Original Article

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Analysis of Olfactory Fossa Anatomy using Cone Beam Computed Tomography

Dentistry Section

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ABSTRACT

Introduction: Olfactory fossa is an important structure in the anterior skull base. It is made of Lateral Lamella of Cribriform Plate (LLCP) and fovea ethmoidalis which are very delicate parts that can get damaged during surgical procedures causing numerous serious complications. To avoid such complications, the knowledge of anatomical variations of these parts is mandatory. As there are very few studies which have used Cone Beam Computed Tomography (CBCT) for evaluation of olfactory fossa, the authors have assessed the olfactory fossa with the help of Kero's and Gera's classification for lateral lamella of cribriform plate.

Aim: To evaluate the anatomy of olfactory fossa using CBCT.

Materials and Methods: A retrospective observational study was conducted in the Department of Oral Medicine and Radiology, from 1st January 2019 to September 2021. The CBCT scans of 107 adults were analysed to evaluate the height of LLCP according to Kero's classification and the angle between the LLCP and the true horizontal plane according to Gera's classification. Comparison of height of lateral lamella (mm) and Gera angle (degree) among right and left sides were done using Student's Independent t-test. The comparison of Gera angle with Kero's type was analysed by one way Analysis of Variance (ANOVA) test. Chi-square test was performed to assess categorical data on the right and left sides.

Results: A total of 107 CBCT scans consisting of 59 males (55.14%) and 48 females (44.86%) were included in the study. The mean age of the study population was 31.60±11.17 years. Kero's type II (69.6%) and Gera's class II (92.1%) LLCP were found to be most commonly seen. The Gera angle on right side (60.26±9.84) was greater than on left side (56.38±10.16) which was statistically significant (p-value=0.005). On right side, Kero's type II was more common in males (71.2%) and on left side, Kero's type II was more common in females (77.1%).

Conclusion: Kero's type II Olfactory fossa (OF) was found as most common type, with no significant difference between gender and /or side. Similarly, class II Gera angle was most common and the values were higher on right side.

Keywords: Ethmoid roof, Fovea ethmoidalis, Gera angle, Kero type, Lateral lamella of cribriform plate

INTRODUCTION

Olfactory fossa (OF) is a depression or valley present in an anterior cranial cavity. A floor of the OF is formed by ethmoid bone and cribriform plate [1,2]. It is laterally bounded by Lateral Lamella of Cribriform Plate (LLCP) and medially by crista galli [1,3]. The lateral lamella where ethmoid artery penetrates anterior cranial fossa is known as the thinnest and delicate bone present in the anterior skull. This bone is dehiscent in about 14% of the population [4-6]. The LLCP laterally articulates with fovea ethmoidalis (FE). The FE which is a part of frontal bone helped in the development of roof of the ethmoid bony labyrinth [2,7]. Thus, LLCP and FE are one of the most delicate and vulnerable parts of the skull base which can contribute to various complications while performing endoscopic surgeries or surgeries of paranasal sinuses [8-10].

Functional Endoscopic Sinus Surgery (FESS) is the frequently used technique to treat chronic or recurrent sinusitis, mucoceles, CSF leak closure, nasal polyposis, sellar tumors, optic nerve decompression, management of epistaxis and epiphora originated by lower lacrimal duct obstruction [11-13]. Serious complications like herniation of orbital fat, injury to extraocular muscles, optic nerve injury and intracranial injuries like injury to major blood vessels, etc. can occur in 0-1.5% of the cases [5,13]. A thorough knowledge of different anatomical variations in patients will help to reduce the unwanted iatrogenic complications by knowing the risks while performing surgeries [14].

The term "dangerous ethmoid" was introduced to define the position of anterior ethmoid artery and the position of lateral lamella in relation to the cribriform plate [3,11,15]. The relationship between OF and ethmoid roof was studied by Kero in 1962 and he derived a three category classification system for assessing the depth of OF in relation to ethmoid roof [16]. Even if the role of OF depth has been given importance earlier, only limited data regarding the slope of the anterior skull base, particularly the angulation of the LLCP in the coronal plane are known. This angulation might have a role when approaching the paranasal sinuses during the dissection of more medial ethmoidal cells [17]. A classification system given by Gera which focuses on the angle formed by LLCP and the horizontal plane passing through cribriform plate may serve this purpose. Some authors suggests that the risk of complications is directly proportional to the depth of OF, while others propose that the complications are closely associated with the angle between LLCP and horizontal plane [15,17,18].

Though Multislice Computed Tomography (MSCT) is the gold standard in the estimation of anatomy and pathologies of cranial structures, paranasal sinuses and nasal cavity, CBCT can definitely be used as a promising alternative by dental surgeons and otolaryngologists to assess cranial and nasal structures and paranasal air sinuses. The CBCT is preferred because of its advantages such as low radiation exposure, high quality images with lower costs [19-21]. Though the role of radiographic analysis of OF was emphasised earlier, there is very limited data available till date. Thus, the aim of this study was to assess the anatomy of OF using CBCT.

MATERIALS AND METHODS

A retrospective observational study was conducted in the Department of Oral Medicine and Radiology using CBCT scans taken during the period of 1st January 2019 to 31st January 2021. The data collection including the statistical analysis and interpretation was done from February 2021 to September 2021. The study protocol was reviewed and approved by the Institutional Review Board of Ethics Committee (SDCH/IEC/2021/49) performed according to Helsinki Declaration guidelines.

The CBCT scans of 107 adults above 18 years were obtained retrospectively from the Department of Oral Medicine and Radiology. The CBCT images obtained using a Promax 3D unit (Planmeca, Helsinki, Finland), operating at 84 kVp, 9-14 mA, with a 0.16 mm voxel size, exposure time of 12 seconds and a field of view of 8×8 cm^2.

Inclusion and Exclusion criteria: The CBCT images showing the medium and superior regions of the face including the crista galli of the ethmoidal bone and nasal fossa were included in the study. Patients having a history of maxillofacial trauma, pathologies in the paranasal sinuses and paranasal sinus surgery were excluded. The CBCT scans with inferior quality images or images with artifacts, producing visualisation of anatomical forms difficult were excluded.

Study Procedure

Two investigators evaluated the CBCT images with inbuilt software (Planmeca, Romexis viewer 4.3.0.R) on a 24-inch Nvidia Quadro FX 380 screen with 1280×1024 resolution in a quiet room with subdued ambient lighting.

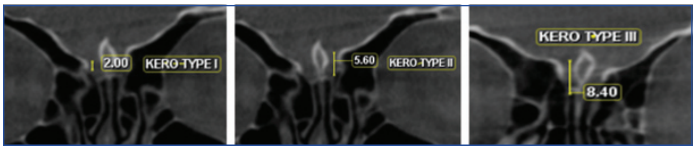
Investigators were checked for intra and inter-examiner variability to refine the intra and interpersonal reliability. Before the study analysis in between each measurement both examiner examined all measurements with an interval of one week. The average was considered, if the variability in between two examiners was set up to be upto 10%. If the variability was more than 10%, another investigator reassessed it. The coronal slices (thickness: 1 mm) were used and linear measurements were done by using the software's ruler to evaluate the following parameters:

1. **Kero's classification:** Olfactory fossa depth was decided by the Height of lateral lamella of cribriform plate , measured as the distance between fovea ethmoidalis (F) to cribriform plate (P) of ethmoid bone using the Kero's classification [Table/Fig-1] [16].

   (i) Type I-height lower than 3.0 mm

   (ii) Type II-height between 4.0 and 7.0 mm

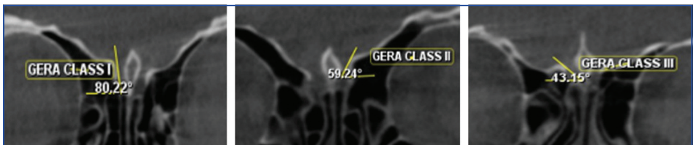
   (iii) Type III-height between 8.0 and 16.0 mm



[Table/Fig-1]: Coronal CBCT showing Kero's Type I, II and III.

2. **Gera's classification:** Angle between lateral lamella of cribriform plate and the continuation of the horizontal plane passing through cribriform plate was measured using the Gera's classification [Table/Fig-2] [17].

- Class I (>80°, low risk)
- Class II (45 to 80°, medium risk)
- Class III (<45°, high risk)



[Table/Fig-2]: Coronal CBCT showing Gera's class I, II and III.

STATISTICAL ANALYSIS

The data analysis was performed using Statistical Package for Social Sciences (SPSS) version 23.0. The mean and percentage were used to assess the prevalence and gender distribution. Comparison of height of lateral lamella (mm) and Gera angle (degree) among right and left sides were done using Student's Independent t-test. The comparison of Gera angle with Kero's type was analysed by one way ANOVA test. Chi-square test was performed to assess categorical data on right and left side. Spearman's correlation test was applied to find the correlation between Kero's and Gera's Class. The $p \leq 0.05$ was considered as statistical significant.

RESULTS

A total of 107 CBCT scans consisting of 59 males (55.14%) and 48 females (44.86%) were included in the study. The mean age of the study population was 31.60±11.17 years.

The mean height of LLCP was 4.63±1.68 mm. The mean Gera angle was 58.32±8.50°. The mean height of LLCP in males was 4.69±1.76 mm and females 4.55±1.59 mm, respectively. The mean Gera angle was 59.03±8.56° in males and females 57.44±8.43°, respectively. The difference was not statistically significant [Table/Fig-3].

Variable	Male	Female	Difference	p-value
LLCP (mm)	4.69±1.76	4.55±1.59	0.14	0.674
Gera angle (°)	59.03±8.56	57.44±8.43	1.59	0.338

[Table/Fig-3]: Overall Mean Height of LLCP and Gera angle among males and females (irrespective of side).
Independent t-test

The height of LLCP on the left side (4.73±1.91 mm) was slightly higher than the right side (4.52±1.87 mm) but the difference was not statistically significant (p-value=0.401). Similarly, the Gera angle on right side (60.26±9.84°) was greater than the left side (56.38±10.16°) which was statistically significant (p-value=0.005) [Table/Fig-4].

Variables	Right side	Left side	Difference	p-value
Height of lateral lamella (mm)	4.52±1.87	4.73±1.91	-0.21	0.401
Gera angle (°)	60.26±9.84	56.38±10.16	3.88	0.005*

[Table/Fig-4]: Comparison of height of lateral lamella (mm) and Gera angle (degree) among right and left side.
Independent t-test; *Indicates significant difference at $p \leq 0.05$

On comparing the sides, Gera angle and height of lateral lamella between males and females showed no statistically significant difference [Table/Fig-5].

Variables	Side	Male	Female	Difference	p-value
Height of lateral lamella (mm)	Right	4.54±1.89	4.49±1.87	0.05	0.885
	Left	4.84±2.04	4.61±1.77	0.23	0.549
Gera angle (°)	Right	60.52±9.63	59.93±10.19	0.59	0.762
	Left	57.55±10.29	54.95±9.90	2.60	0.189

[Table/Fig-5]: Comparison of height of lateral lamella (mm) and Gera angle (degree) among males and females.
Independent t-test

The Kero's Type II (69.6 %) was most commonly seen. The Gera Type II (92.2%) was more common followed by Type III (4.7%) and Type I (3.3%), respectively [Table/Fig-6].

Variables	Category	N	%
Kero's type	Type I	41	19.2
	Type II	149	69.6
	Type III	24	11.2
Gera angle	Class I	7	3.3
	Class II	197	92.1
	Class III	10	4.7

[Table/Fig-6]: Kero's distribution and Gera distribution.
N=214 as seen for both the sides

On comparing with sides, Kero's Type II was prevalent in the population studied followed by type I and III. The difference in Kero's type between right and left side was statistically non significant (p-value=0.678) among the types. Similarly, Gera's Class II angle was prevalent followed by Class III and Class I. However, there was no statistically significant difference in Gera angle between right and left side (p-value=0.085) among the all the classes [Table/Fig-7].

Kero's type II was more prevalent in males than females on right side. The comparison of different types according to gender was statistically non significant. Similar findings were noted on left side [Table/Fig-8].

Variables	Category	Right side	Left side	p-value
Kero's type	Type I	23 (21.5%)	18 (16.8%)	0.678
	Type II	72 (67.3%)	77 (71.9%)	
	Type III	12 (11.2%)	12 (11.2%)	
Gera angle class	Class I	5 (4.7%)	2 (1.9%)	0.085
	Class II	100 (93.5%)	97 (90.7%)	
	Class III	2 (1.9%)	8 (7.5%)	

[Table/Fig-7]: Comparison of Kero's type and Gera angle class among right and left side.
Chi-square test

Side	Category	Male	Female	p-value
Right	Type I	11 (18.6%)	12 (25.0%)	0.631
	Type II	42 (71.2%)	30 (62.5%)	
	Type III	6 (10.2%)	6 (12.5%)	
Left	Type I	10 (16.9%)	8 (16.7%)	0.328
	Type II	40 (67.8%)	37 (77.1%)	
	Type III	9 (15.3%)	3 (6.2%)	

[Table/Fig-8]: Comparison of Kero's type among right and left side.
Chi-square test

There was no significant difference in Gera angle between males and females on both sides (p-value=0.281) and (p-value=0.097). Gera Class II angle was slightly more prevalent in males than females but the difference was statistically non significant [Table/Fig-9].

Side	Category	Male	Female	p-value
Right	Class I	3 (5.1%)	2 (4.2%)	0.281
	Class II	56 (94.9%)	44 (91.7%)	
	Class III	0	2 (4.2%)	
Left	Class I	2 (3.4%)	0	0.097
	Class II	55 (93.2%)	42 (87.5%)	
	Class III	2 (3.4%)	6 (12.5%)	

[Table/Fig-9]: Comparison of Gera angle class among right and left side.
Chi-square test

There was no significant difference in mean age among Kero's types and Gera angle between right and left side (p-value >0.05) [Table/Fig-10,11].

Variables	Type I	Type II	Type III	p-value
Kero right	36.00±12.21	30.07±9.71	32.33±15.45	0.082
Kero left	31.83±9.29	31.01±11.08	35.00±14.32	0.518

[Table/Fig-10]: Comparison of mean age as per Kero's type.
One way ANOVA test

Variables	Class I	Class II	Class III	p-value
Gera right	34.00±10.17	31.36±11.08	37.50±23.34	0.663
Gera left	32.00±5.66	32.01±11.48	26.50±6.70	0.410

[Table/Fig-11]: Comparison of age as per Gera angle.
One way ANOVA test

On left side, there was a statistically significant difference when Kero's type was compared with Gera angle [Table/Fig-12]. When the height of LLCP was compared between the Gera's type, statistically significant (p-value=0.047) was found on the right side [Table/Fig-13].

[Table/Fig-14] shows negligible non significant correlation between Kero's and Gera classification.

DISCUSSION

An ethmoid roof is one of the most complex and delicate bones in the skull. The thinnest structure where lateral lamella of cribriform

Side	Kero's type	Gera angle class				p-value
		Class I	Class II	Class III	Total	
Right	Type I	2 (8.7)	20 (87.0)	1 (4.3)	23 (100)	0.621
	Type II	3 (4.2)	68 (94.4)	1 (1.4)	72 (100)	
	Type III	0	12 (100)	0	12 (100)	
Left	Type I	0	15 (83.3)	3 (16.7)	18 (100)	0.001*
	Type II	0	74 (96.1)	3 (3.9)	77 (100)	
	Type III	2 (16.7)	8 (66.7)	2 (16.7)	12 (100)	

[Table/Fig-12]: Comparison of distribution of Gera angle class according to Kero's classification.
Chi-square test; *indicates significant difference at p≤0.05

Variables	Type I	Type II	Type III	p-value
Kero right	55.84±11.12	61.64±9.25	60.39±8.97	0.047*
Kero left	54.14±10.19	56.12±9.10	61.42±14.99	0.143

[Table/Fig-13]: Comparison of Gera angles as per Kero's type.
One way ANOVA test; * indicates significant difference at p≤0.05

Variables	r value	p-value	Interpretation
Kero type vs Gera class (Right side)	0.047	0.634	Negligible positive non significant correlation
Kero type vs Gera class (Left side)	-0.154	0.113	Negligible negative non significant correlation
Kero type vs Gera class (Overall)	0.097	0.155	Negligible positive non significant correlation

[Table/Fig-14]: Correlation between Kero's type and Gera's Class.
Spearman's rank correlation test

plate attaches to middle turbinate is considered as "locus minoris resistentiae". Understanding the complex anatomical relationship of the ethmoid roof, the anterior skull base and olfactory zone is of paramount importance as the knowledge of these structures will avoid unnecessary complications [2,10,12,17-19,22].

The CBCT can be used as a potent alternative to CT for analysis of paranasal sinuses and adjacent structures as it gives high resolution spatial images with remarkable reduction in radiation dosage to the patient [19-21,23]. In the present study, viewing that the coronal plane was best for estimating, the ethmoid roof anatomy, CBCT images were selected that came up with detailed information about this segment that normally presents many dissimilarities (right and left side) in a same individual and as a result, risks were minimised in surgical interventions [12,22].

The levels of the ethmoid roof and cribriform plate can vary considerably in different individuals and also in the same individual on right and left sides [3-5,7,10,15]. Analysing the Kero's types, based on population, it is seen that majority of the studies have reported Kero's type II to be more prevalent [Table/Fig-15] [1,3-15,17,20,22,24-26]. Shows the list of various authors that have studied the depth of OF using the Kero's classification.

Likewise, studies reported from India have also found Type II to be more prevalent except for a study by Deepa G and Shrikrishna BH., [28] who reported Type I to be more prevalent [1,13,27,28]. The Kero's type III is considered to be the most vulnerable for iatrogenic injuries due to its long length of lateral lamella [2,28]. In the literature Kero's type III has been reported to be ranging from 0-32.3% [14,22,25]. In this study, Kero's type III was reported to be 11.2% which is slightly higher than previously reported in Indian population [1,13,27,28]. Few authors have reported difference between Kero's type and gender [1,4,5,7-9,11,14,27], while others have reported no difference which was in agreement with the present study [15,17,20].

The possibility of injury to the skull base increases with increasing height of LLCP. As the LLCP height increases, OF will become narrower and deeper; also the ethmoid roof will be more low

S. No.	Author/Year	Place of study	No. of subjects	Imaging modality used	Parameters compared	Kero's types			Conclusion
						Type I (%)	Type II (%)	Type III (%)	
	KERO'S TYPE II -MORE PREVALENT								
1	Abdullah B et al., 2020 [14]	Malaysia	150	CT	Height of LLCP	24.3	72.7	0	No significant correlation between Kero and Gera classification systems
2	Shorek A et al., 2016 [15]	Poland	64	CT	Depth and width of OF	9.17	75.83	15	No significant difference seen with age, gender and side. Kero's classification alone is not enough to know 'danger ethmoid'
3	Gera R et al., 2018 [17]	Italy	190	CT	Depth of OF and the angle between LLCP and horizontal plane	20	64.7	15.3	Gera angle was significantly correlated with Kero's type
4	Souza SA et al., 2008 [12]	Brazil	400	CT	Depth of OF and the angle between LLCP and horizontal plane	9	53	0.5	Ethmoid roof asymmetry was related to angulation of LLCP
5	Costa ALF et al., 2019 [20]	Brazil	174	CBCT	Depth of OF	13.79	65.52	20.69	- No significant difference was seen with gender, age and sides - CBCT can be recommended for OF analysis
6	Adeel M et al., 2013 [4]	Dubai	77	CT	Depth of OF	29.9	48.7	21.4	Gender-related differences as well as individual asymmetry was reported
7	Erdogan S et al., 2015 [22]	Turkey	110	CT	Height of LLCP	10	67.72	22.28	Kero's type II was most common and asymmetry was apparent in all patients
8	Erdem G et al., 2004 [25]	Turkey	136	CT	Depth of CP	8.1	59.6	32.3	In the group with excessive cribriform plate depth (Kero's type III), the middle turbinate was short, care should be taken especially during middle turbinate resections - Asymmetry is typically found
9	Güler Cet al., 2012 [24]	Turkey	300	CT	Depth of OF	26	66	8	Kero's type III was associated with higher risk for complications
10	Karatay E et al., 2020 [11]	Turkey	522	CT	Depth of OF	30.85	66.75	2.4	- Most of the patients showed asymmetry - Significant difference according to gender and age
11	Kaplanoglu H et al., 2013 [10]	Turkey	500	CT	Height of LLCP	13.4	76.1	10.5	80% of the population showed asymmetry
12	Elwany S et al., 2010 [7]	Egypt	300	CT	Length of LLCP	42.5	56.8	0.6	Type II was most common in males, while type I was most common in females
13	Babu AC et al., 2018 [1]	India	1200	CT	Depth of OF	17.5	74.6	7.9	- Prevalence of type III even though low, is significant especially among males on right side - Type III was more common in males than females - Asymmetry was reported
14	Gupta P and Ramesh P. 2017 [27]	India	100	CT	Height of LLCP	39	59	2	- Gender difference-Most common Kero type in males- Type II, in females- Type I - Side difference- Significant asymmetry between right and left sides
15	Murthy AV and Bollineni S. 2017 [13]	India	100	CT	Height of LLCP	19.5	71.5	9	- Deep ethmoid roof (Kero's type III) occurred on the right side than on the left side - No significant differences according to gender and age
16	Jacob TG and Kaul JM. 2014 [3]	India	32	Dry skulls	Length of LLCP, Angle between lateral wall of OF and medial part of anterior cranial fossa	23.44	70.83	5.73	No significant differences between right and left sides
17	Present study	India	107	CBCT	Height of LLCP	19.2	69.6	11.2	Type II was most common and no significant side difference reported
	KERO'S TYPE I MORE PREVALENT								
18	Solares CA et al., 2008 [6]	US	50	CT	Height of LLCP and Angle between LLCP and horizontal plane	83	15	2	Asymmetry of the relative ethmoid roof position is common
19	Alazzawi S et al., 2012 [5]	3 Ethnic groups- Malaysia, China, India	300	CT	Height of LLCP	80	20	0	- Indian males had higher prevalence of type II makes them more susceptible to the risk of operative complications - Significant individual asymmetry reported
20	Shama SAM and Montaser M 2015 [8]	Egypt	100	MDCT	Height of LLCP	56.5	40.5	3	- More than two thirds showed symmetrical height of LLCP - Type II and III were common in males while type II was common in females for Egyptian population
21	Paber JEL et al., 2008 [9]	Philippine	165	CT	Height of LLCP	81.8	17.7	0.5	- No side and gender difference seen - Mean height for LLCP was higher in males than in females
22	Deepa G and Shrikrishna BH 2019 [28]	India	80	CT	Height of LLCP	76.25	20.63	3.12	Type I was most common with variations between right and left sides

[Table/Fig-15]: Summary of studies that used Kero's classification [1,3-15,17,20,22,24-26].

lying [2,28]. The mean height of LLCP was 4.63±1.68 mm in the current study which is slightly lesser than that reported in the previous studies by Skorek A et al., [15] 5.77 mm, Erdem G et al., [25] 6.1 mm; Meloni F et al., [29] 5.9 mm and Jacob TG et al., [3] 4.9 mm, respectively [Table/Fig-16] [1,8,10,13,25,28].

Author/Year	Mean height of LLCP	
	Right side	Left side
Deepa G and Shrikrishna BH 2019 [28]	3.47±1.68 mm	3.08±1.59 mm
Murthy AV and Bollineni S 2017 [13]	5.43 mm	4.98 mm
Babu AC et al., 2018 [1]	5.27±1.72 mm	5.25±1.65 mm
Shama SAM and Montaser M 2015 [8]	4.92±1.70 mm	4.87±1.71 mm
Erdem G et al., 2004 [25]	6.1±2.3	6.1±2.2
Kaplanoglu H et al., 2013 [10]	4.87±1.71 mm	4.91±1.66 mm

[Table/Fig-16]: Comparison of mean height of LLCP in literature [1,8,10,13,25,28].

and Class I (3.3%) respectively which is in accordance with previous studies [14,17,18]. The prevalence of Class II in the present study is more as compared to previous studies [Table/Fig-17] [14,17,18]. Also, there was no significant difference in Gera angle with gender which is in accordance to previous studies [14,17].

Thus, it can be noted that individuals classified as low risk according to Kero's classification may show high risk according to the Gera classification. Considering the risk of iatrogenic injury, in this study authors reported 16.7 % having Gera Class III as Kero type III on left side which is not in accordance with the previous study [14].

In the present study we found no significant correlation between Kero and Gera classification which is in accordance with Abdullah B. et al., [14] while Gera R et al., [17] found a positive correlation. This difference could be due to anatomical variation in different populations.

S. No.	Author/Year	Place of study	No. of subjects	Imaging modality used	Mean Gera angle	Gera class			Conclusion
						Class I (%)	Class II (%)	Class III (%)	
1	Abdullah B et al., 2020 [14]	Malaysia	150	CT	70±13.1	23.7	72.3	4	Class II was most common
2	Altunay ZO and Onerci TM 2020 [18]	Turkey	54	CT	67±11.4	34	55	11	No association between high septal deviation and Gera angle was found
3	Gera R et al., 2018 [17]	Italy	190	CT	71.71±12.1	32.6	62.7	4.7	Class II was most common and Gera angle can provide indirect information regarding thickness of anterior base of skull
4	Present study	India	107	CBCT	58.32±8.50	3.3	92.1	4.7	Class II was the most common type

[Table/Fig-17]: Summary of studies that used Gera's classification [14,17,18].

Studies reported from India by Babu AC et al., (5.26±1.69 mm) Murthy AV and Bollineni S (5.21 mm) have shown mean height to be more than that reported in the present study, except that reported by Deepa G and Shrikrishna BH (3.3±1.63 mm) [1,13,28].

In the present study, no difference was noted in the height of OF between the right and left sides which is in accordance to the previous studies [3,9,13,15,20,25,29]. It is possible to speculate that the differences in the anatomic development in the ethmoidal roof might be related not only with heredity, environmental factors and previous chronic infections that could have affected the development of the sinuses, but also with ethnicity [30]. Similarly, according to Jacob TG et al., [3] the degree of pneumatisation of frontal sinus and ethmoid labyrinth varies in different populations which could be a factor for different results [3]. Furthermore, differences in technique may influence the apparent measurements.

Some studies have demonstrated that the LLCP is uniformed in less than 50% of people, and that this asymmetry is associated with flattening of the Fovea Ethmoidalis (FE) with angulation of the LLCP, which may result in surgical difficulties [4,12]. Whereas other authors noted a high percentage of asymmetry and describe a wide range of 9.5-93% [3-7,10,15,31,32]. In the present study no asymmetry was seen on the right and left sides. Shorek A et al., [15] and Abdullah B et al., [14] observed that only Kero's classification was not enough to identify the 'dangerous ethmoids'; since the Kero's classification does not describe the risk of intracranial entry. So, the angle between the LLCP to horizontal plane, which is called as Gera angle was proposed to analyse the theoretical risk of iatrogenic injuries [2,12,14,18].

In the present study, the mean degree of Gera angle was reported as 58.32±8.50º which is lesser than reported in the previous studies [Table/Fig-17] [14,17,18,26].

Class I angle denotes a higher risk of iatrogenic injury followed by Class II and Class III [17,26]. In the present study, most commonly reported Gera angle was Class II (92.1%) followed by Class III (4.7%)

Limitation(s)

The sample size was small with unequal distribution among gender including age wise distribution of study participants was limitation of the study.

CONCLUSION(S)

Thus, in the present study, Kero's type II OF was found as most common type, with no significant difference associated with gender and/or side. Similarly, class II Gera angle was also most common and the values were higher on right side with no difference in age and gender. The occurrence of substantial relationships between multiple ethmoidal measurements emphasises the need of examining more than simply the height of the ethmoidal skull base. Authors believe that the implementation of categorisation systems could be effective in the preoperative assessment of ethmoid sinus imaging in order to avoid serious issues.

Large scale collaborative studies including classification systems that are based on axial, sagittal and coronal planes are required to improve our knowledge of anatomical variations and their distribution. The estimate of the depth of the olfactory fossae and ethmoidal roof asymmetry presence should be included in routine description of CBCT reports because it constitutes a significant facet in endoscopic surgeries. Further prospective longitudinal studies or retrospectively analysing patients who showed iatrogenic complications during surgical procedures will help to validate the postulated results.

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