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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Radiological Correlation Between Ethmoid Roof Asymmetry and Variations of Nasal Turbinates

Etmoid Çatı Asimetrisi ile Burun Türbinatlarının Varyasyonları Arasındaki Radyolojik İlişki

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ABSTRACT

Introduction: Etmoid roof and nasal turbinates have many anatomic variations that are important during endoscopic sinus surgery (ESS). During ESS, nasal turbinates that act as anatomical markers can be intervened at the beginning of the surgery. Anatomical knowledge of variations and their relationships increases the success of surgery by reducing complications. In this study, we assess the relation of skull base asymmetry with variations of nasal turbinates.

Material and Method: Paranasal sinus tomography images of 124 patients [(64 (62%) females and 60 (48%) males] were retrospectively analyzed. Statistical analysis of variations of nasal turbinates (middle, superior, supreme turbinate and accessory, secondary turbinate) has been made in conjunction with measurements of the bilateral lateral lamella of the cribriform plate (LLCP).

Results: In the existence of bilateral bullous middle turbinate (BMT), unilateral accessory middle turbinate (AMT), bilateral secondary middle turbinate (SeMT), bilateral superior concha bullosa (SCB), unilateral and bilateral supreme turbinate (SuprT), mean of difference of right LLCP (RLLCP) and left LLCP (LLLCP) is statistically significant ($p<0.05$). It is determined that the vertical diameter of the superior turbinate was correlated with the vertical diameter of contralateral superior turbinate, as well as the LLCP of the ipsilateral and contralateral side ($p<0.05$).

Conclusion: This study suggests bilateral BMT, unilateral AMT, bilateral SeMT, bilateral SCB, unilateral and bilateral SuprT should be carefully evaluated in the presence of anterior skull base asymmetry in order not to experience complications during ESC.

Keywords: Computed tomography, skull base, accessory turbinate, anatomic variation

ÖZ

Giriş: Etmoid çatı ve burun konkaları endoskopik sinüs cerrahisi (ESC) sırasında öneme sahip birçok varyasyona sahiptir. ESC sırasında, anatomik belirteç görevi gören burun konkalarına ameliyatın başlangıcında müdahale edilebilir. Anatomik varyasyonların ve birbirleri ile olan ilişkilerinin bilinmesi komplikasyonları azaltarak cerrahinin başarısını arttırır. Bu çalışmada, konka varyasyonları ile kafa tabanı asimetrisinin ilişkisini değerlendirdik.

Gereç ve Yöntem: 124 hastanın [(64 (%62) kadın ve 60 (%48) erkek] paranazal sinüs tomografi görüntüleri retrospektif olarak incelendi. Lateral nazal duvar (orta, üst, yüksek (supreme) konka ve aksesuar ve sekonder konka) varyasyonlarının istatistiksel analizi yapıldı. İki taraflı kribriform plakanın lateral lamellerinin (LLCP) ölçümleri yapılmıştır ve birbirleri ve konka varyasyonları ile ilişkileri analiz edilmiştir.

Bulgular: Bilateral büllöz orta konka (BMT), unilateral aksesuar orta konka (AMT), bilateral sekonder orta konka (SeMT), bilateral superior konka bülloza (SCB), unilateral ve bilateral yüksek konka (SuprT) varlığında, sağ LLCP (RLLCP) ve sol LLCP (LLLCP) fark ortalamaları istatistiksel olarak anlamlıdır ($p<0.05$). Üst konkanın dikey çapının karşı taraf üst konkanın dikey çapı ve ayrıca aynı taraf ve karşı tarafın LLCP'si ile korrele olduğu saptandı ($p<0.05$).

Sonuç: Bu çalışma, ESC sırasında komplikasyon yaşamamak için bilateral BMT, unilateral AMT, bilateral SeMT, bilateral SCB, unilateral ve bilateral SuprT'nin ön kafa tabanı asimetrisi varlığında dikkatle değerlendirilmesi gerektiğini düşündürmektedir.

Anahtar kelimeler: Bilgisayarlı tomografi, kafa tabanı, aksesuar konka, anatomik varyasyon

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INTRODUCTION

Endoscopic sinus surgery (ESS), has been widely used in operations in sinonasal pathologies (chronic rhinosinusitis, nasal polyposis, antrochoanal polyps, malign sinonasal tumors, sinus mucoceles, orbital decompression, cerebrospinal leak closure, choanal atresia repair, dacryocystorhinostomy, and in control of epistaxis) since 1985. Anterior skull base variations like anomalies of the asymmetrical skull base, dehiscences predisposing to potential terrible complications such as brain injury, CSF rhinorrhea, recurrent meningitis, and vision loss (2).Preoperative tomographic evaluation gains importance in detecting these variations(3).

Cribriform plate and ethmoid roof form ethmoid skull base which is in the middle of the anterior skull base (4). The ethmoid roof is formed by the fovea ethmoidalis (FE) which is the medial part of the orbital frontal bone. Cribriform plate and ethmoid roof meet at the lateral lamella of cribriform plate (LLCP), a very weak area predisposing to iatrogenic skull base injuries during ESS. LLCP is also the lateral boundary of the olfactory fossa (OF) and its medial site is formed by crista galli, the bottom is formed by medial lamella of cribriform plate (5,6). Keros in 1962 classified OF into three groups based on the length of the LLCP and determined the iatrogenic risk during surgical manipulations in the ethmoidal region (6-8)

FE, OF, LLCP, and course of the ethmoid artery are necessary in the evaluation of anterior skull base variations before ESS to avoid complications (9). In the analysis of anteriorskull base asymmetry by Adeel, he stated that Adeel,Lebowitz, and Alazzawi found ethmoid asymmetry according to FE measurements in 10%, 9,5%, and 93% respectively (10).Keros investigated the skull base according to lateral lamella height (10). In his study of 450 skulls, he found Keros 1 in 11,59%, type 2 53%, type 3 18,25% of cases (8,10). We see many articles about skull base asymmetries and the coexistence of paranasal sinus variations and clinical situations in the literature. Damar et al. studied LLCP height for studying the asymmetry of the skull base and found no relation to the severity of nasal septal deviation (11). Kayabaşı et al. in their study observed that the mean heights of LLCP of hypoplastic and aplastic frontal sinuses were significantly greater than those of the normal control group (12). Kızılkaya et al. investigated handedness discrepancies in the height of right and left ethmoid roofs and he observed lower ethmoid roofs on the right side among right-handers, also found the lower ethmoid roof was on the left side among left-handers, predominantly (13).

Furthermore, in the literature,relationship of ethmoid roof asymmetry with frontal sinus pneumatization (14), concha bullosa (15), length of the middle turbinate (16), and septal deviation (17) have been investigated. However, to the best of our knowledge, relationship between cribriform plate asymmetry and SeMT, AMT, superior and SuprT has not been examined. The purpose of this study is to investigate whether the presence of SeMT, AMT, superior, and SuprT point out a skull base asymmetry.

In the literature, the relationship of ethmoid roof asymmetry with frontal sinus pneumatization (14), concha bullosa (15), length of the middle turbinate (16), and septal deviation (17) have been investigated. However, to the best of our knowledge, the relationship between cribriform plate asymmetry and SeMT, AMT, superior, and SuprT has not been examined. This study investigates whether SeMT, AMT, superior turbinate, and SuprT besides middle turbinate point out a skull base asymmetry.

MATERIAL AND METHOD

This retrospective study was performed in a digital radiology database of the paranasal sinus CT scans obtained from January 01, 2021, to December 31, 2021. This study was carried out under the

ethical principles stated in the Declaration of Helsinki. And, it was approved by the Ethical Committee of noninvasive Clinical Research of the Mardin Artuklu University (Date: Oct 11,2021 and numbered:2021/2). All patients were referred for CT scans owing to clinical symptoms probably related to sinonasal disorders, such as nasal obstruction, anosmia, facial pain, etc. Previous trauma and surgery, sinonasal tumor, sinonasal polyposis, notable rhinosinusitis (defined as inflammatory changes that prevented visualization of nasal structures, and anterior ethmoid roof), cerebrospinal fluid leak marked facial deformity, rotated or tilted scans, and age less than 18 years old were the exclusion criteria.

FE, OF, LLCP, and course of the ethmoid artery are necessary for the evaluation of anterior skull base variations before FESS to avoid complications (9). In the analysis of anterior skull base asymmetry by Adeel, it is stated that Adeel, Lebowitz, Alazzawi had used FE and found ethmoid asymmetry in 10%, 9,5% and 93% respectively (10). All patients underwent axial CT scan (tube voltage, kV 120-130; 80–150 mA; field of view, 140 mm; high resolution, 0.625-mm contiguous axial slice) obtained using a General Electric IQ™ 32-Detector Spiral MSCT device. The evaluation was performed using RadiAnt DICOM Viewer 2020.2 (64-bit) version on axial, coronal, and sagittal reconstructed images.

The bone window was used in interpreting the scans. The coronal CT scan with the visualization of the infraorbital nerve was chosen to measure the parameters. The following anatomical parameters were identified and used for measurements (**Figure 1**) (15). The Software's ruler tool was used for linear measurements (in millimeters). RLFE: Right fovea ethmoidal length, LLFE: Left fovea ethmoidal length, RLMCP: Right medial cribriform plate length (the horizontal length of the base of olfactory fossa), LLMCP: Left medial cribriform plate length, RLLCP: Right LLCP (vertical length of olfactory fossa), LLLCP: Left length of LLCP is measured (**Figure 1**).

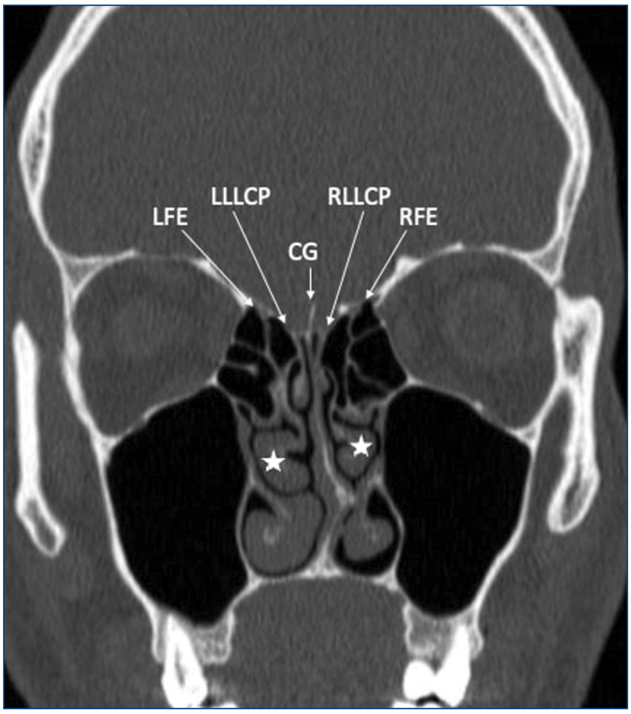

Figure 1. Coronal reformatted image. Bilateral paradoxical middle turbinate (white asterisces), crista Galli (CG), left lateral lamella of cribriform plate (LLLCP), right lateral lamella of cribriform plate (RLLCP), left fovea ethmoidalis (LFE), right fovea ethmoidalis (RFE).

Roof asymmetry: Roof asymmetry was assessed by comparing the difference in height of LLCP on two sides. The difference in the height of right and left sides >2mm was accepted roof asymmetry .<2mm was accepted as the symmetric roof (9).

Pneumatized (bullous) middle turbinate (BMT), paradoxical middle turbinate (PMT) were assessed on coronal, axial, and sagittal planes (16). Accessory middle turbinate (AMT) secondary middle turbinate (SeMT) and bullous secondary middle turbinate (BSeMT) was also evaluated on coronal, axial, and sagittal planes.

Due to the irregular margins and small size of the bullous superior turbinate, measurement in exact dimensions was difficult. Therefore, the vertical and horizontal dimensions of the pneumatised part were measured to evaluate the size. Because of the the horizontal and vertical diameters of the superior pneumatized turbinate are nearly alike, only vertical diameter was taken. The diameter of the superior turbinate is recorded as RSTvertical on the right side and LSTvertical on the left side. The presence of superior bullous concha was recorded as SCB.

Supreme turbinate (SuprT): If SuprT were present, it was registered as present or absent on coronal, sagittal, and axial planes. Both Zuckerkandl and Santorini conchas were registered as SuprT without making a distinction. Bullous SuprT (BSuprT) was also recorded.

In order To see the relation between the presence of lateral nasal wall variations and skull base asymmetry, change of right and left LLCP measurements were analyzed.

Statistical Analysis

For statistical analysis, SPSS 22.0 trial program for Windows was used. In descriptive statistics, the number, percentage for categorical variables, and mean, standard deviation, minimum, and maximum for numerical variables were given. Kolmogorov-Smirnov test was used to examine the normality of quantitative data. Paired sample t-test was used between groups. Paired sample test was used for the comparison of numerical variables in two independent groups since a normal distribution condition was obtained. Correlation analysis was made among measurements of the ethmoid roof and superior turbinate diameter. Chi-square analysis was used for gender and side comparisons. The statistical significance level was accepted as $p < 0.05$.

RESULTS

CT scans of 124 patients were included in this study. The ages of the patients ranged from 18 to 83 with a mean±SD; of 34,09± 15,9. There were 64 (62%) females and 60 (48%) males. Distribution of measurements, ethmoid roof and right and left superior turbinate was given in **Table 1**.

Table 1. Measurements of ethmoid roof and superior turbinate (right and left)

	n	Mean (mm)	Std. Dev. (mm)	Min (mm)	Max (mm)
RLFE	124	8.9484	1.52275	6.00	13.60
LLFE	124	8.7653	1.59165	4.90	14.30
RLMCP	124	4.4669	.86727	2.60	8.70
LLMCP	124	4.4107	.91550	2.30	8.70
RSTvertikal	124	15.9573	3.46912	7.50	24.00
LSTvertikal	124	15.6242	3.24597	8.00	24.00
RLLCP	124	5.2016	1.49127	2.00	10.00
LLLCP	124	4.8613	1.39719	1.40	9.40

RLFE: Right fovea ethmoidalis, LLFE: Left fovea ethmoidalis, RLMCP: Right medial cribriform plate length, LLMCP: Left medial cribriform plate length, RSTvertical: Right superior turbinate vertical diameter, LSTvertical: Left superior turbinate vertical diameter, RLLCP: Right lateral lamella of cribriform plate length, LLLCP: Left lateral lamella of cribriform plate length.

RLFE, LLFE, RLMCP, LLMCP, RSTvertical, LSTvertical, RLLCP and LLLCP measurements were normally distributed ($p>0.05$). Although, RLLCP (mean±SD; 5,20±1,49) is higher than the left side (mean±SD; 4,86±1,39), andmeasurements of RLLCP and LLLCP were found to be statistically alike ($p<0.05$). The difference between the means of RLLCP and LLLCP parameters is 0,340 a statistically significant value (p=0.000 mean of difference). There is a positive correlation between RLLCP and LLLCP variables, and a correlation coefficient of r=0,784 is a statistically significant value. Change in RLLCP parameter affects the LLLCP parameter at 62%.

Although, no significant difference was found between the right and left LLCP in women and men, the mean of men was found to be higher than the mean of women (p>0.05). The mean of right LLCP was found to be statistically significantly higher (p<0.05) (**Table 2**) Middle turbinate anatomic variations according to symmetry/asymmetry of ethmoid roof and differences of LLCP were analyzed (**Table 3**). None of the parameters were found to be associated with asymmetry of the ethmoid roof (p>0.05). None of the parameters were found to be associated with the asymmetry of the ethmoid roof (p>0.05). According to paired sample t-test; the mean differences of LLCP, in patients without unilateral/bilateral BMT, unilateral/bilateral PMT (**Figure 1**), unilateral/bilateral AMT (**Figure 2**), unilateral/bilateral SeMT, unilateral/bilateral bullous SeMT were statistically significant (p<0.05). In patients with bilateral BMT, unilateral AMT, and bilateral SeMT significant relation was found in the mean difference of LLCP (p<0.05).

Table 2. Distribution of length of LLCP by gender and side.

		n	Mean±SD (mm)	t	p
Gender					
Female	RLLCP LLLCP	64	5.1109±1.41333 4.7891±1.35120	2.916	.005
Male	RLLCP LLLCP	60	5.2983±1.57636 4.9383±1.45207	2.706	.009
Side					
	RLLCP LLLCP	124 124	5.2016±1.49127 4.8613±1.39719	3.975	0.000

RLLCP: Right lateral lamella of cribriform plate length, LLLCP: Left lateral lamella of cribriform plate length. **lines that make up the statistical difference (p<0.05), t value: is found when degree of freedom and confidence level is known in the statistical table and gives an idea about effect size (Cohen's d).

Table 3. Distributions of middle turbinate anatomic variations according to symmetry/asymmetry of ethmoid roof.

		n	Mean±SD	t	p	symmetry	asymmetry	p"
Unilateral BMT	+	32	5.5531±1.57909 5.3000±1.37278	1.567	.127	29 (23.4%)	3 (2.4%)	0.55
	-	92	5.0793±1.44842 4.7087±1.38037	3.666	.000**	82 (66.1%)	10 (8.1%)	
Bilateral BMT	+	58	5.0914±1.37360 4.7052±1.28451	3.538	.001**	53 (42.7%)	5 (4%)	0.369
	-	66	5.2985±1.59166 4.9985±1.48536	2.312	.024**	58 (46.8%)	8 (6.5%)	
Unilateral PMT	+	9	5.4889±.58129 5.5444±1.46553	-.280	.787	9 (7.3%)	0 (0%)	0.356
	-	115	5.1791±1.47616 4.8078±1.38413	4.101	.000**	102 (82.3%)	13 (10.5%)	
Bilateral PMT	+	6	4.5667±2.70160 4.8333±2.21871	-.684	.524	5 (4%)	1 (0.8%)	0.61
	-	118	5.2339±1.41574 4.8627±1.35715	4.257	.000**	106 (85.5%)	12 (9.7%)	
Unilateral AMT	+	19	5.4105±1.64042 4.8211±1.77093	3.526	.002**	17 (13.7%)	2 (1.6%)	0.99
	-	105	5.1638±1.46800 4.8686±1.32877	3.072	.003**	94 (75.8%)	11 (8.9%)	
Bilateral AMT	+	19	5.7211±1.35834 5.3368±1.01883	1.361	.190	17	2	0.99
	-	105	5.1076±1.50088 4.7752±1.44234	3.778	.000**	94	11	
Unilateral BSeMT	+	13	4.9154±1.99284 4.9692±1.71968	-.203	.843	11 (8.9%)	2 (1.6%)	0.54
	-	111	5.2351±1.42922 4.8486±1.36334	4.302	.000**	100 (80.6%)	11 (8.9%)	
Bilateral BSeMT	+	14	4.9929±1.48917 5.0571±1.58051	-.420	.682	14 (11.3%)	0 (0%)	0.17
	-	110	5.2282±1.49624 4.8364±1.37819	4.188	.000**	97 (78.2%)	13 (10.5%)	
Unilateral SeMT	+	29	5.0207±1.83875 4.9517±1.67089	.379	.708	26 (21%)	3 (2.4%)	0.97
	-	95	5.2568±1.37467 4.8337±1.31129	4.413	.000**	85 (68.5%)	10 (8.1%)	
Bilateral SeMT	+	41	5.1976±1.38969 4.8341±1.24129	2.306	.026**	37 (29.8%)	4 (3.2%)	0.85
	-	83	5.2036±1.54718 4.8747±1.47515	3.219	.002**	74 (59.7%)	9 (7.3%)	

BMT: Bullous middle turbinate, PMT: Paradoxical middle turbinate, AMT: Accessory middle turbinate, BSeMT: Bullous secondary middle turbinate, SeMT: Secondary middle turbinate, **lines that make up the statistical difference (p<0.05), p Independent t-test, p"Chi-square test
t value: is found when degree of freedom and confidence level is known in statistical table and gives idea about effect size(Cohen's d).

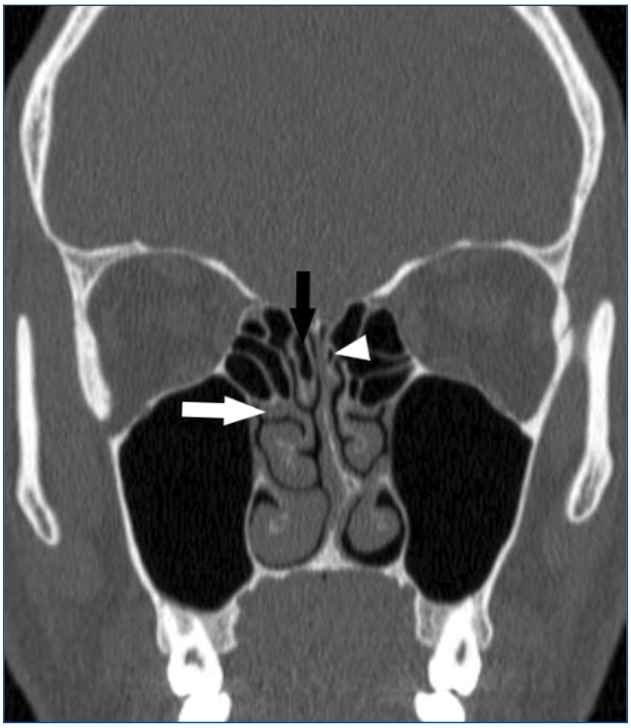

Figure 2. Coronal reformatted image. Right accessory middle turbinate (white arrow), right pneumatized superior turbinate (black arrow), left pneumatized superior turbinate (white arrowhead).

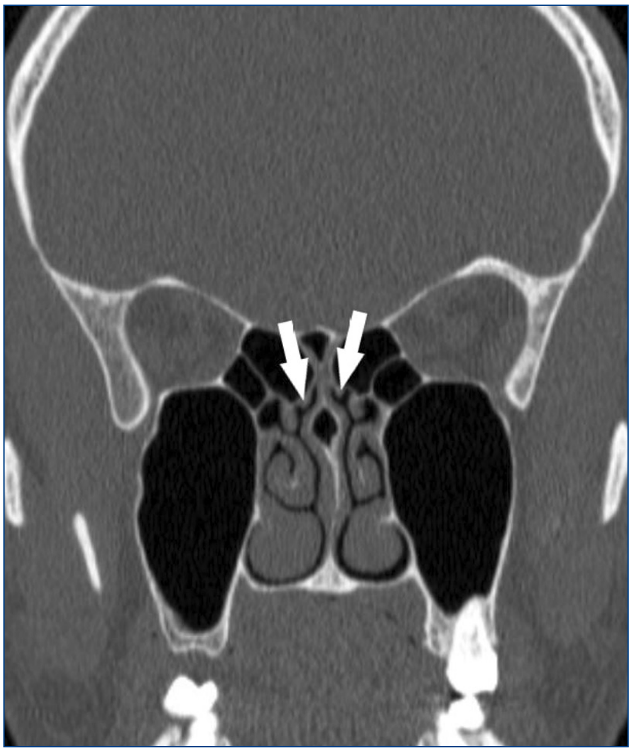

Figure 3. Coronal reformatted image. Bilateral supreme conchae (white arrow).

The presence and bullosity of superior and supreme turbinate were evaluated and their relation to symmetry/asymmetry of the ethmoid roof and mean of difference of LLCP were analyzed (**Figure 2**), (**Table 4**). None of the parameters were found to be associated if there is asymmetry or not (p>0.05). According to the mean of difference of LLCP, patients without; unilateral/bilateral SCB, and bilateral SuprT (**Figure 3**), unilateral/bilateral bullous SuprT were statistically significant. In patients with; bilateral SCB, bilateral SuprT was statistically significant (p<0.05) (**Table 4**).

Table 4. Superior and supreme concha and their anatomic variations with symmetry/asymmetry of the ethmoid roof

		n	Mean±SD(mm)	t	p	symmetry	asymmetry	p"
Unilateral SCB	+	19	5.0789±1.95607 5.0263±1.49177	.226	.824	15 (12.1%)	4 (3.2%)	0.10
	-	105	5.2238±1.40168 4.8314±1.38483	4.290	.000**	96 (77.4%)	9 (7.3%)	
Bilateral SCB	+	31	5.6161±1.62421 5.1581±1.65263	2.284	.030**	28 (22.6%)	3 (2.4%)	0.86
	-	93	5.0634±1.42682 4.7624±1.29606	3.241	.002**	83 (66.9%)	10 (8.1%)	
Unilateral SuprT	+	23	6.2522±1.82853 5.5217±1.74927	3.033	.006	19 (15.3%)	4 (3.2%)	0.23
	-	101	4.9624±1.29930 4.7109±1.26680	2.859	.005	92 (74.2%)	9 (7.3%)	
Bilateral SuprT	+	49	4.9878±1.36605 4.7061±1.31266	2.163	.036**	42 (33.9%)	7 (5.6%)	0.26
	-	75	5.3413±1.56076 4.9627±1.44940	3.332	.001**	69 (55.6%)	6 (4.8%)	
Unilateral BSuprT	+	7	4.6000±1.65126 4.2143±1.40882	1.113	.308	6 (4.8%)	1 (0.8%)	0.73
	-	117	5.2376±1.48119 4.9000±1.39302	3.807	.000**	105 (84.7%)	12 (9.7%)	
Bilateral BSuprT	+	2	3.6500±1.20208 3.8000±0.84853	-.600	.656	2 (1.6%)	0 (0%)	0.62
	-	122	5.2270±1.48603 4.8787±1.39984	4.014	.000**	109 (87.9%)	13 (10.5%)	

SCB: Superior concha bullosa, SuprT: Supreme turbinate, BSuprT: Bullous supreme turbinate, **lines that make up the statistical difference (p<0.05), p Independent t-test, p"Chi-square test, t value: is found when degree of freedom and confidence level is known in statistical table and gives an idea about effect size(Cohen's d).

Table 5.Correlation of measurements of ethmoid roof and superior turbinate vertical diameter									
		RLFE	**LLFE**	**RLMCP**	**LLMCP**	**RSTvertical**	**LSTvertical**	**RLLCP**	**LLLCP**
RLFE	r (correlation coefficient)	1	.816 (**)	-.223 (*)	-.190 (*)	.072	-.030	.022	.103
	p		0.000	.013	.034	.428	.744	.807	.257
	n	124	124	124	124	124	124	124	124
LLFE	Pearson Correlation	.816 (**)	1	-.154	-.370 (**)	.030	.015	-.048	.077
	Sig. (2-tailed)	.000		.087	.000	.742	.869	.597	.394
	N	124	124	124	124	124	124	124	124
RLMCP	Pearson Correlation	-.223 (*)	-.154	1	.432 (**)	.006	.019	-.014	-.030
	Sig. (2-tailed)	.013	.087		.000	.943	.832	.881	.737
	N	124	124	124	124	124	124	124	124
LLMCP	Pearson Correlation	-.190 (*)	-.370 (**)	.432 (**)	1	.104	.096	.099	-.014
	Sig. (2-tailed)	.034	.000	.000		.249	.291	.274	.876
	N	124	124	124	124	124	124	124	124
RSTvertical	Pearson Correlation	.072	.030	.006	.104	1	.895 (**)	.303 (**)	.344 (**)
	Sig. (2-tailed)	.428	.742	.943	.249		.000	.001	.000
	N	124	124	124	124	124	124	124	124
LSTvertical	Pearson Correlation	-.030	.015	.019	.096	.895 (**)	1	.291 (**)	.322 (**)
	Sig. (2-tailed)	.744	.869	.832	.291	.000		.001	.000
	N	124	124	124	124	124	124	124	124
RLLCP	Pearson Correlation	.022	-.048	-.014	.099	.303 (**)	.291 (**)	1	.784 (**)
	Sig. (2-tailed)	.807	.597	.881	.274	.001	.001		.000
	N	124	124	124	124	124	124	124	124
LLLCP	Pearson Correlation	.103	.077	-.030	-.014	.344 (**)	.322 (**)	.784 (**)	1
	Sig. (2-tailed)	.257	.394	.737	.876	.000	.000	.000	
	N	124	124	124	124	124	124	124	124

RLFE: Right fovea ethmoidalis, LLFE: Left fovea ethmoidalis, RLMCP: Right medial cribriform plate length, LLMCP: Left medial cribriform plate length, RSTvertical: Right superior turbinate vertical diameter, LSTvertical: Left superior turbinate vertical diameter, RLLCP: Right lateral lamella of cribriform plate length, LLLCP: Left lateral lamella of cribriform plate length. **lines that make up the statistical difference ($p<0.05$)

In correlation analysis in **Table 5**; correlation was seen between RSTvertical and LSTvertical (r=0,89, $p<0.05$), RLLCP (r=0,30, $p<0.05$), LLLCP (r=0,34, $p<0.05$). Correlation was observed between LSTvertical and RSTvertical (r=0,89, $p<0.05$), RLLLCP (r=0,29, $p<0.05$), LLLCP (r=0,32, $p<0.05$). For further details, see table **Table 5**.

DISCUSSION

Nasal turbinates originate from the embryological lateral nasal wall. Inferior nasal turbinate is a separate bone derived from maxilloturbinate whereas uncinate process, middle turbinate, superior turbinate, and, if exists, supreme turbinates are derived from ethmoturbinals that are the ethmoidal bone origin. In 1882, Emil Zuckerkandl described the fourth nasal ethmoidal turbinate; supreme turbinate or concha of Zuckerkandl. Nieto in 2015 described the first supreme turbinate; Santorini and the second supreme turbinate; Zuckerkandl. Santorini can be found in 95%, and Zuckerkandl can be found in 6.7% (18). Pneumatizations of turbinates, SeMT, and AMT are the other variations of lateral nasal wall. SeMT originates from middle turbinate, whereas AMT is described as a medially twisted uncinate process. Incidence of SeMT is 0,8-6,8 % (19). Turbinate pneumatization is the existence of air cells inside turbinates. (20) In this study, we studied the relation of the asymmetry of the ethmoid roof with variations of turbinates.

Middle turbinate variations are concha bullosa, paradoxical middle turbinate, accessory middle turbinate and secondary middle turbinate (21). Concha bullosa (CB) is a prevelant variation seen at 10%-50% in the population. CB affects nearby structures. Açıkalın et al. examined the relationship between unilateral CB and ethmoid roof asymmetry and found that ethmoid roof asymmetry was higher in patients with unilateralCB (15). In this study, unilateral BMT was seen at 25,5%, and bilateral BMT was seen at 46,8%. Gün et al. observed a relationship significantly between the width of the anterior ethmoid roof and the axial diameter of middle CB. In this study, in bilateral CB mean differences of LLCP between the right and the left side were statistically significant. In a study conducted by Açıkalın, a statistically significant difference was observed between the group with and without unilateral CB. Also, in the presence of unilateral accessory middle turbinate (AMT) (**Figure 4**), bilateral secondary middle turbinate (SeMT) mean of the difference between right and left LLCP is statistically significant. In the absence of unilateral/bilateral PMT (**Figure 1**), the mean difference between right and left LLCP is statistically significant. But, no significant relation was found between the groups with and without asymmetry in other variations of nasal turbinates that are examined in this study.

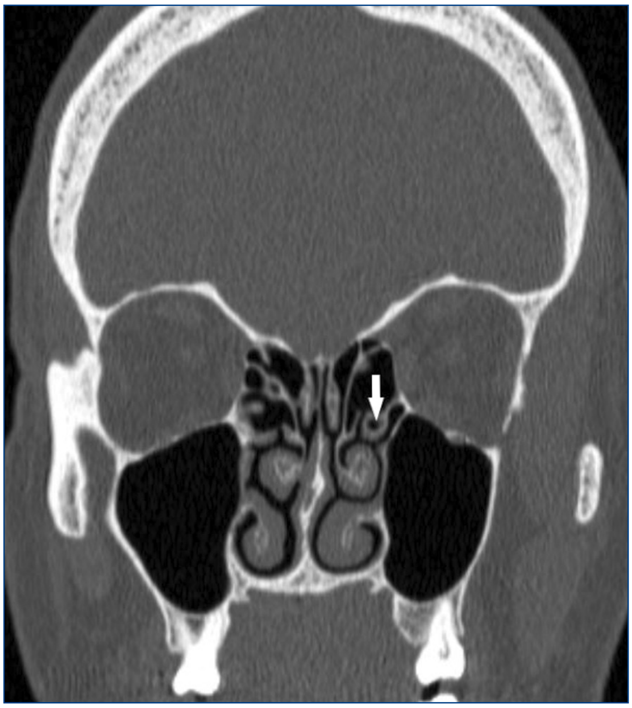

Figure 4. Coronal reformatted image. Pneumatized left accessory turbinate (white arrow).

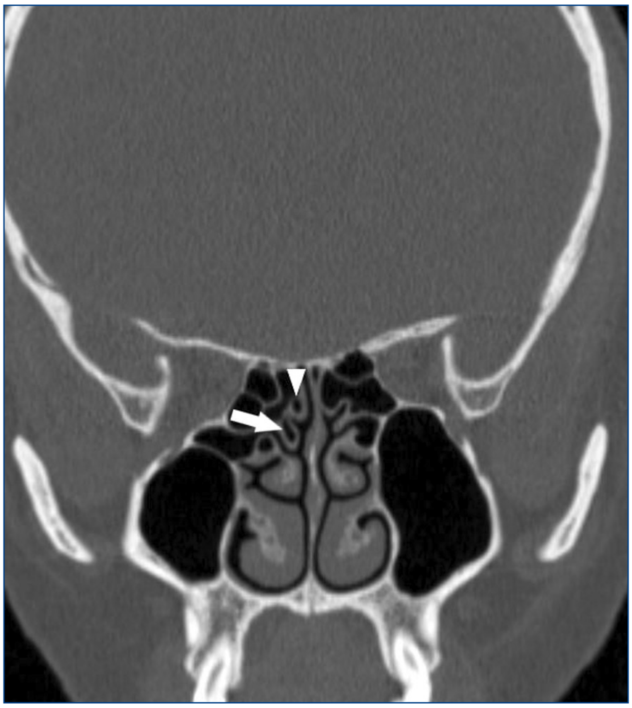

Figure 5. Coronal reformatted image. Right bullous superior turbinate (white arrow), right bullous supreme turbinate (white arrowhead).

Superior turbinate is a vantage point in endoscopic posterior ethmoidectomy and sphenoidotomy (22). Superior turbinate was identified in 100% of cases in a study by Eweiss et al. (22). Pneumatization of superior turbinate was observed at 7,1% by Kajiwara et al. (23). SCB is a quite rare abnormality and is usually seen together with the other nasal anatomic abnormalities like septum deviation, middle concha bullosa, and sinusitis. The incidence of the superior pneumatized turbinate is between 12,2-50%.

Ila et al. in their study observed 61,1% unilateral SCB and 38,9% bilateral SCB (24). In this study,unilateral SCB was seen at 15,3% and bilateral SCB was seen at 25%. In the presence of bilateral SCB, the asymmetry or difference of LLLCP is statistically significant. Bullosity in superior turbinate and asymmetry of the ethmoid roof were not related statistically. The vertical diameter of superior turbinate was found to be statistically related to the diameter of the opposite side and LLCP of the same side and opposite side in this study.

SuprT is an additional landmark besides superior turbinate when superior turbinate and middle turbinate are destroyed by tumor etc in FESS. It is located lateral to the sphenoid ostium. Its prevalence is 60-77% and may be present unilateral or bilateral (25). In this study, unilateral SuprT was seen at 18,5%, bilateral SuprT has seen at 39,5% (**Figure 5**). Bullosity of supreme turbinate 7% unilateral, 2% bilateral on CT examination. Also in the literature bullosity of supreme turbinate was present (26). In unilateral and bilateral SuprT, the mean difference between right and left LLCP was found to be statistically significant. Therefore, unilateral and bilateral SuprT points out asymmetry of the ethmoid roof.

Our study has some limitation, in some subgroups number of variations were relatively small number. More accurate results should be obtained if studied with a larger number of participants. As far as we know, it is the first study examining the correlation of ethmoid roof with turbinate variations like superior, supreme concha, and accessory and secondary turbinates. More accurate results should be obtained if studied in a larger number of cases.

CONCLUSION

Our conclusion from the study is that LLCP should be carefully evaluated in patients with turbinate variations (bilateral middle concha bullosa, unilateral AMT, bilateral SCB, unilateral and bilateral SuprT).

ETHICAL DECLARATIONS

Ethics Committee Approval: This study was approved by the Ethical Committee of noninvasive Clinical Research of the Mardin Artuklu University (Date: Oct 11,2021 and numbered :2021/2)

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Cashman EC, Macmahon PJ, Smyth D. Computed tomography scans of paranasal sinuses before 308 functional endoscopic sinus surgery. World J Radiol 2011;28:199-204
2. Lee JC, Song, YJ, Chung YS, Lee BJ, Jang YJ. Height and shape of the skull base as risk factors for skull base penetration during endoscopic sinus surgery. Ann of Otol Rhinol Laryngol, 2007;116:199-205.
3. Stankiewicz JA, Chow JM. The low skull base: an invitation to disaster. Am J Rhinol 2004;18:35-40
4. Hashemi SM, Berjis N, Ebrahimi H. Relationship between Height of Ethmoid Skull Base and Length of Lateral Lamella by Sectional Coronal Computed Tomography Scan before Endoscopic Sinus Surgery. Adv Biomed Res 2018;7:48
5. Madani GA, El-Mardi AS, El-Din WA. Analysis of the anatomic variations of the ethmoid roof among Saudi population: A radiological study. Eur J Anat 2020;24:121-8.
6. Muñoz-Leija MA, Yamamoto-Ramos M, Barrera-Flores FJ, et al. Anatomical variations of the ethmoidal roof: differences between men and women. Eur Arch Otorhinolaryngol 2018;275:1831-6.
7. Costa ALF, Paixão AK, Gonçalves BC, et al. Cone Beam Computed Tomography-Based Anatomical Assessment of the Olfactory Fossa. Int J Dent 2019:1-7
8. Keros P. On the practical value of differences in the level of the lamina cribrosa of the ethmoid. Z Laryngol Rhinol Otol. 1962;41:809-13.
9. Ali A, Kurien M, Shyamkumar NK, Selveraj. Anterior skull base: High risk areas in endoscopic sinus surgery in chronic rhinosinusitis: A computed tomographic analysis. Indian J Otolaryngol Head Neck Surg, 2005;57:5-8
10. Adeel M, Ikram M, Rajput MS, Arain A, Khattak YJ. Asymmetry of lateral lamella of the cribriform plate: a software-based analysis of coronal computed tomography and its clinical relevance in endoscopic sinus surgery. Surg Radiol Anat 2013;9:843-7.
11. 11.Damar M, Dinç AE, Eliçora SŞ, et al. Does the degree of septal deviation affect cribriform plate dimensions and middle turbinate length? J Craniofac Surg 2016;27:51-5.
12. Kayabasi S, Hizli O, Ozkan D. Does paranasal sinus development affect olfactory fossa depth and lateral lamella length? Laryngoscope 2019;129:2458-63.
13. Kizilkaya E, Kantarci M, Cinar Basekim C, et al. Asymmetry of the height of the ethmoid roof in relationship to handedness. Laterality 2006;11:297-303
14. Gumus C, Yildirim A. Radiological correlation between pneumatization of frontal sinus and height of fovea ethmoidalis. Am J Rhinol 2007;21:626-8.
15. Acikalin RM, Bayram O, Haci C, et al. Is there a relationship between middle concha bullosa and ethmoid roof asymmetry? Braz J Otorhinolaryngol 2022;88:101-4.
16. Gun R, Yorgancilar E, Bakir, et al. The relationship between pneumatized middle turbinate and the anterior ethmoid roof dimensions: a radiologic study. Eur Arch Otorhinolaryngol 2013;270:1365-71.
17. Saylisoy S, Acar M, San T, Karabag A, Muluk NB, Cingi C Is there a relationship between cribriform plate dimensions and septal deviation angle? Eur Arch Otorhinolaryngol, 2014;271:1067-71.
18. Rusu MC, Săndulescu M, Mogoantă CA, Jianu AM The extremely rare concha of Zuckerkandl reviewed and reported. Rom J Morphol Embryol 2019;60:775-9.
19. Lin YL, Lin YS, Su WF, Wang CH A secondary middle turbinate co-existing with an accessory middle turbinate: an unusual combination of two anatomic variations. Acta Otolaryngol 2006;126:429-31.
20. Köse E, Dönmez Tarakçı Ö. First report of lateral nasal wall pneumatization. Surg Radiol Anat 2019;41:979-81.
21. El-Anwar MW, Ali AH, Almolla RM, Abdulmonaem G, Raafat A, Hassan ME. Radiological middle turbinate variations and their relation to nasal septum deviation in asymptomatic adult. Egypt J Radiol Nuclear Med 2020;51:1-5.
22. Eweiss AZ, Ibrahim AA, Khalil HS. The safe gate to the posterior paranasal sinuses: reassessing the role of the superior turbinate. Eur Arch Otorhinolaryngol 2012;269:1451-6.
23. Kajiwara R, Omura K, Takeda T, et al. Anatomical variation of the pneumatized superior turbinate and its impact on endoscopic sinus surgery in chronic rhinosinusitis. Surg Radiol Anat 2020;42:81-6.
24. İla K, Yilmaz N, Öner S, Başaran E, Öner Z. Evaluation of superior concha bullosa by computed tomography. Surg Radiol Anat, 2018;40:841-6.
25. Abdullah SN, Abdullah B. Supreme Nasal Turbinate as an Additional Surgical Landmark in Endoscopic Sinus and Skull Base Surgeries. Cureus 2020;12:8132.
26. Măru N, Rusu MC, Săndulescu M. Variant anatomy of nasal turbinates: supreme, superior and middle conchae bullosae, paradoxical superior and inferior turbinates, and middle accessory turbinate. Rom J Morphol Embryol 2015;56:1223-6.