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RESEARCH ARTICLE

Evaluation of Osteomeatal Complex Anomalies and Maxillary Sinus Diseases Using Cone Beam Computed Tomography

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Abstract: ***Introduction*:** Although obstruction of osteomeatal area was not accepted as an important factor in the pathogenesis of sinus infections for years, recent studies point out the importance of this area. For the maintenance of normal functions of paranasal sinuses, ventilation and drainage of this area is necessary.

The purpose of this study was to determine the effect of anomalies of the osteomeatal area on sinus diseases.

***Methods*:** This study included cone beam computed tomography scans of 200 patients. Osteomeatal area anomalies were classified as concha bullosa, septal deviation, paradox middle concha, deviation of uncinate process, uncinate bulla, Haller cells and Agger nasi cells. Ethmoid infundibulum and presence of sinus pathologies were recorded.

***Results*:** Pathologies were not determined in 243 (60.8 %) of the evaluated 400 sinuses while detected in 157 (39.3 %) sinuses. Pathologies were found to be more frequent in males than females ($p<0.05$). Sinus diseases were more prevalent in patients with an obstructed ethmoid infundibulum ($p<0.05$). Septum deviation was found in 64.5 %, concha bullosa in 47 %, Haller cells in 17 %, paradox middle concha in 8 %, deviation of uncinate process in 5.5 %, over pneumatisation of agger nasi in % 5, and uncinate bulla in 5 % of the investigated patients. Although we found a statistically significant link between ethmoid infundibulum clarity and pathology presence; there was no statistically significant relationship between sinus pathologies and evaluated anomalies.

***Conclusion*:** Although we found no relationship between these anomalies and sinus diseases, further studies including the dimensions of the osteomeatal area anomalies will be helpful to determine the effect of these anomalies on sinus diseases.

Keywords: CBCT, osteomeatal complex, paranasal sinus, nasal septum, middle concha, anomaly.

INTRODUCTION

Lateral wall of nasal cavity consists of inferior, middle and sometimes superior conchae and their related meatus. Middle meatus, the most important of these structures, generates the drainage pathways of paranasal sinuses with hiatus semilunaris. Middle concha and meatus, hiatus semilunaris, maxillary sinus ostium, uncinate process and infundibulum are the major anatomic formations in the osteomeatal area (Fig. **1**) [1]. Although obstruction of osteomeatal area has not been thought to be an important factor in the pathogenesis of paranasal sinus diseases, recent studies point to the importance of this area [2]. Ventilation and drainage of this area is necessary for the maintenance of normal functions of paranasal sinuses. Especially drainage of maxillary, frontal and ethmoid sinuses are in a close relationship with o

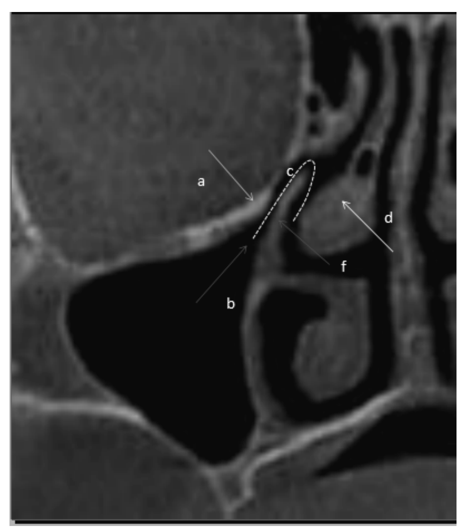

Fig. (1). a: lamina papyrecea b: ostium c: infundibulum and hiatus semilunaris d: middle concha f: uncinate process.

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Table 1. Age and gender distribution of patients.

		Gender				
		n	**Mean**	**Min**	**Max**	**SS**
Age	Male	96	57,2	33,0	73,0	8,6
	Female	104	56,8	32,0	86,0	10,1
	Total	200	57,0	32,0	86,0	9,4

steomeatal area [3]. Anatomic variations are frequently seen in middle meatus and lateral nasal wall and these variations may be the primal factor of the underlying sinus disease [4]. These variations can be classified according to originating tissues as middle concha, uncinate process, ethmoid bulla and nasal septum anomalies. Concha bullosa is the pneumatisation of middle concha by ethmoid air cells [1]. Paradox middle concha is the lateral convexity of middle concha [5]. Uncinate process deviation is the dislocation of the tip of the uncinate process medially or laterally [1]. Uncinate bulla is the pneumatisation of uncinate process [3]. Haller cells are infraorbital ethmoid air cells located at the roof of maxillary sinus and lateral wall of infundibulum [6]. Agger nasi cells are the most anterior ethmoid air cells [7]. Deviation of the nasal septum is the inclination of structures that build the nasal septum as a result of various reasons [8]. All the previously mentioned anomalies are thought to be related with the obstruction of ethmoid infundibulum and hiatus semilunaris and underlying sinus disease.

Cone beam computed tomography can be an alternative of the conventional tomography for the imaging and evaluation of pathologies seen in head and neck area with its low radiation dose and cost. Cone beam computed tomography has been used in previous studies and defined as a useful tool for the interpretation of paranasal sinus diseases and paranasal sinus anatomy [9-13].

In this study our goal was to define if there is a relationship between anomalies seen in osteomeatal complex and maxillary sinus diseases.

MATERIALS AND METHODS

This study included cone beam computed tomography scans of maxillary posterior edentulous 200 patients who had undergone cone beam computed tomographic examination between June 2011 and March 2013 for various reasons such as, evaluation before implant surgery, sinonasal assessment for sinus augmentation processess or any kind of surgical process, from the archives of Gazi University Faculty of Dentistry Department of Dentomaxillofacial Radiology. Age and gender distribution of the patients are given in Table **1**. Cone beam computed tomography images were taken using Planmeca Promax 3D with exposure parameters 90 kVp, 10 mA and 14 sn. and Romexis software was used for image reconstruction. Study included maxillary posterior edentulous patients in order to keep the effects of maxillary posterior teeth to sinus mucosa. The inclusion criteria were having no sign of recent tooth extraction from the maxillary posterior area and paranasal sinus surgery. Imaging field contained paranasal sinuses, osteomeatal complex and maxillary alveolar bone.

Pathologies were classified as ‘no pathology, mucosal thickening (Fig. **2**), polypoid mucosal thickening (Fig. **3**), air-fluid level (Fig. **4**), retention pseudocyst (Fig. **5**) and sinonasal polyposis (Fig. **6**)’. Anomalies seen in osteomeatal complex area were defined as ‘nasal septum deviation (Fig. **7**), concha bullosa (Fig. **8**), overpneumatised agger nasi cell (Fig. **9**), uncinate bulla (Fig. **10**), uncinate process deviation (Fig. **11**), paradox middle concha (Fig. **12**) and Haller cells (Fig. **13**). Clarity of ethmoid infundibulums were recorded.

Any deviation from midline was considered as nasal septum deviation. Radiolucencies inside middle concha were taken as pneumatization and these lesions were diagnosed as concha bullosa. Agger nasi cells are the most anterior ethmoid air cells and for this diagnosis overpneumatization or asymmetric pneumatizations of Agger nasi cells which can cause obstruction of the osteomeatal area were taken in to

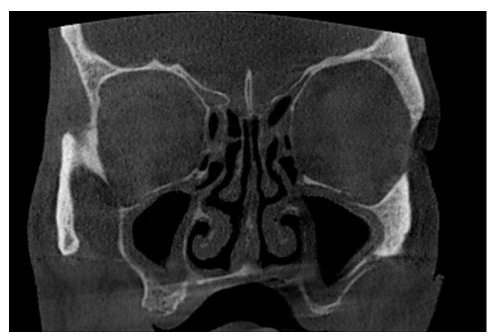

Fig. (2). Bilateral mucosal thickening.

Fig. (3). Bilateral polypoid mucosal thickening.

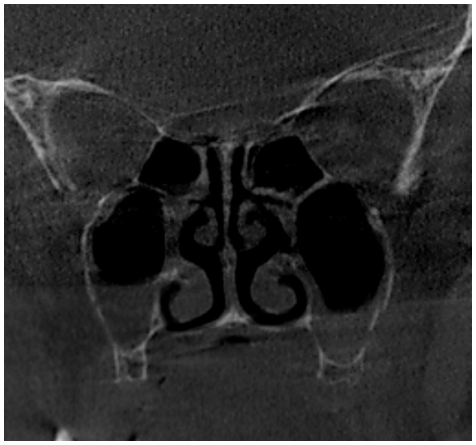

Fig. (4). Air-fluid level in right maxillary sinus.

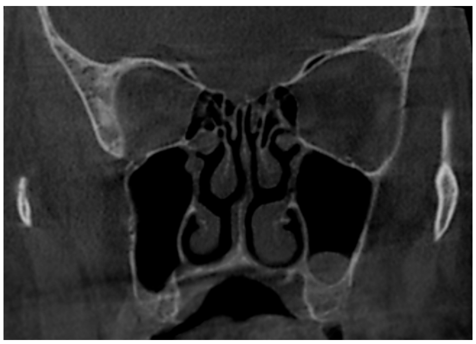

Fig. (5). Retention pseudocyst in left maxillary sinus.

Fig. (6). Sinonasal polyposis.

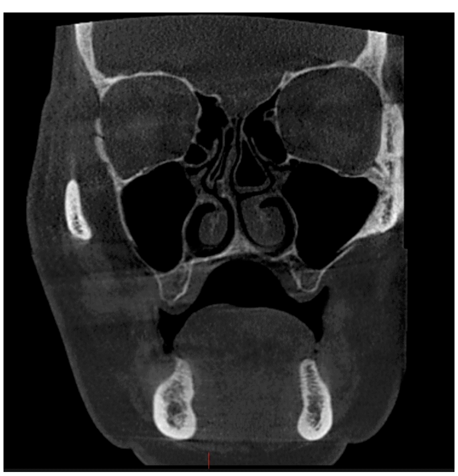

Fig. (7). Right nasal septum deviation.

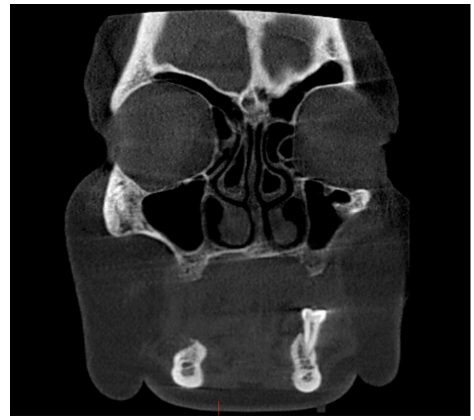

Fig. (8). Bilateral concha bullosa.

Fig. (9). Agger nasi cell.

Fig. (10). Uncinate bulla.

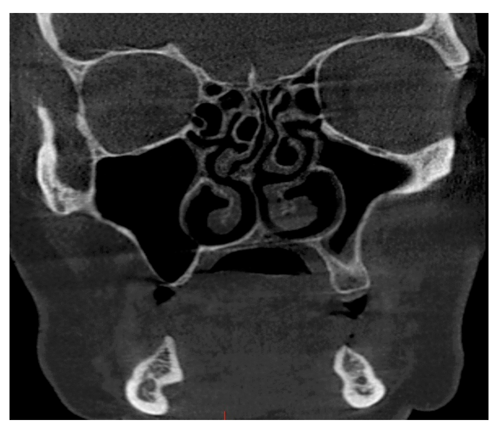

Fig. (11). Left medial uncinate process deviation.

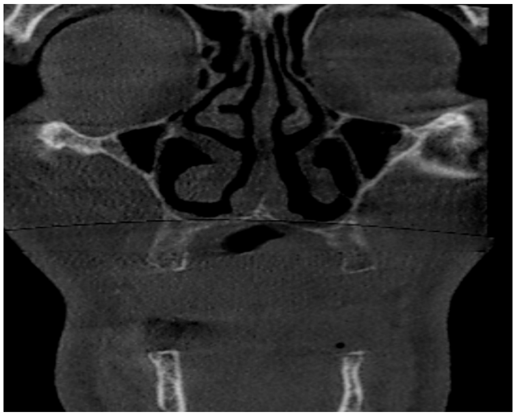

Fig. (12). Bilateral paradox middle concha.

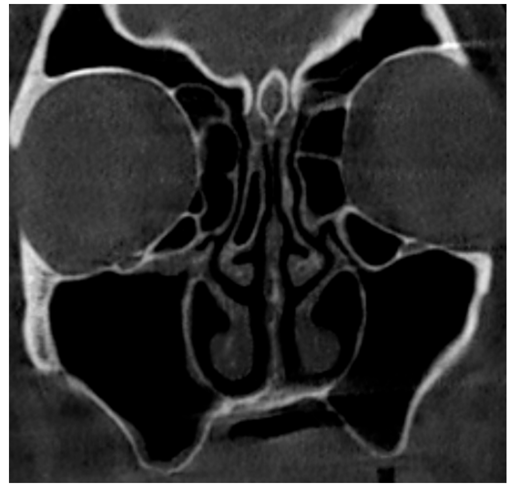

Fig. (13). Left Haller cell.

consideration. Pneumatization of uncinate process appears as a radiolucency on this bony structure and any type of radiolucency involving uncinate process are called as uncinate bulla. Uncinate process deviation was diagnosed as medial or lateral deviation from the regular uncinate process position. Normally convexity of middle concha is directed medially, and lateral convexity of middle concha was diagnosed as paradox middle concha. Pneumatizations inferior to the orbit, along the lateral wall of infundibulum and at the roof of maxillary sinus were recorded as Haller cells.

SPSS 20 package software was used for data analysis. Descriptive statistics, Mann Whitney U test and Chi-Square tests were uperformed for statistical analysis of the obtained data.

RESULTS

While no pathologies were seen in 243 (60.8 %) of the evaluated 400 sinuses, 157 (39.3) showed pathologies. Mucosal thickening was the most frequent pathology with a percentage of 19 % and followed by retention pseudocysts (7.7%), polypoid mucosal thickening (5.5 %), air-fluid level (4.2 %) and sinonasal polyposis (2.7 %), respectively.

Pathologies were found more frequent in male patients than females for left and right sinuses ($p<0.05$). There was no statistically significant relationship between age and pathologies ($p>0.05$). Table **2** and **3** demonstrates relationships between pathologies and gender and age.

Ethmoid infundibulum was obstructed in 40 (20 %) of sinuses in right and 58 (29 %) in left. There was a statistically significant relationship between ethmoid infundibulum obstruction and pathology presence ($p<0.05$). Table **4** shows the relationship between ethmoid infundibulum clarity and for left and right maxillary sinus pathologies.

Deviation of nasal septum was found in 129 (64.5%) of the evaluated 200 patients. There was no statistically significant relationship between nasal septum deviation and age and gender ($p>0.05$). As the connections between nasal septum deviation and presence of pathology were estimated; 55.6 % of patients with a right nasal septum deviation showed no sign of pathology in right and left maxillary sinuses and 56% of patients with a left nasal septum deviation had no pathologies. No statistically significant relationship between nasal septum deviation and pathology was found ($p>0.05$). Beside these findings we found a link between left nasal deviation left ethmoid infundibulum clarity. Left ethmoid infundibulums of patients with a left nasal septal deviation seem to be more obstructed than patients without left

Table 2. Relationship between gender groups and pathologies for left and right maxillary sinuses.

		Gender				Chi-square Test	
		Male		Female			
		n	%	n	%	Chi-square	p
Pathologies seen in CBCT for right sinus	No pathology	48	50,0	76	73,1	11,284	0,001*
	Pathology	48	50,0	28	26,9		
	Total	96	10,.0	104	100,0		
Pathologies seen in CBCT for left sinus	No pathology	42	43,8	77	74,0	19,005	0,000*
	Pathology	54	56,3	27	26,0		
	Total	96	100,0	104	100,0		

*$p<0.05$: there is a statistically significant relationship between gender and pathology. Pathologies are seen more frequent in males than females for both right and left maxillary sinuses.

Table 3. Relationship between age and pathologies for left and right maxillary sinuses.

		Age					Mann Whitney U Test		
		n	Mean	Min	Max	SD	Mean Rank	U	p
Pathologies seen in CBCT for right sinus	No pathology	124	56,7	33,0	86,0	9,5	97,7	4359,5	0,375
	Pathology	76	57,5	32,0	85,0	9,4	105,1		
	Total	200	57,0	32,0	86,0	9,4			
Pathologies seen in CBCT for left sinus	No pathology	119	56,4	33,0	86,0	9,3	95,9	4275,5	0,175
	Pathology	81	57,9	32,0	85,0	9,6	107,2		
	Total	200	57,0	32,0	86,0	9,4			

Table 4. Relationship between right and left ethmoid infundibulum obstruction and right and left sinus pathologies.

		Pathologies seen in CBCT for right sinus				Chi-square Test	
		No pathology		Pathology			
		n	%	n	%	Chi-square	p
Right ethmoid infundibulum clarity	Obstructed	10	8,1	30	39,5	27,124	0,000*
	Open	114	91,9	46	60,5		
	Total	124	100,0	76	100,0		
		Pathologies seen in CBCT for left sinus				**Chi-square test**	
		No pathology		**Pathology**			
		n	**%**	**n**	**%**	**Chi-square**	**p**
Left ethmoid infundibulum clarity	Obstructed	18	15,1	40	49,4	25,83	0,000*
	Open	101	84,9	41	50,6		
	Toplam	119	100,0	81	100,0		

*p<0.05: Pathologies are more frequent in patients with an obstructed ethmoid infundibulum in right and left maxillary sinuses.

deviation ($p<0.05$). This connection was not significant for right area ($p>0.05$).

Concha bullosa was seen in 78 (39 %) right and 64 (32 %) left of the evaluated 200 osteomeatal areas. As considered in patient distribution of this anomaly, 94 (47 %) of the patients had concha bullosa. Pathologies and ethmoid infundibulum clarity showed no significant relationship with ipsilateral concha bullosa presence ($p>0.05$) (Table **5**).

Table **6** demostrates the distribution of overpneumatised agger nasi cell, uncinate bulla, uncinate process deviation, paradox middle concha and Haller cells. None of these anomalies showed a significant relationship with age, gender, ethmoid infundibulum clarity and pathology presence ($p>0.05$).

DISCUSSION

The importance of paranasal sinus diseases for dentistry is a well known issue for years. Especially pathologic events in maxillary sinuses can mimic odontogenic diseases, also dental pathologies can effect maxillary sinuses or give the symptoms of maxillary sinus diseases [14]. At the same time intraosseous implant procedures, which are getting more common lately, increases the interest on paranasal sinuses. Proximity of maxillary posterior area to maxillary sinuses can lead to some problems in implant surgery of patients with inadequate bone height, however sinus augmentation procedures overcome this problem [15]. Although complications in sinus augmentation procedures are rare; problems like sinus membrane perforation and hemorrhage, problems in post-operative wound healing, sinusitis, infection of the graft may be seen. Many of these problems are related with sinus anatomy and pathologies present in sinuses [16]. Sinus diseases and anomalies have a great frequency in patients who will undergo sinus augmentation process. Presence of these cases cause increases in complications during surgery and post-operatively. Definition of these problems is of importance to reduce the risk of complications [17]. Radiographic evaluation is worthy in determination of sinus diseases. Anatomy of the osteomeatal area has a great importance in evolution of maxillary sinus diseases and drainage of paranasal sinuses has a close relationship with this area [3].

Table 5. Relationship between concha bullosa presence and ethmoid infundibulum clarity.

		Right ethmoid infundibulum clarity						Statistical analysis	
		Obstructed		Open		Total			
		n	%	n	%	n	%	Chi-square	p
Right concha bullosa presence	No	28	70.00	94	58.75	122	61,00	4,226	0,238
	Yes	12	30.00	66	41.25	78	39,00		
	Total	40	100,00	160	100,00	200	100,00		
		Left ethmoid infundibulum clarity						Statistical analysis	
		Obstructed		Open		Total			
		n	%	n	%	n	%	Chi-square	p
Left concha bullosa presence	No	40	68,97	96	67,61	136	68,00	0,576	0,902
	Yes	18	22,41	46	20,42	64	32,00		
	Total	58	100,00	142	100,00	200	100.00		
		Pathologies seen in CBCT for right sinus						Statistical analysis	
		No		Yes		Total			
		n	%	n	%	n	%	Chi-square	p
Right concha bullosa presence	No	73	61,3	49	60,5	122	61,0	4,921	0,178
	Yes	46	38.7	32	39.5	78	34.0		
	Total	119	100,0	81	100,0	200	100,0		
		Pathologies seen in CBCT for left sinus						Statistical analysis	
		No		Yes		Total			
		n	%	n	%	n	%	Chi-square	p
Left concha bullosa presence	No	85	68,5	51	67,1	136	68,0	2,081	0,556
	Yes	39	31.5	25	32.9	64	32.0		
	Total	124	100,0	76	100,0	200	100,0		

Table 6. Distribution of overpneumatised agger nasi cell, uncinate bulla, uncinate process deviation, paradox middle concha and Haller cells.

	Female	Male	Total	%
Overpneumatised Agger nasi cell	4	6	10	5
Uncinate bulla	6	4	10	5
Uncinate process deviation	6	5	11	5.5
Paradox middle concha	9	7	16	8
Haller cells	14	20	34	17

For this study we used cone beam computed tomography scans of maxillary posterior edentulous patients who had no sign of recent tooth extraction to distinguish maxillary sinus diseases of dental origin. Sinus pathologies and osteomeatal area anomalies are interpreted in cone beam computed tomography images which is described as a useful method for the diagnosis of maxillary sinus diseses and definition of sinonasal anatomy [9-13].

In dental and especially otorhinolaryngology literature there are various researches made with different radiographic and diagnostic methods for the definition of the prevalence

Table 7. Studies made to define the prevalence and age and gender characteristics of maxillary sinus diseases.

Researchers	Method	#	Prevalence	Age	Gender
Ritter *et al.* [13]	CBCT	1029 patients	56.3 %	More common in patients over 60	Male predominancy
Cho and Jung [18]	CBCT	564 patients	59.2 %	More common in elderly	Female predominancy
Rege *et al.* [11]	CBCT	1406 sinuses	66 % mucosal thickening 10.1 % mucous retention cyst 7.8 % total opacification 5.6 % polyps	No relationship	No predominancy
Gracio *et al.* [19]	CBCT	513 patients	50.3 %	Not defined	More common mucous retantion cysts in males
Smith *et al.* [20]	CBCT	883 patients	50 %	Not defined	Male predominancy
Shanbhag *et al.* [21]	CBCT	128 patients	60.6 % mucosal thickening	Not defined	Not defined
Cerrah *et al.* [22]	CT	1008 patients	64 %	Not defined	Not defined
Konen *et al.* [23]	Water's CT	134	72.4 %	Not defined	Not defined

of maxillary sinus diseases and osteomeatal complex anomalies and relationships between these.

Table **7** demonstrates some studies made to define the prevalence and age and gender characteristics of maxillary sinus diseases.

In our study we found sinus pathologies in 39.3 % of the evaluated 400 sinuses and 50 % of the 200 patients. While our results are compatible with some of these studies [13, 19, 20], some studies showed higher prevalence values than ours'. In our opinion, differences in patient groups and inclusion criteria as a pathology are the main causes of the discordances. For example, in Shanbhag *et al.* study [21] while 2 mm. of mucosal thickenings are considered as pathology; we counted minimum 3 mm. mucosal thickenings as pathologic. Likewise, in Cho and Jung's research [18] there is no definition of pathology inclusion criteria. Cerrah *et al.* [22] and Konen *et al.* [23] studies, which had higher frequencies, are researches performed in otolaryngology clinics including patients with sinonasal complaints. Mucosal thickening was the most common sinus pathology in our study and our results are concordant with other works [11, 13, 21]. As we look in gender and age groups, while we found a male predominancy, no relationship was seen between age and sinus pathologies. Of the above mentioned studies only one work concluded with female predominancy [18]. Besides, two studies indicated that pathologies are more common in elderly [13, 19]. This difference with our study may be the result of definition of patient groups. Our workgroup was made of patients with maxillary posterior edentulous patients with higher ages.

CBCT study conducted by Smith *et al.* including 883 patients to research prevalence and relationships between nasal septum deviation, concha bullosa and sinus diseases concluded with a 67.5 % septum deviation, 19.4 % concha bullosa prevalence and no relationship was found between these anomalies and sinus diseases [20]. Another CT study containing 172 patients consisting of 90 patients with paranasal sinus complaints and 82 asymptomatic patients defined having 28.8 % concha bullosa, 22.2 % septum deviation, 12.2 % paradox middle concha, 7.77 % agger nasi cells, 5.55 % Haller cells and 2.22 % uncinated process deviation in symptomatic group; having 12 % septum deviation, 7.31 % paradox middle concha, 4.88 % agger nasi cells and 3.65 % Haller cells in asymptomatic group. No relation between these anomalies and age and gender was found in this study [24]. Fifty five percent concha bullosa and 44 % nasal septum deviation was found in another study made using CT scans of 800 patients [25]. Vincent and Gendeh's study with CT scans of 137 patients who will undergo or had undergone endoscopic sinus surgery resulted with a 25.5 % concha bullosa prevalence and female predominancy. Nasal septum deviation was found in 46.7 % of patients and no statistically significant relationship was found between these two anomalies and sinus pathologies [26]. While concha bullosa and contralateral septum deviation was found to be related, no relation between these anomalies and sinus diseases was found in a CT study containing 998 scans, which resulted with a 65 % septum deviation and 44 % concha bullosa prevalence [27]. Results of previously mentioned Cerrah *et al.* study with 1008 patients' CT scans demonstrated 53.7 % agger nasi cells, 41.6 % concha bullosa, 30.7 % septum deviation, 18.2 % uncinated bulla, 17.1 % Haller cells, 8.4 % paradox middle concha and 4.9 % uncinate process deviation. Also these anomalies were related with sinus diseases in this study [22]. Case-control study of Dursun *et al.* which aimed to define the contractions between sinus pathologies and osteomeatal complex anomalies consisted of CT scans of 415 chronic rhinosinusitis and 60 asymptomatic patients. According to results of this study septum deviation was found 60.5 % of symptomatic and 16.6 % of asymptomatic group and statistically significant relationship was found between septum deviation and sinus pathologies. Concha bullosa was found in 48.4% of symptomatic and 25 % of asymptomatic group and uncinated process deviation was seen in 29.6 % of symptomatic and 10 % of asymptomatic group. Besides, in terms of these two variables significant difference was found between symptomatic and asymptomatic patients. While no Haller cells and uncinate bulla was discovered in asymptomatic group, prevalence was 12.8 % and 2.4 % in symptomatic group respectively and with regard to Haller cells frequency relationship was found. No significant difference between two groups was determined in terms of paradox middle concha and agger nasi cells prevalence [3]. Ünal *et al*. intended to define the interactions between osteomeatal area apertures and sinus diseases and found 48.9 % Haller cells, 46.9 % paradox middle concha, 42.8 % concha bullosa, 40.8 % septum deviation, 16.3 % uncinate process deviation and 12.2 % uncinate bulla in 48 patients [28]. Another CT study including 120 symptomatic and 120 asymptomatic patients showed 40.8 % and 47.5 % concha bullosa, 12 % and 23 % paradox middle concha, 51 % and 62 % Haller cells, 83 % and 79 % agger nasi cells and 56 % and 60.8 % septum deviation, respectively [5].

We found nasal septum deviation in 64.5 % of the evaluated 200 patients. Concha bullosa was present in 47 % of the study group. Haller cells showed 17 % frequency and followed by 8 % paradox middle concha, 5.5 % uncinate process deviation and 5 % uncinate bulla and overpneumatized agger nasi cells. None of the evaluated anomalies showed a statistically significant relationship with age and gender, also with maxillary sinus diseases.

As mentioned before, there are various studies made to define the prevalence of osteomeatal complex anomalies and sinus diseases. Our results seem to be compatible with some of these studies. Main differences between our results and other studies may be the consequence of differences between evaluation criteria. For example, in our study we accepted a minimal deviation from the line that is drawn from crista galli to middle palatal suture as nasal septum deviation. While many studies did not define the criteria of inclusion as septum deviation, only one of the studies [20] reported the acception criteria as 4 mm. deviation from mid-sagittal plane as deviation and another [26] as deviation caused obstruction in osteomeatal area. We found none of the anomalies discussed above to be related with sinus diseases. While this finding is in accordance with some of the studies, there is discrepancy between some. Situation here that must be explained is the inclusion criteria as pathology and anomaly. We accepted 3 mm. or above changes in sinus mucosa as pathology, Cerrah *et al.* admitted Lund-Mackay classification which defines 2mm. or above changes in sinus mucosa as pathology [22]. Many of the other studies did not state any inclusion criteria as pathology. Another problem that must be clarified is the previously mentioned anomaly inclusion criteria. Haller cells are defined as infraorbital ethmoid air cells and agger nasi cells are the most anterior ethmoid air cells. We accepted cells not expanding beyond inferior wall of orbita as Haller cells and asymmetric overpneumatised cells as agger nasi cells. Any deviation of uncinate process' parallelity from lamina papyracea, which defines the inferomedial wall of orbita, as uncinate process deviation. Also, there may be controversies in the definition of concha bullosa. Pneumatisation of middle concha may effect the lamellar, bulbous or both parts of middle concha which is called as real concha bullosa [29].

Sinus diseases seem to sustain the interest on and many researches should be carried on to define the prevalence and cause of them. Sinus procedures and three dimensional imaging techniques are getting more widespread in dentistry and definition of sinus diseases and anomalies is getting more important. In our study, we found a positive relationship between ethmoid infundibulum clarity and sinus health. Although we found no relationship between sinus pathologies and osteomeatal area anomalies, further researches including the dimensions of anomaly such as angular value of deviations or volume of the existing anomaly with standardized pathology inclusion criteria will be useful to define the interactions between osteomeatal area anomalies and sinus diseases.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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