European Journal of
Human Health

ORIGINAL ARTICLE

Evaluation of anatomical variations of the paranasal sinus in children with coronal plan computed tomography

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ABSTRACT

Aim: In this study, we aimed to evaluate the frequency of the most common anatomical variations of the paranasal sinuses and lateral nasal wall in coronal sinus CT scans of pediatric cases.

Methods: Paranasal sinus CT scans of a total of 200 pediatric patients who underwent paranasal sinus coronal CT between December 2000 and June 2005 in the Department of Radiology, Faculty of Medicine, Harran University were evaluated retrospectively. Out of 200 patients, 71 patients with pansinusitis, trauma and nasal polyposis were excluded from the study and 129 patients were included in the study.

Results: In our cases, the anatomical variation rates in the bone structure detected by CT in order of frequency were: septal deviation 72.9%, concha bullosa 60.5%, Agger nazi cell 45.8%, paradox middle turbinate 31.7%, pneumotized superior turbinate 26.4%, Haller cell 24.1%, maxillary sinus hypoplasia 23.3%, pneumotized uncinate prominence (UP) 21%, pterygoid recess pneumotization 20.2%, supraorbital ethmoid cell 17.1%, maxillary sinus septation 14%, uncinate process atelectasis 12.5%, Onodi cell 11.6%, paradoxical superior turbinate 10.9%, anterior clinoid pneumotization 9.3%, ethmomaxillary sinus 7.8% and pneumotized inferior turbinate 1.6%. Maxillary sinus hypoplasia existed in all cases with UP atelectasis. We detected decreased ipsilateral maxillary sinus volume in all but one of our ethmomaxillary sinus cases. At the same time, we observed the ipsilateral superior meatus to be wider than normal in these cases.

Conclusions: There was no significant difference between the rates of anatomical variation in bone structure in pediatric cases that we evaluated compared to the rates of anatomical variation reported in the literature for both pediatric and adult groups.

Keywords: Sinusitis, Tomography, Paranasal Sinuses

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Received: ***November 19, 2021;*** *Accepted:* ***November 24, 2021;*** *Published Online:* ***December 31, 2021***

Cite this article as: Kat, N. & Ozturk, A. (2021). Evaluation of Anatomical Variations of the Paranasal Sinus in Children with Coronal Plan Computed Tomography. European Journal of Human Health 1(3), 105-114.

Introduction

Endoscopic sinus surgery (FESC) is a treatment method that is progressively used in the pediatric age group with chronic sinusitis that does not respond to medical treatment. In pediatric cases, the early results acquired after FESC application are promising (1-3). Anatomical variations are thought to acting a slight role in pediatric sinusitis. Direct radiographs are not adequate to indicate chronic sinusitis in the pediatric age group. Coronal plane paranasal sinus CT is a part of the evaluation in pediatric patients with chronic sinusitis who do not respond to medical therapy and who are scheduled for surgery (4-6).

In the present study, we aimed to determine the frequency of the most common anatomical variations of the paranasal sinuses and lateral nasal wall in coronal sinus CT scans of pediatric cases.

Methods

This study was carried out as a thesis study by retrospectively evaluating the CT scans of 200 pediatric patients who underwent paranasal sinus coronal CT between December 2000 and June 2005 in the Department of Radiology, Faculty of Medicine, Harran University.

While determining the study group, the upper limit age was accepted as 18 years. Pre-diagnosis was not considered because it was aimed to determine the frequency of the most common anatomical variations of the paranasal sinuses and lateral nasal wall in coronal sinus CT sections of pediatric cases. Out of 200 patients, 71 patients with pansinusitis, trauma, tumor, antrachoanal polyp, nasal polyposis or with sinusitis that anatomical variations could not be evaluated were excluded from the study and 129 patients were included in the study.

CT scans of the cases were performed using a Toshiba Xvision TSX-002A model computerized tomography device at Harran University Faculty of Medicine, Department of Radiology, without IV contrast material. While taking the lateral scanogram of the head in the coronal plane, cross-sections were obtained between the glabella and the dorsum sella with 3mm cross-section intervals perpendicular to the infraorbito-meatal line. Sections were examined mostly in 800-2000 WW / -200 +200 WL windows, and soft tissue technique was used when necessary.

The age and gender of the patients were recorded. In the paranasal sinus CT sections, the right and left sides were evaluated independently of each other and each was recorded separately in the data table. The presence of anatomical variations such as Agger nasi cell on both sides, Haller cell, Onodi cell, paradox middle turbinate, septal deviation, upper turbinate pneumatization, paradox upper turbinate, uncinate bulla, deviant UP, UP aplasia, ethmomaxillary sinus, crista Galli pneumatization, septum pneumaplasia, maxillary sinus hypoplasia and septation, lower turbinate pneumatization, pterygoid recess pneumatization and supraorbital ethmoid cell were evaluated in detail. The development of frontal and sphenoid sinuses in the pediatric age group was investigated.

SPSS 11.5 program (SPSS for Windows, 11.5 SPSS Inc., USA) was used for the statistical evaluation of the obtained data.

Results

A total of 129 cases, 55 (42.6%) female and 74 (57.4%) male, were included in the study. The age range was 4-18, with a mean age of 12. The anatomical variation rates in the bone structure detected by CT in our cases are shown in Table I. As shown in Table I, we found that the rates of anatomical variation in the pediatric population, in order of frequency; septal deviation 72.9%, concha

bullosa 60.5%, Aggernazi cell 45.8%, paradox middle turbinate 31.7%, pneumatized upper turbinate 26.4%, Haller cell 24.1%, maxillary sinus hypoplasia 23.3%, pneumatized UP 21%, pterygoid recess pneumatization 20%. supraorbital ethmoid cell 17.1%, maxillary sinus septation 14%, UP atelectasis 12.5%, Onodi cell 11.6%, paradox upper turbinate 10.9%, anterior clinoid recess pneumatization 9.3%, ethmomaxillary sinus 7.8%, and pneumatized lower turbinate 1.6%. Frontal sinus was not developed in 11 cases and sphenoid sinus was not developed in 9 cases.

Table1. Distribution of Anatomical Variations in 129 Pediatric Cases

Anatomical variation	Right 11(%)	Left 11(%)	Billateral 11(%)	Total 11(%)
Septal deviation	49(38.0)	43(33.3)	2(1.6)	94(72.9)
Concha bullosa	16(12.4)	16(12.4)	46(35.7)	78(60.5)
Aggernazi cell	7(5.4)	14(10.9)	38(29.5)	59(45.8)
Paradox middle turbinate	19(14.7)	11(8.5)	11(8.5)	41(31.7)
Pneumatized upper turbinate	11(8.5)	13(10.1)	10(7.8)	34 (26.4)
Haller cell	13(10.1)	9(7.0)	9(7.0)	31(24.1)
Maxillary sinus hypoplasia	15(11.6)	6(4.7)	9(7.0)	30(23.3)
Pneumatic UP	9(7.O)	10(7.8)	8(6.2)	27(21.0)
Pterygoid recess pneumatization	6(4.7)	12(9.3)	8(6.2)	26(20.2)
Supraorbital ethmoid cell	7(5.4)	10(7.8)	5(3.9)	22(17.1)
Maxillary sinus septation	9(7.O)	5(3.9)	4(3.1)	18(14.0)
UP atelectasis	10(7.8)	5(3.9)	1 (0.8)	16(12.5)
Onodi cell	8(6.2)	4 (3.1)	3(2.3)	15(11.6)
Paradox top turbinate	6(4.7)	-	8(6.2)	14(10.9)
Anterior clinoid recess pneumatization	4(3.1)	5(3.9)	3(2.3)	12(9.3)
Ethmomaxillary sinus	5(3.9)	3(2.3)	2(1.6)	10(7.8)
Pneumatized lower turbinate	-	-	2(1.6)	2(1.6)

Septal deviation was the most common anatomic variation. Deviation to the right was detected in 38% of our cases and to the left in 33.3%.

Concha bullosa was the second most common variation. Concha bullosa was detected in 78 (60.5%) patients, it was unilateral in 24.8% and bilateral in 35.7%. We divided the concha bullosas into 3 groups as lamellar, bulbous and extensive types. (Table II) (Figure 1)

Table2. Distribution of Concha Bullosa Types

Concha bullosa	Right n(%)	Left n(%)	Totaln(%)
Lamellerkonkabülloza	42(32.6)	44(34.1)	86(66.7)
Bullous concha bullosa	4(3.1)	6(4.7)	10(7.8)
Extensive concha bullosa	16(12.4)	12(9.3)	28(21.7)
Total	62	62	124

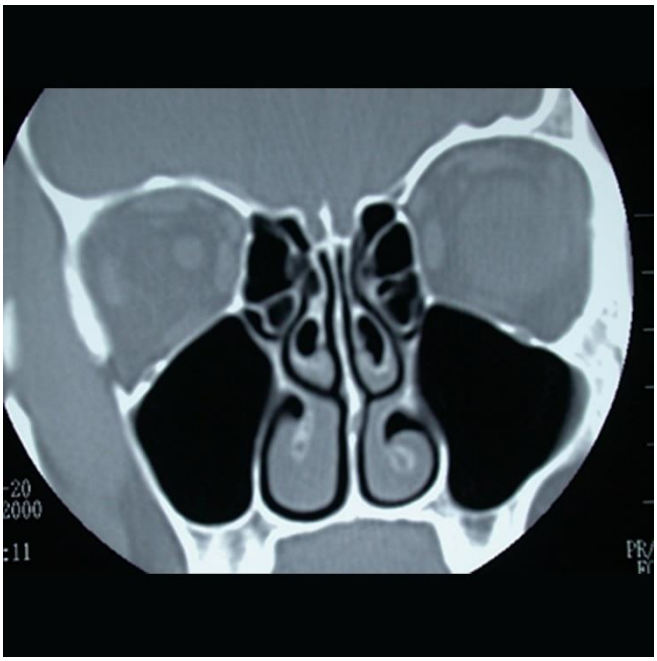

Figure 1.CT view of Bilateral Bullous Type Concha Bullosa

Aggernazi cells were seen in 59 (45.7%) cases. It was unilateral in 16.3% of the cases and bilateral in 29.5%. (Figure 2) Paradox middle turbinate was detected in 41 (31.7%) cases in 129 cases included in our study, and it was unilateral in 23.2% and bilateral in 8.5%.

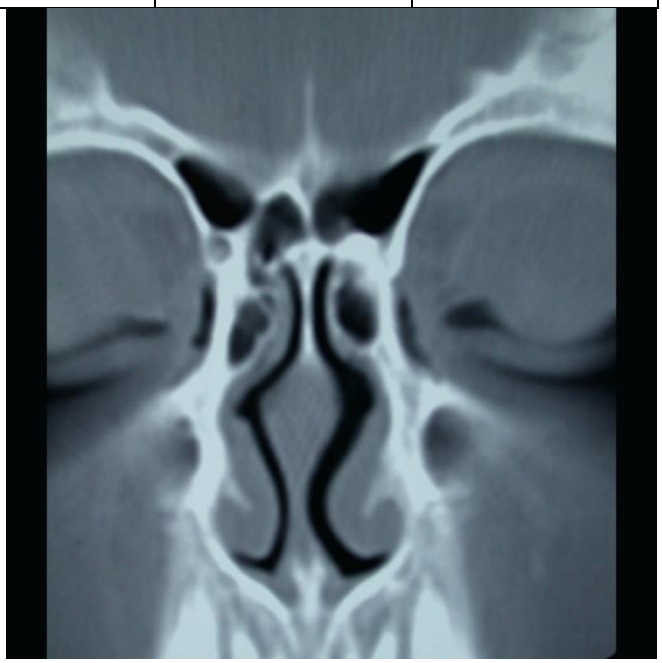

Figure2. Bilateral Agger Nazi Cell

Haller cell was found in 31 (24%) cases, 7% bilateral and 17.1% unilateral. (Figure 3) Onodi cell was found in 15 (11.6%) cases and it was detected as bilateral in 2.3% and unilateral in 9.3%.

Figure3. Haller Cell on the Left

UP pneumatization was detected in 27 (21%) patients, it was found to be bilateral in 6.2% and unilateral in 14.8%. Pneumatized superior turbinate was observed in 34 (26.4%) patients, 7.8% were bilateral and 18.6% were unilateral. (Figure 4) Maxillary sinus hypoplasia was found in 30 (23.3%) patients. Of these, 7% were bilateral and 16.3% unilateral. Paradoxical superior turbinate was observed in 14 (10.9%) patients, of which 16.2% were bilateral and 4.7% unilateral. UP aplasia was present in 16 (12.5%) patients. It was bilateral in 0.8% of the cases and unilateral in 11.7%.

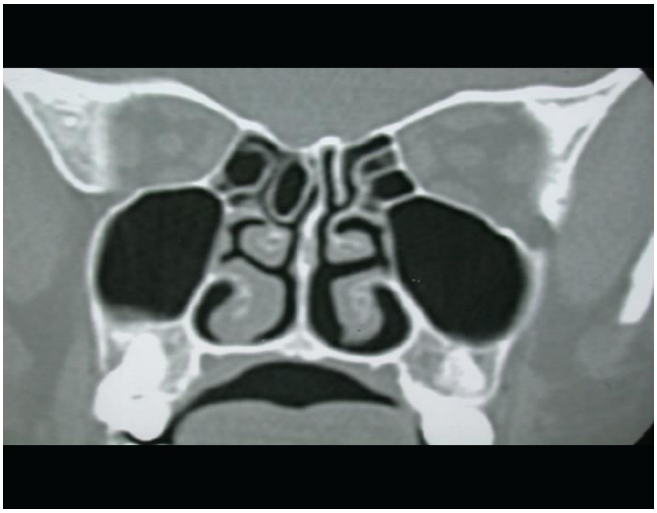

Figure4. Pneumotized Superior Turbinate on the Right

All of the cases with UP aplasia were accompanied by maxillary sinus hypoplasia. Ethmomaxillary sinus was seen in 10 (7.8%) patients. 1.6% were bilateral and 6.2% were unilateral. In nine of our cases with ethmomaxillary sinus, ipsilateral maxillary sinus volume was observed to be decreased. At the same time, ipsilateral superior meatus was observed to be wider than normal in all of our cases with ethmomaxillary sinus. Pneumatized lower turbinate was seen in 2 (1.6%) patients. Both cases were bilateral. Pterigoid recess pneumatization was observed in 26 (20.2%) patients, of which 6.2% were bilateral and 14% were unilateral. Supraorbital ethmoid cell was seen in 22 (17.1%) patients. It was detected bilaterally in 3.9% of the cases and unilaterally in 13.2%.

Discussion

The sinonasal region is one of the regions where anatomical variations are most common. Comprehension of the variations, pathologies and relationships in this region is essential for correct diagnosis and treatment. Endoscopic evaluation provides detailed preoperative information regarding morphology and pathology, together with proper radiological visualization of small structures in the paranasal region, and leads to a dramatic reduction in morbidity in patients (4,7,8).

Aggernazi cells are generally accepted as cells formed as a result of the extension of anterior ethmoidal cells to the lacrimal bone, which placed below the frontal sinus, in front of the attachment of the middle turbinate to the lateral nasal wall and in the lower-lateral aspect of the lacrimal sinus. It is suggested that it causes frontal sinus disease by disrupting frontal sinus drainage (9,10). Sivaslı et al 15% and Palabiyik reported an incidence of 4.8% in the pediatric group (1,3). In our study, we found Aggernazi cells with a

rate of 45.7%. The incidence of this cell in the adult age group has been reported to be 3–98.5% (11,12). The reported incidence differences may be related to the degree of identification and pneumatization of these cells.

One of the most frequently encountered anatomical variations in our study was concha bullosa. Although it is stated that this may be an etiological factor in recurrent sinusitis, there are studies that did not find a relationship between concha bullosa and the development of maxillary sinusitis (11,12,13). Milczuk 9.6%, Lusk 10%, Aydın 26%, April 24% and Sivaslı reported 58% concha bullosa rates in their study (1,5,6,14,15). We included bullous, lamellar and extensive type concha bullosas as classified by Bolger. We considered all degree of pneumatization significant. We detected concha bullosa in 60.5% of our case group. Of these, 24.8% were unilateral and 35.7% were bilateral. In present study group, we found the lamellar type as the most common type of concha bullosa with a rate of 66.7%. This was followed by extensive type concha bullosa with 21.7% and bulbous type concha bullosa with 7.8%.

Apart from the middle turbinate, pneumatization of the upper and lower turbinates is also encountered. In our study, we detected lower turbinate pneumatization in 2 (1.6%) cases. Both have had bilateral lower turbinate pneumatizations.

In our study, we found the incidence of upper turbinate pneumatization to be 26.4%. We found bilateral upper turbinate pneumatization in 7.8% of our cases and unilateral in 18.6%.

Paradoxical middle turbinate is the convexity of the middle turbinate laterally rather than medially (9,12,14). We found this variation at a rate of 31.8%. It was unilateral in 23.2% of our cases and bilateral in 8.5%. In the literature, the frequency of paradoxical middle turbinate has been reported as 4%-23% in cases with pediatric sinusitis.

Haller's cell is a cell which belonging to the anterior ethmoid cell group and associated with the orbital floor. It is a clinically significant variation. It is thought that this cell is effective in the development of sinusitis by narrowing the infundibulum and maxillary sinus ostium. In addition, the presence of Haller cells may increase the risk of orbital injury during ethmoidectomy (16). The incidence of this variation in the pediatric group was found in previous studies as Milczuk 5.3%, Lusk 10%, April 18%, Aydın 6%, Palabiyik 10% and Sivaslı 30% (1,3,5,6,14,17). We found this variation at a rate of 24% in our study.

Onodi cell is an excessive lateral pneumatization of the posterior ethmoid air cell beyond the sphenoid sinus. The optic nerve is at risk in the presence of sphenoethmoid or Onodi cells during FESC. It is very important to specify in the radiological evaluation in order to prevent possible complications (3,16). The prevalence of Onodi cell ranges from 1.3-42%, in our study it was 11.6% (1,19).

Maxillary sinus hypoplasia is an uncommon condition and may be primary developmental or secondary such as surgery or trauma (1). Since our cases did not have a history of surgery or trauma, we think that the rate of maxillary sinus hypoplasia found in this study will represent the prevalence of all pediatric patients. We found maxillary sinus hypoplasia in 23.3% of our cases. It was unilateral in 16.3% of our cases and bilateral in 7%. Lusk 6.9%, April 7%, Milczuk 17.5% and Sivaslı 4% maxillary sinus hypoplasia reported. Bolger reported this rate as 10.4% in adult cases (1,5,6,12,14).

It has been suggested that the hypoplastic maxillary sinus is more prone to infection, and that UP malformations are more common with hypoplastic

maxillary sinus. Milczuk found that the UP was laterally deviated in 11 (55%) of 20 patients with maxillary sinus hypoplasia (5). UP adheres to the inferomedialorbita, causing narrowing of the infundibulum and is called atelectatic uncinate. This condition is often characterized by an ipsilateral hypoplastic maxillary sinus (20). In our study group, 12.4% of UP aplasia was detected. Of these, 0.8% were bilateral and 11.7% were unilateral. Considering that UP is used as an anatomical marker during FESC, not detecting the presence of hypoplasia or aplasia before the operation increases the possibility of orbital medial wall damage and orbital penetration (1,5,6,14).

The septation of the maxillary sinus extends from the infraorbital canal to the lateral wall of the sinus. If this sinus is not recognized on preoperative CT, only the medial maxillary sinus is drained, resulting in untreated persistent disease of the sinus. We found maxillary sinus septation with a rate of 14% in our study group, 10.9% of the cases were unilateral and 3.1% were bilateral.

Septum deviation is a shift of the nasal septa to the right or left. It is the most common variation. Severe septal deviations may cause compression of the middle turbinate and obstruction of the middle meatus, leading to infection (3,11,16). Septum deviation has been reported between 4 and 96.9% in the literature. We found septum deviation as the most common anatomic variation with a rate of 72.9%. Bolger 18.8%, Palabiyik 53%, Calhoun 40% incidence rate reported (3,12,18). April reported the rate of septal deviation in children as 13% and stated that septal deviation is less common in children, and therefore concluded that the septal defect is acquired (14). Contrary to April's statement, we found the rate of septal deviation to be high in our study.

Pneumatization of the UP is called "uncinate bulla". It has been suggested that pneumatized UP is associated with osteomeatal obstruction (12,16,21,24). It has been reported between 0.4% and 6% in the literature. Bolger et al 2.5%, Arslan et al 2% reported UP pneumatization (12,22). Lusk did not detect uncinate bullae in his study on 115 patients in the pediatric age group (6). In our study, we found the rate of uncinate bulla to be 20.9%.

Ethmomaxillary sinus is a rare anomaly located in the posterior-superior part of the maxillary sinuses and characterized by the expansion of one of the posterior ethmoidal air cells into the maxillary sinus. Shirikci reported 2% ethmomaxillary sinus (23). In present study, we found this rate to be 7.8%. In our study group, the ethmomaxillary sinus was 6.2% unilateral and 1.6% bilateral. We think that the 2% rate does not reflect the true frequency of the ethmomaxillary sinus, since other studies only included patients with the disease. We express that our rate reflects the true incidence of the ethmomaxillary sinus, as our study group included patients with and without the disease.

When neurosurgery is performed in the anterior cranial fossa, the presence of supra-orbital ethmoid cells in the operation area may impair sterility and cause nasal inflammatory pathology. Arslan et al. reported this variation rate as 6%. In our study, the rate of supraorbital ethmoid cells was found 17.1% (22).

The groove formed by the cribriform plate on both sides of the crista Galli and in which the olfactory bulb is located is called the olfactory fossa. When the depth of the olfactory fossa is unrevealed, it becomes an extremely risky area for intracranial penetration during FESC. The cribroform plate-ethmoid roof height relationship is divided into 3 types by the Keros classification. In type I, the olfactory fossa is flat. In type II, the lateral lamella is higher, the fovea ethmoidalis is higher, and the olfactory fossa is deeper. In type III, the ethmoid roof is higher than the lamina cribrosa, the lateral lamella is slightly longer

and thinner, and the olfactory fossa is deeper. In the previous studies, it has been reported that the lowest measurement as 0 mm and the highest measurement as 17 mm. Since perforation is possible in the lateral lamella of the lamina cribrosa, type III is the most dangerous for the surgeon (10,24,25). Arslan et al found the level difference as 2-14 mm (mean 8 mm) on the right and 3-16 mm (mean 9.5 mm) on the left (22). In present study, we found the level difference as 1-9 mm (mean 3.8 mm) on the right and 1-10 mm (mean 4.3 mm) on the left.

Pneumatization of structures such as pterygoid recess, anterior clinoid process, septum and crista Galli are anatomical variations that cannot be expressed in the etiology of sinusitis and should be evaluated in routine tomography examinations. Detection of these preoperatively may provide advantages during endoscopic intranasal surgery. In our study, pterygoid recess pneumatization was observed with a rate of 20.2%. Bolger reported 43.6% and Arslan 16% (12, 22).

When crista Galli become pneumatized, it is associated with the frontal recess. Pneumatization of crista Galli gains importance in determining the dissection margins during surgery of the parasphenoidal and skull base region (9,10,12,24). In our study, we found crista Galli pneumatization at a rate of 3.1%. Arslan et al. reported this rate as 24% (22).

The optic nerve is associated with the lateral nasal wall, which is close to the cells at the apex. The anterior clinoid recess become pneumatized and surrounds the optic nerve. The bone wall of the clinoid recess is thinner than 0.5 mm and separates the nerve from the cavity. This condition is often pronounced tomographically as a defect. Similar to crista Galli, the pneumatization of the anterior clinoid process is also important in determining the dissection margins during parasphenoidal and skull base surgery (10,12,22,26). In our study, we found anterior clinoid recess pneumatization to be 9.3%. Bolger found this to be 13.3% in all patients. Arslan determined it as 6%. Şirikçi reported 29.3% (12,22,26).

If the septum pneumatization reaches a sufficient size, it may make endoscopic examination of this region impossible. When the posterior superior nasal septum is pneumatized, it always drains into the sphenoid sinus. Palabiyik reported this variation as 21.3% in children (3). In our study, we found septum pneumatization to be 24%. In all of our cases, septum pneumatization was observed to drain into the sphenoid sinus.

Deviated UP is a curving of the UP laterally or medially. It narrows the entrance to the meatus when it deviates medially, and the infundibulum when it deviates laterally. In the literature, deviated uncinate prominence has been reported as 5%-31% in symptomatic patients and 16% in asymptomatic patients. In our cases, we considered the deviation of the UP as right and left sides. Accordingly, we found the deviation of the UP on the right as 38%, and on the left as 43.4%. We found medial deviation to be 17.8% on the right and 28.7% on the left. We detected lateral deviation as 11.6% on the right and 10.9% on the left.

Protrusion of orbital contents into the ethmoid sinus is rare and occurs due to congenital, traumatic, or iatrogenic defects in lamina papiresea. No lamina papiresea defect was detected in our series.

In our study group, the incidence of paradox superior turbinate was found to be 10.9%. 6.2% of them were bilateral and 4.7% unilateral, and unilateral ones were observed only on the right side.

The age groups of the cases in this study were between 4 and 18 years of age, and the study group included individuals with and without sinonasal disease

who underwent coronal paranasal sinus CT. The most common anatomical variations in the present study were septal deviation, concha bullosa, and Aggernazi cell. There was no significant difference between the rates of anatomical variation in the bone structure we found in pediatric cases and the anatomical variation rates reported in the previous studies for the pediatric and adult groups. In our opinion, anatomical variations do not contribute to sinus infection. Local, systemic or environmental factors seem to be more important in pediatric sinusitis.

In conclusion, well identification and reporting of anatomical variations is very important in terms of clarification of sinonasal complaints as well as directing the surgeon's approach in FESC and preventing complications. Complications are more common in the pediatric age group than in adults.

Conflict of interest

The authors declare that there is no conflict of interest.

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