

Are Variations of Paranasal Sinuses and Infundibular Trace Length Responsible for Development of Maxillary Sinusitis?

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Abstract

Purpose: To determine whether the length and width of ethmoid infundibulum relate to maxillary sinusitis. In addition, evaluation of the relationship of maxillary sinusitis to the type of infundibulum and to anatomical sinonasal variations is also aimed to observe.

Materials and methods: Paranasal sinus computerized tomography images of 491 clinically proven rhinosinusitis cases are analyzed retrospectively by two radiologists. The length is measured by drawing curve traces and width is measured from the narrowest region for 982 ethmoid infundibula in-total. Maxillary sinusitis of the cases is graded according to the Lund and MacKay score. Type, width and length of ethmoid infundibulum and sinonasal anatomical variations are compared for the cases in terms of having with and without maxillary sinusitis.

Results: Type and length of ethmoid infundibulum are found not to be risk factors for maxillary sinusitis ($p>0.05$). Length of EI are similar between score 0 and score 1-2 maxillary sinusitis ($p>0.05$) but width was much more in patients with having score 1 and 2 maxillary sinusitis compared with those not having sinusitis (score 0) ($p<0.05$). Maxillary ostial closure with according expansion of ethmoid infundibulum is seen in maxillary sinusitis. Sinusitis risk is increased in presence of ethmoid bulla. The other anatomical variations can not be determined as risk factors for sinusitis.

Conclusion: In contrary to general belief, paranasal variations do not constitute risk for maxillary sinusitis apart from ethmoid bulla. Type and trace length of infundibulum are not risk factors for sinusitis. Ethmoid infundibulum is expanded with sinusitis.

Keywords: Ethmoid infundibulum; Maxillary sinusitis; Computed tomography

Introduction

The Ostiomeatal Complex (OMC) is a drainage mechanism for maxillary, frontal, anterior and posterior ethmoid cells. The OMC is composed of ethmoid infundibulum, uncinat process, ethmoid bulla, semilunar hiatus and medial meatus. Normal mucociliary drainage is related to ostium opening. Even with open ostium, a breakdown of mucociliary drainage, accumulating mucus and resulting with infection are claimed to occur in the contact of two opposing mucosal surface. Obstruction with mucociliary drainage dysfunction resulting in repeated inflammatory sinonasal diseases is thought to occur. Ethmoid Infundibulum (EI) which forms the main constitution of OMC was found to be wider and shorter than normal in children with acute complicated sinusitis and the uncinat process which forms the medial wall of the EI was found shorter in another study conducted on adults with chronic sinusitis.

The relation between sinonasal anatomical variations and sinonasal infections is not clear. While some researchers have claimed that anatomical variations increase chronic sinusitis risk, other researchers have not found a relation between sinonasal variations and sinusitis. Showing sinonasal anatomical variations before functional endoscopic sinus surgery blocks the possible complications. Computed Tomography (CT) is the preferred imaging modality for demonstrating sinonasal variations and pathologies. In this study, the anatomical variations of the OMC, in particular the length and width of EI are studied in relation to maxillary sinusitis and ostiomeatal disease to detect whether a correlation exists [1-21].

Material and Methods

Local ethics committee approval was obtained. Images of 200

(40.7%) females average age 40.36 ± 13.99 and 291 (59.3%) male with average age of 38 (12-85) totaling 491 cases with clinically proven rhinosinusitis are studied by use of scanning paranasal CT without contrast. Postoperative cases, those having sinonasal polyposis or sinonasal malignancy cases are excluded from the study. Paranasal CT images are acquired from the PACS retrospectively. Scans are performed with 64 slice (Aquilion 64, Toshiba Medical Systems, 2011, Japan) CT device. Scanning parameters in 64 detectors CT were as follows: FOV: 16 cm, collimation 64×1 , gantry rotation time 0.6 s, slice thickness 1 mm, step value 0.64, 120 kV and 250 mA. Anterior and lateral scanogram are performed after patients lying down in supine position. Scanning in axial plan is realized from frontal sinus roof to mandible. The images are evaluated using Osirix soft ware (7.0, 64 bit, Switzerland). CT images of all the cases are evaluated by two experienced radiologists. Coronal and sagittal Multiplanar Reconstruction (MPR) images are obtained through axial images. Infundibulum widths are calculated coronal plan images with 950% augmentation from uncinat process to outward contour of orbital medial wall (Figure 1). Infundibulum length is measured coronal plan 3-D curved multiplanar reconstruction imaging with 100% augmentation drawing trace from

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ostium to semilunar hiatus (Figures 2 and 3). Uncinate process adhering with lamina papyracea is classified as type 1, cribriform plate as type 2, middle concha as type 3 EI (Figures 4-6). Anatomical variations such as Haller cell, uncinate aeration, ethmoid bulla, middle turbinate lamella aeration, bullous middle turbinate, paradoxical middle turbinate, septum deformity are recorded. Maxillary sinusitis is graded according to Lund and MacKay score.

Score 0: No abnormality.

Score 1: Partial opacification.

Score 2: Total opacification.

Statistical Analysis

One way variance analysis (One way ANOVA) is used to compare between maxillary sinusitis score and EI length, width. Chi square test is used to compare between sinusitis score and nominal variants (sinus type, variations). Score 0 maxillary sinus is grouped as sinusitis is absent. Score 1 and 2 grouped as “sinusitis is present”. T test is used to evaluate the difference between length and width, chi square test is used to compare with nominal variants and sinusitis status (present-absent)

for these two groups. Independent variants (sinus type and variations) that can affect sinusitis existence are analyzed by logistic regression analysis. SPSS 11.5 package program is used in analysis and $p < 0.05$ is accepted as statistically significant level.

Results

Average EI length of 982 subjects were 1.33 ± 0.29 (0.45-2.57) (Min-Max) millimeters. Average EI width were 2.01 ± 0.64 (0.58-6.69) (Min-Max) millimeters. 662 (67.4%) of 982 ethmoid infundibula were Type 1, 139 (14.2%) were Type 2, 181 (18.4%) were type 3. Of all 982 subjects, 294 (29.9%) have score 0, 614 (62.6%) have score 1, and 74 (7.5%) have score 2 maxillary sinusitis. Score 0 maxillary sinus subjects were considered as control group. Haller cell was encountered in 864 (88%), aerated uncinate process in 880 (89.6%), ethmoid bulla in 489 (49.8%), bullous middle turbinate in 556 (75.5%), paradoxical middle turbinate in 820 (83.5%).

There was no relation between sinusitis scores and infundibulum length ($p > 0.05$).

Length of EI are similar between scores 0-2 maxillary sinusitis ($p > 0.05$) but width was much more in patients with having score 1 and

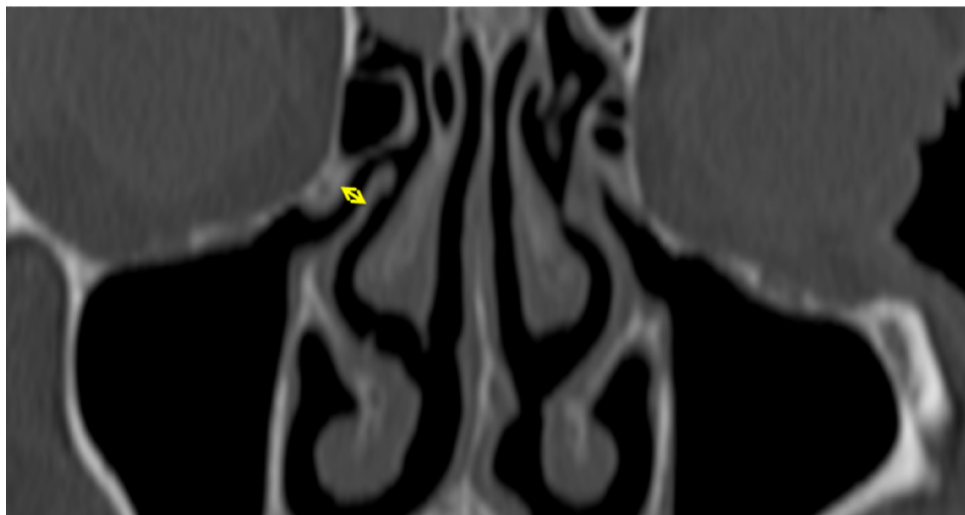


Figure 1: Ethmoid infundibulum width is measured from bone to bone in narrowest region (the yellow arrow) on coronal computed tomography Multiplanar Reconstruction Image (MPR).

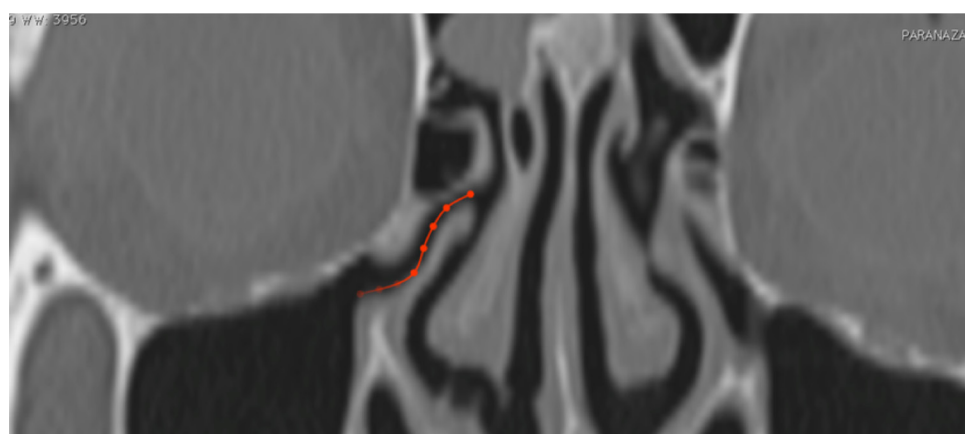


Figure 2: Ethmoid infundibulum trace is measured certain length from ostium to semilunar hiatus (dotted red line) on coronal CT image.

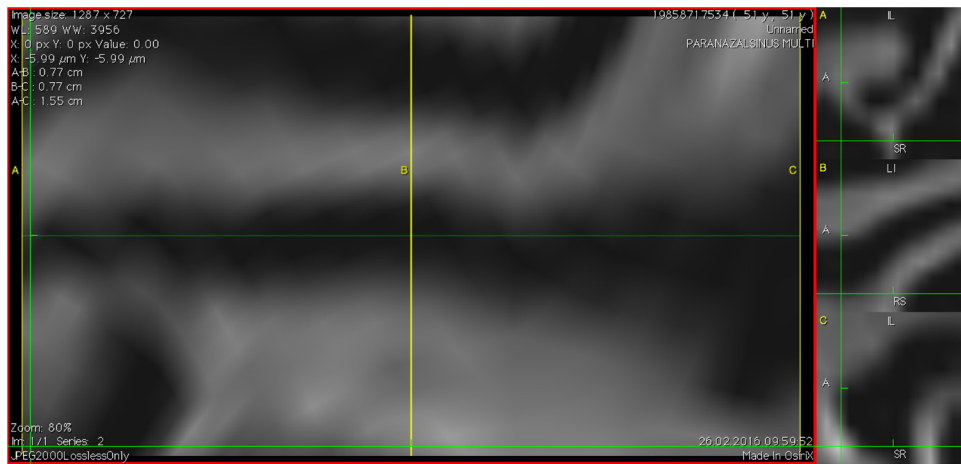


Figure 3: Ethmoid infundibulum trace is flattened after drawing in coronal curved MPR image.

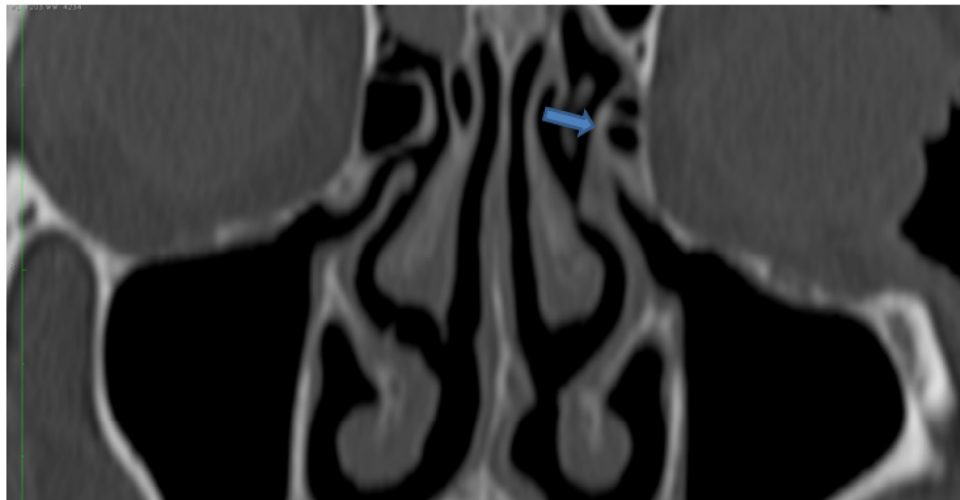


Figure 4: Type 1 ethmoid infundibulum. Left uncinate process adheres with lamina papyracea (blue arrow) on coronal CT image.

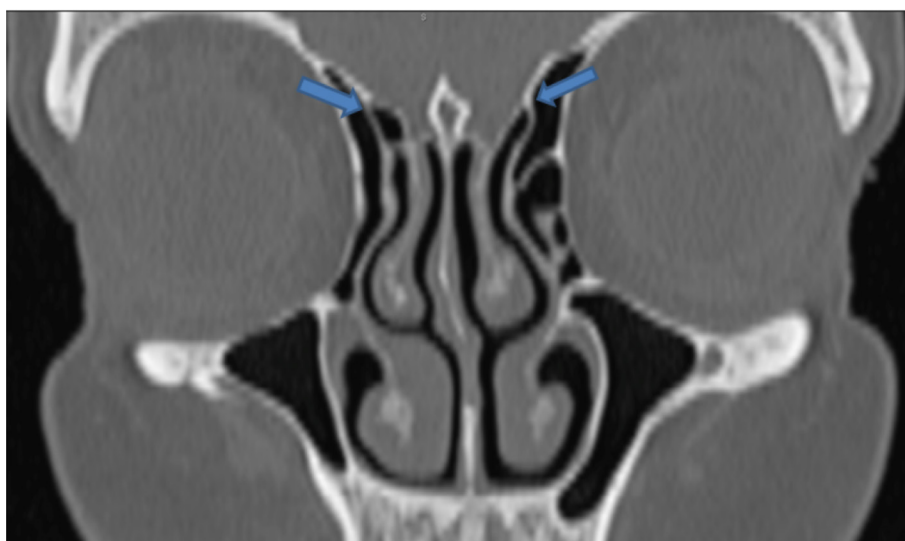


Figure 5: Type 2 ethmoid infundibulum. Bilateral uncinate processes adhere with cribriform plate (blue arrows) on coronal CT image.

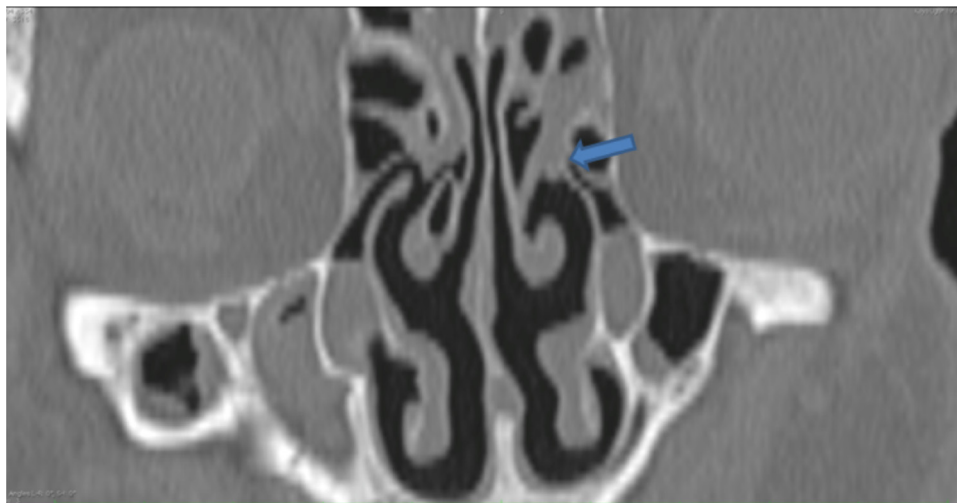


Figure 6: Type 3 ethmoid infundibulum. Uuncinate process adheres with middle concha in left (blue arrow) on coronal CT image.

2 maxillary sinusitis compared with those not having sinusitis (score 0) ($p < 0.05$) (Table 1).

The relation between sinusitis scores, infundibulum type and paranasal variations is summarized in Table 2. A relation between sinusitis scores and infundibulum types is not found ($p > 0.05$). Haller cells are more frequent in score 1 ($p < 0.05$). Sinusitis scores and uncinata aeration are not related to each other ($p > 0.05$).

There is relation between sinusitis score and ethmoidal bulla ($p < 0.001$). Ethmoid bulla is more frequent in score 1 maxillary sinusitis. Middle turbinate lamellar aeration is similar in score 0 and 1-2 patients. Any relation is not detected between sinusitis score and bullous middle concha ($p > 0.05$). There were no significant difference between sinusitis score and paradoxical middle concha frequencies. Score 1 sinusitis is more frequent compared with score 0 and 2 sinusitis in patients with septum deformity ($p < 0.05$). The relation between infundibulum type, paranasal variations and sinusitis scores is shown in Table 3. Ethmoid bulla is more frequent in patients who had score 1-2 sinusitis in comparison with those score 0 maxillary sinuses ($p < 0.01$). Independent variants (infundibulum type, length, variations) that can affect existence of sinusitis are inserted in a logistic regression analysis and risk factors affecting sinusitis existence are analyzed by retrospective elimination method. An end logistic model is generated with statistically significant variants. Ethmoid bulla is found to be an independent risk factor affecting the existence of sinusitis with regard to this model. Sinusitis risk is increased 1.489 fold in patients had ethmoid bulla (Table 4).

Discussion and Conclusion

The OMC is comprised of ostium of the frontal sinus, frontal recess, maxillary sinus ostium, ethmoid infundibulum and middle meatus. Ethmoid infundibulum is the air passage connecting the maxillary sinus ostium to the middle meatus. The uncinata process comprises the medial wall. The lateral wall is formed by the lamina papyracea and frontal process of maxilla and the ethmoid bulla form the posterior wall. EI mainly drains the maxillary sinus [4,10]. It is thought that interference with the drainage process causes sinusitis. Whether bony alterations or mucosal pathologies at the OMC cause the obstruction, is a matter of ongoing debate. Study researching the relation between EI length, width and maxillary sinusitis is limited in

	Sinusitis present (N=294)	Sinusitis absent (N=688)	p
	Average \pm SD	Average \pm SD	
EI Length	1.31 \pm 0.25	1.33 \pm 0.31	0.320
EI Width	1.93 \pm 0.56	2.04 \pm 0.66	0.006*

SD: Standard Deviation; N: Number; * $p < 0.05$

Table 1: Relation between sinusitis existence and infundibulum dimensions.

	Score 0		Score 1		Score 2		p
	N	%	N	%	N	%	
Infundibulum Type							
1	184	27.8	428	64.6	50	7.6	0.060
2	52	37.4	78	56.1	9	6.5	
3	58	32	108	49.7	15	8.3	
Haller Cell							
Absent	254	29.4	538	62.3	72	8.3	0.024*
Present	40	33.9	76	64.4	2	1.7	
Aerated Uncinate							
Absent	263	29.9	547	62.2	70	8	0.498
Present	31	30.4	67	65.7	4	3.9	
Ethmoid Bulla							
Absent	126	25.8	306	62.6	57	11.7	0.001*
Present	168	34.1	308	62.5	17	3.4	
Lamellar Aeration							
Absent	157	28.2	348	62.6	51	9.2	0.014
Present	137	32.2	266	62.5	23	5.4	
Bullous Concha							
Absent	212	28.6	469	63.3	60	8.1	0.077
Present	82	34	145	60.1	14	5.8	
Paradoxical Middle Concha							
Absent	243	29.6	515	62.8	62	7.6	0.811
Present	51	31.5	99	61.1	12	7.4	
Septum Deformity							
Absent	74	35.6	111	53.4	23	11.1	0.038*
Present	220	56.9	431	129.9	51	13.1	

* $p < 0.05$; N: Number

Table 2: Relation between infundibular type-paranasal variations and sinusitis score.

	Sinusitis Present (N=294)		Sinusitis Absent (N=688)		p
	N	%	N	%	
Type of Infundibulum					
1	184	27.8	478	72.2	0.063
2	52	37.4	87	62.6	
3	58	32	123	68	
Haller Cell					
Absent	254	29.4	610	70.6	0.314
Present	40	33.9	78	66.1	
Aerated Uncinate					
Absent	263	29.9	617	70.1	0.916
Present	31	30.4	71	69.6	
Ethmoidal Bulla					
Absent	126	25.8	363	74.2	0.004*
Present	168	34.1	325	65.9	
Lamellar Middle Concha					
Absent	157	28.2	399	71.8	0.184
Present	137	32.2	289	67.8	
Bullous concha					
Absent	212	28.6	529	71.4	0.111
Present	82	34	159	66	
Paradoxical Middle Concha					
Absent	243	29.6	577	70.4	0.639
Present	51	31.5	111	68.5	
Septum Deformity					
Absent	74	35.6	134	64.4	0.135
Present	220	56.5	554	143.1	

*p<0.05; N: Number

Table 3: Relation between existence of sinusitis and type of infundibulum-paranasal variations.

	Odds ratio	95% CI	p
Without Ethmoidal Bulla	1	-	-
With Ethmoidal Bulla	1.489	1.131 - 1.961	0.005

Table 4: Relation between sinusitis existence and ethmoid bulla.

literature. Thorp et al. [21] report that the infundibulum is shorter and wider in children with acute sinusitis than in healthy children. Also they report that mucosal changes play a role more than bony changes in the ostiomeatal complex for sinusitis pathogenesis. Pruna [16] made 15 different quantitative measures of structures forming the OMC and report the uncinate process length is shorter in patients with sinusitis. Messerklinger [14] reports the anatomical variations of the middle meatus and infundibulum trigger inflammation by narrowing sinus ostia and the disease extends from there to the other related sinuses.

Treatment modalities are also based upon the bony narrowing concept and therefore aim to widen the drainage routes for example by removing the uncinate process. Our study contradicts this while showing EI length measured drawing trace is not a risk factor for maxillary sinusitis. The ostium is found closed in patients with sinusitis. The infundibulum is widened probably due to the mass effect of inflammatory secretion and decreased mucociliary activity.

A lot of anatomical variations are seen in paranasal sinuses. Certain studies claim some anatomical variations cause inflammation and chronic rhinosinusitis by obstructing sinus drainage ways [6,7,17,20]. On the contrary, Kim et al. [9], Lerdlum et al. [11], Stallman et al. [20] and Katia et al. [17] report there is no relation between anatomical variations and rhinosinusitis as well as that local,

systemic, environmental factors and intrinsic mucosal disease are more important in chronic rhinosinusitis pathogenesis. In the study any relation between Haller cell and sinusitis is not detected, on the contrary Haller cell is rarer in patients with sinusitis. A statistical relation between Haller cell existence and maxillary sinusitis is not detected by cone beam CT imaging in Mathew et al. [13]. Also, the relation is not detected in some other studies [9,15,19,20]. On the other hand, there is one study claim that Haller cell existence and narrow infundibulum are related to recurrent acute rhinosinusitis [1]. Nasal septum deformity is seen in 90% of population [1,6,17,22]. Orlandi et al reported that type 3 nasal deformity according to Mladina's classification has the higher frequency among chronic rhinosinusitis patients [23]. In our study, septal deformities are more frequent in score 1 maxillary sinusitis.

Fadda et al. report ethmoid bulla and ethmoid sinusitis are not related to each other [6]. A study claims there is association between a big ethmoid bulla and maxillary sinusitis [18]. A relation between maxillary sinusitis and bullous concha is not statistically significant in some studies [16,17]. In our study ethmoid bulla is more frequent in patients who had score 1-2 sinusitis in comparison with those score 0 maxillary sinuses so there is correlation of maxillary sinusitis and ethmoid bulla. Ethmoid bulla can narrow the EI and cause maxillary sinusitis.

Bullous concha characterized by bullous part of middle concha pneumatization is reported 9-20%. Maxillary and ethmoid sinusitis can be formed because of bullous and deformed middle concha narrowing middle meatus in some studies [18]. Bullous concha and maxillary sinusitis are not related to each other in Smith et al. study with 883 patients [19]. Bullous middle concha paradoxical middle concha and maxillary sinusitis are not related to each other in our study. Also no significant difference is seen between the sinusitis score, bullous middle concha and paradoxical middle concha rates. However septal deformity is found more frequent in score 1 maxillary sinusitis.

There are some limitations in our study. The concurrence of different anatomical variations has not researched. Medial and lateral deviations of uncinate process are not evaluated. We didn't calculate the volume of EI. EI volume may be more useful for evaluating the relation with the maxillary sinusitis. Before functional endoscopic sinus surgery reporting anatomical variations is necessary. Because existence of these anatomical variations can affect surgical approaches. These are important for preventing possible complications during surgery [12]. Our study declares the researched variations do not increase sinusitis risk except ethmoid bulla. It is thought that even if a long infundibulum tends to be obstructed and causes sinusitis in general, this condition is not important in the case of sufficient mucociliary activity.

Disclosure of Interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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