result of the expansion of normal pneumatization of the ethmoid sinus cells.[30] This process leads to the existence of several types of concha bullosa which are lamellar, bulbous and extensive types, where several studies suggest that the severity of chronic rhinosinusitis correlates with the level of pneumatization of the concha bullosa.[31-33] Bullous types with a bulbous and extensive type are known to fill the space between the septal wall and the lateral wall of the nasal cavity, causing obstruction to the drainage and ventilation of the anterior sinus.[33,34] The study by Calhoun *et al* (1991) found that the concha bullosa was more common in patients with rhinosinusitis (p<0.05) and this study was reported that the concha bullosa was associated with anterior ethmoid rhinosinusitis (p<0.05).[35] Some literature also assesses a link between bullosa and deviation of the nasal septum with the severity of rhinosinusitis. This linkage has been confirmed in several studies, however, several studies do not support this statement.[28] In this study, this linkage was not assessed.

Table 6 Analysis the relationship between the type of concha bullosa and the score of maxillary **sinus**, anterior and posterior ethmoidalis, and frontal sinus

Sinus score	**Type of konka bulosa**			***p value****
	Lamellar	**Bulbous**	**Ekstensif**	
Maxillary				

0	9 (16.7)	9 (16.7)	3 (5.6)	0.024
1	1 (1.9)	15 (27.8)	8 (14.8)	
2	2 (3.7)	4 (7.4)	3 (5.6)	
Total	12 (22.2)	28 (51.9)	14 (25.9)	
Ethmoid anterior				
0	7 (13.0)	10 (18.5)	4 (7.4)	0.215
1	1 (1.9)	12 (22.2)	5 (9.3)	
2	4 (7.4)	6 (11.1)	5 (9.3)	
Total	12 (22.2)	28 (51.9)	14 (25.9)	
Frontalis				
0	11 (20.4)	18 (33.3)	11 (20.4)	0.580
1	1 (1.9)	6 (11.1)	2 (3.7)	
2	0 (0)	4 (7.4)	1 (1.9)	
Total	12 (22.2)	28 (51.9)	14 (25.9)	

*Fisher exact test

Table 7 Analysis of paradoxical media concha relationship to maxillary sinus, anterior and frontal ethmoid scores

Sinus Score	**Concha Media Paradoksal**		***p value****
	No	**Yes**	
Maxillary			
0	74 (57.8)	2 (1.6)	0.018
1	30 (23.4)	3 (2.3)	
2	15 (11.7)	4 (3.1)	
Total	119 (93.0)	9 (7.0)	
Ethmoid anterior			
0	60 (46.9)	0 (0)	0.013
1	32 (26.9)	8 (6.3)	
2	27 (21.1)	1 (0.8)	
Total	119 (93.0)	9 (7.0)	
Frontalis			
0	97 (75.8)	2 (1.6)	0.000
1	15 (11.7)	4 (3.1)	
2	7 (5.5)	3 (2.3)	
Total	119 (93.0)	9 (7.0)	

*Fisher exact test

In Table 7, although there were only 9 samples (7.0%) of paradoxical medial concha, based on the results of statistical analysis showed a significant relationship between paradoxical medial conchae and the severity of maxillary, anterior ethmoidal and frontal sinusitis ($p<0.05$).

The study of Fadda GL *et al* (2012) found that the paradoxical medial concha was 6.4% and there was no significant relationship between the paradoxical medial concha and the severity degree of CRS.[5] As with the bullous turbinate, the paradoxical turbinate is also often associated with deviation of the nasal septum. Contributes to the pathogenesis of obstructive osteo-meatal complex, but remains to be proven further. Mohaputra's research (2017) out of a total of 40 paradoxical turbinate samples, 14 cases were found on the right side, 16 cases on the left side and 10 cases were obtained bilaterally. However, this study did not find a significant relationship between paradoxical medial concha and the deviation degree of the nasal septum (p=0.692).[36]

Table 8 Analysis the relationship of ethmoid bulla hypertrophy to maxillary sinus, anterior and frontal ethmoid scores

Sinus Score	**Bulla Ethmoid**		***p value****
	No	**Yes**	
Maxillary			
0	44 (34.4)	9 (7.0)	0.039
1	35 (27.3)	19 (14.8)	
2	12 (9.4)	9 (7.0)	
Total	91 (71.1)	37 (28.9)	
Ethmoid anterior			
0	55 (43.0)	21 (16.4)	0.926
1	23 (18.0)	10 (7.8)	
2	13 (10.2)	6 (4.7)	
Total	91 (71.1)	37 (28.9)	
Frontalis			
0	71 (55.5)	28 (21.9)	0.060
1	16 (12.5)	3 (2.3)	
2	4 (3.1)	6 (4.7)	
Total	91 (71.1)	37 (28.9)	

It was found that 37 samples (28.9%) patients had ethmoid bulla hypertrophy where as many as 19 samples (14.8%) had a score of 1, and 9 samples (7.0%) had a maxillary sinus score of 2. Based on statistical analysis, there was a significant relationship between ethmoid bulla hypertrophy and the severity of maxillary sinusitis ($p < 0.05$). Whereas in the analysis of the relationship between ethmoid bulla hypertrophy anterior and frontal sinus scores, no significant relationship was found ($p > 0.05$). The ethmoid bulla is the air cell of the largest ethmoid sinus cell and also the second ethmoid lamella which is supero-posterior to the infundibulum and hiatus semilunaris. The ethmoid bulla may enlarge aggressively and may push the middle concha medially, thus appearing to be in contact with the septal wall. Its pneumatization can obstruct the osteomeatal complex and eventually interfere with ventilation and sinus drainage.[31,37] The observational study of Chauhan P *et al* (2021) from June 2018 to May 2019, an evaluation of anatomical variations was carried out in patients with CRS using nasoendoscopy and CT scans. He received ethmoid bull hypertrophy in 16 samples, where this variation had a significant relationship to maxillary sinusitis (p=0.068), anterior ethmoidalis (p=0.004), frontalis (p=0.027), and posterior ethmoidalis (p=0.001).[38] Likewise, the results of the study by Basic U and Gokce E (2015) found a frequency of ethmoid bulla hypertrophy was 6.3% of 400 cases of CRS and found a significant relationship to changes in the mucosa paranasal sinuses (p = 0.002).[33] The study of Fadda GL *et al*. (2012) reported 32.8% and found a correlation between ethmoid bulla hypertrophy and anterior ethmoid sinusitis ($p<0.01$).[5]

Table 9 Analysis the relationship of the Haller cell to the maxillary sinus score

Maxillary Sinus Score	**Haller Cell**		***p value****
	No	**Yes**	
0	42 (32.8)	11 (8.6)	0.739

1	46 (35.9)	8 (6.3)	
2	18 (14.1)	3 (2.3)	
Total	106 (82.8)	22 (17.2)	

*Fisher's exact test

Haller cells / infraorbital ethmoid cells / maxillary-ethmoid cells are anatomical variations of the anterior ethmoid cells that undergo pneumatization along the inferior orbital floor and lateral ethmoid bulla to the roof of the maxillary sinus which can continue to form part of the lateral wall of the infundibulum.[39,40] Haller cell variations also associated with sex, age, race, size and shape of Haller cells. The average size is 2-4 mm with an oval shape.[41] Haller cells are not a pathological thing, but these cells, if they have a large size, can narrow the ethmoid infundibulum and inhibit the maxillary sinus drainage process, causing maxillary sinusitis.[39,41]

Table 9 stated that Haller cells were obtained in 22 samples (17.2%), but statistically, there was no relationship between Haller cells and the severity of maxillary sinusitis (p>0.05).

Table 10 Analysis the relationship of uncinate process deflection to maxillary sinus score

Sinus Score	**Prosessus Unsinatus Deflection**		***p value****
	Lateral	**Medial**	
Maxillary			
0	13 (28.3)	8 (17.4)	0.029
1	5 (10.9)	12 (26.1)	
2	1 (2.2)	7 (15.2)	
Total	19 (41.3)	27 (58.7)	
Ethmoidalis Anterior			
0	11 (23.9)	16 (34.8)	0.841
1	4 (8.7)	7 (15.2)	
2	4 (8.7)	4 (8.7)	
Total	19 (41.3)	27 (58.7)	
Frontalis			
0	14 (30.4)	19 (41.3)	0.576
1	4 (8.7)	4 (8.7)	
2	1 (2.2)	4 (8.7)	
Total	19 (41.3)	27 (58.7)	

* Fisher exact test

The study by Reeti R *et al* (2020) was found that Haller cells were 12% (18 cases) and also reported that there was no significant relationship between Haller cells and the incidence of maxillary rhinosinusitis (p=0.616).[40] However, the study from Fadda GL *et al* (2012) reported a Haller cell incidence of 22.8% from 200 CT scans and from this study found a significant association with maxillary sinusitis (p<0.01).[5] The research by Bolger *et al* (1991) was also reported that Haller cells were found in 45.9% of patients with CRS and 41.6% with non-RSK patients. From the statistical analysis, there was no significant difference between the two groups, so Bolger suggested carrying out a specific evaluation for each patient, such as the Haller cell size factor, the presence/absence of inflammation in these cells and whether the Haller cell mucosa was in contact with the surrounding structures.[21]

Table 11 Analysis variation of the superior insertion of the processus Unsinatus to maxillary sinus score

Sinus Score	Variation insertion of prosesus unsinatus						*p value**
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	
Maxillary							
0	16 (12.5)	9 (7.0)	9 (7.0)	2 (1.6)	3 (2.3)	14 (10.9)	0.453
1	17 (13.3)	12 (9.4)	5 (3.9)	2 (1.6)	4 (3.1)	14 (10.9)	
2	11 (8.6)	0 (0.0)	3 (2.3)	1 (0.8)	1 (0.8)	5 (3.9)	
Total	44 (34.4)	21 (16.4)	17 (13.3)	5 (3.9)	8 (6.3)	33 (25.8)	
Ethmoidalis Anterior							
0	25 (19.5)	14 (10.9)	10 (7.8)	2 (1.6)	4 (3.1)	21 (16.4)	0.540
1	11 (8.6)	7 (5.5)	5 (3.9)	2 (1.6)	2 (1.6)	6 (4.7)	
2	8 (6.3)	0 (0.0)	2 (1.6)	1 (0.8)	2 (1.6)	6 (4.7)	
Total	44 (34.4)	21 (16.4)	17 (13.3)	5 (3.9)	8 (6.3)	33 (25.8)	
Frontalis							
0	31 (24.2)	20 (15.6)	12 (9.4)	5 (3.9)	4 (3.1)	27 (21.1)	0.153
1	8 (6.3)	1 (0.8)	3 (2.3)	0 (0.0)	4 (3.1)	3 (2.3)	
2	5 (3.9)	0 (0.0)	2 (1.6)	0 (0.0)	0 (0.0)	3 (2.3)	
Total	44 (34.4)	21 (16.4)	17 (13.3)	5 (3.9)	8 (6.3)	33 (25.8)	

*Fisher exact test

Table 12 Analysis the relationship of pneumatization of the processus Unsinatus to maxillary sinus score

Sinus Maxillary Score	Processus Unsinatus Pneumatization		*p value**
	No	Yes	
0	51 (39.8)	2 (1.6)	1.000
1	52 (40.6)	2 (1.6)	
2	20 (15.6)	1 (0.8)	
Total	123 (96.1)	5 (3.9)	

*Fisher exact test

In this study, there were three assessment points such as the analysis of the relationship between the deflection of the processus unsinatus, variations in the superior insertion of the processus unsinatus, and the processus unsinatus pneumatization. These variations can act as triggers for rhinosinusitis because of their role in causing obstruction in the KOM area.[42] Variations in deflection of the prosesus unsinatus are known to influence the severity of chronic rhinosinusitis. Table 10 showed that the medial deflection (58.7%) is more dominant than the lateral deflection (41.3%) and based on the results of statistical analysis, there is a significant relationship between the deflection of the prosesus unsinatus and the maxillary sinus score ($p<0.05$). However, there was no significant relationship between the deflection of the prosesus unsinatus and the severity of anterior ethmoid sinusitis and frontal sinusitis ($p>0.05$).

Stammberger and Wolf (1988) reported that the most frequent and significant variation associated with rhinosinusitis was medial deflection of the prosesus unsinatus. This condition allows for contact between the prosesus unsinatus and the medial concha area.[43] A study conducted by Shrivastava M and Tyagi S (2015), found that the medial deflection was 18.8% and the lateral deflection was 2.3%, but it was not explained how this was related to the incidence of rhinosinusitis.[44] Tuli IP *et al* (2013) also reported 30% deflection of the prosesus unsinatus, of which 24% was medial deflection and found a significant relationship between the variation in deflection and rhinosinusitis (p=0.033).[45]

However, the study by Wardani RS *et al* (2017) stated that the lateral deflection (70.7%) was more dominant than the medial deflection (29.3%). The prevalence of lateral deflection that occurs towards ipsilateral maxillary sinusitis is 71.5% and from the results of statistical analysis, a significant relationship was found (p=0.03). This is assumed because the lateral deflection of the prosessus unsinatus impairs the drainage of the maxillary sinus ostium due to narrowing of the infundibulum and causes ipsilateral maxillary sinusitis.[46]

The second variation of the prosessus unsinatus assessed is the superior insertion variation of the prosessus unsinatus. Table 11 showed that 17 samples (13.3%) and 11 samples (8.6%) with type 1 insertion respectively had scores of 1 and 2 in the maxillary sinus. It is also known that 14 samples (10.9%) with type 6 insertion had a score of 0 and 1 in the maxillary sinus. Statistically, it was concluded that there was no significant relationship between the superior insertion of the prosessus unsinatus and the severity of maxillary sinusitis (p>0.05). Likewise, the results of the analysis of the relationship between the superior insertion of the prosessus unsinatus and the score of the anterior ethmoidal sinus and frontal sinus was no significant relationship between the two sinuses (p>0.05).

These insertions or attachments will affect sinus drainage, such as if there is a superior insertion in the lamina papyracea (Type 1) it will affect the drainage of the maxillary sinuses, insertions in the middle concha and ethmoid roof (type 6) will affect the drainage of the maxillary and frontal sinuses. The variation of attachment that is often found is the insertion in the lamina papyracea (type 1), both from sex and age. 42,45,47 From the results of a study by Punagi AQ (2016) it was found that the variation in the type of superior insertion of the prosessus unsinatus that is most commonly experienced is type 1 (52.4%), followed by type 2 (14.3%), type 4 (11.9%), type 3 (9.5%), type 6 (7.1%), and type 5 (4.8%). Statistical test results showed a significant relationship between various types of insertion of the prosessus unsinatus and the incidence of frontal rhinosinusitis (p=0.001).[48]

Another variation assessed of the prosessus unsinatus is pneumatization of the prosessus unsinatus. The results of the CT scan was found that this pneumatization occurred due to hyper-pneumatization of the postero-superior part of the agger nasi cells (or antero-superior processus uncinate).[42,49] Table 12 presented the results of the analysis of the relationship between the superior insertion variation of the uncinate process and the maxillary sinus score, It was found that 5 samples (3.9%) had pneumatization of the uncinate process where 2 samples (1.6%) with pneumatization of the uncinate process respectively had scores of 0 and 1 in the maxillary sinus and only 1 sample (0.8%) had scores of 2 maxillary sinuses. The results of statistical analysis was concluded that there was no significant relationship between pneumatization of the uncinate process and the severity of maxillary sinusitis (p>0.05).

Table 13 Analysis the relationship of frontal sinus cells to the frontal sinus score

Frontalis Sinus Score	**Sinus Frontalis Cells**			***p value****
	Anterior Cell	**Posterior Cell**	**Medial Cell**	
0	46 (42.6)	33 (29.6)	6 (5.6)	0.144
1	7 (6.5)	9 (8.3)	0 (0.0)	
2	2 (1.9)	4 (3.7)	2 (1.9)	
Total	55 (50.9)	45 (41.7)	8 (7.4)	

*Fisher exact test

The prevalence of process pneumatization in this study was less (3.9%) compared to research conducted by Suri N *et al* (2016) which reported 15 samples out of 120 (12.5%).[17] Study by Yenigun A *et al* (2016) stated that the number of prosessus unsinatus pneumatization were detected in a total of 47 patients (6.26%). Pneumatization of the prosessus unsinatus on the right side of 19 samples (2.53%), left side 16 (2.13%) and bilateral 12 patients (1.60%). This variation was found in 34 samples (72.3%) male and 13 samples (27.7%) female with an average age of 31 ± 13.9 years. Maxillary sinusitis was detected in 22.8% of 47 patients (94 sites). From this study, it was found that there was a significant relationship between pneumatization of the prosessus unsinatus and maxillary sinusitis, both on the right side (p=0.046) and the left side (p=0.035).[50]

The frontal sinus cells influence the drainage of the frontal sinus. These cells have many types with different sizes, arrangements and extensions and so have many different names and descriptions.[53] Table 13 obtained that 46 samples (42.6%), 33 samples (29.6%) and 6 samples (5.6%) anterior, posterior and medial frontal sinus cells had a score of 0 in the frontal sinus, whereas in a score of 2 frontal sinuses found in 2 (1.9%) anterior cell samples, 4 (3.7%) posterior cell samples and 2 (1.9%) medial cell samples. Statistically, there was no relationship between frontal sinus cells and the severity of frontal sinusitis ($p>0.05$).

The frontal sinus cells influence the drainage of the frontal sinus. These cells have many types with different sizes, arrangements and extensions, so they have many different names and descriptions.[51] The study Senthilnathan V *et al* (2019) was found that the anterior group of cells is the most common anatomical variation found in CT Scan of SPN in a patient with frontal sinusitis.[52] Agger nasi cells are one of the anterior sinus cell types. Almost all patients have these cells and they are located very close to the frontal recess so that if the operator opens these agger nasi cells they will give way to the frontal recess.[31,53]

In the prospective study of Nofal AAB and El-Anwar MW (2021) which was conducted in 100 patients (200 sides). They not only reported the prevalence but also assessed the infection rate of each type of frontal sinus cells and its relation to frontal sinusitis. From the evaluation results, it was found that the percentage of the anterior sinus cell group was the most infected, namely 30.8% of the total 312 cells (ANC 26%, SAC 40%, SAFC 36%), the posterior sinus cell group infected 25% of the 274 cells (SBC 31%, SBFC 17%, SOEC 19%) and the medial cell group which was infected was 33% of the 42 cells. From the results of this evaluation, it was found that there was a relationship with frontal sinusitis.[51] However, it was not explained how this was related to the severity of frontal sinusitis.

4. Conclusion

The most frequent nasal and paranasal sinus anatomical variations were the bullous concha (42.2%) followed by nasal septum deviation (36.7%) and uncinate process deflection (36.7%). The maxillary sinusitis was the most common Sinus infection (58.6%) with the highest sinus score being 1 (42.2%) followed by anterior ethmoidal sinusitis (40.3%) with a score of 1 being predominant (25.8%). Five of the 9 anatomical variations found a significant relationship between anatomic variations and the severity of chronic rhinosinusitis, the degree of deviation of the nasal septum, the type of concha bullosa, the hypertrophy of the ethmoid bulla and the deflection of the uncinate process to the severity of maxillary sinusitis and also the paradoxical concha media to the severity of maxillary sinusitis, ethmoidalis anterior and frontalis.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have declared that no competing interests exist in this study.

Statement of ethical approval

The Study has been approved by the Health Research Ethics Committee of the Faculty of Medicine at Universitas Syiah Kuala with a number of ethical contributions KEPPKN(Description of ethical expedited number: 064/FK/-RSUDZA/2022.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

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