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# Assessment of ethmoid roof and olfactory fossa variations using Keros classification in a tertiary care hospital

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## Abstract

**Background:** Functional endoscopic sinus surgery is a common surgery done in otorhinolaryngology, but it is also riddled with complications. The most dangerous complication is the injury to the skull base leading to cerebrospinal fluid leak, meningitis or damage to intracerebral vessels. Lateral lamella of the cribriform plate is the most common site of injury. Keros described the depth of the olfactory fossa in detail and divided them into three types.

This study aims to assess the anatomical variations of type of ethmoid roof and depth of olfactory fossa as per Keros classification

**Methods:** Descriptive study where CT scans were evaluated from the radiology department from 29 September 2018 to 20 May 2020. All the CT films were assessed according to the observation checklist.

**Results:** Our study included 256 patients. Males constituted 54.3% of patients, and 45.7% of patients were females. Type 2 Keros was the most common followed by type 1 and type 3. Type 3 was seen more in males, and it was statistically significant too.

**Conclusion:** The study evaluated the depth categorization of the ethmoid roof and its variations on the basis of age and gender. In our study, the most common type was Keros type 2, but there was a noteworthy difference between the two sides in the same individual. Therefore, extra care must be taken during surgery to note the type of Keros on each side.

**Keywords:** Keros, FESS, Cribriform plate, Skull base

## Background

Endoscopic sinus surgery (ESS) is a common procedure; it is indicated for chronic rhinosinusitis which is not controlled by medical management [1, 2], and this is furthermore done in cases of nasal polyposis, mucocoele, sellar and parasellar tumours and optic nerve decompression and other intracranial lesions by using extended approaches of the ESS [3, 4].

The chief problems of ESS are ophthalmic damage, meningitis, cerebrospinal fluid leak and intracerebral vessel damage [5–7]. The ethmoid bone is the main site of maximum complications of ESS [8–11].

As stated by previous studies, the lateral lamella of the cribriform plate is the most common site of damage during ESS [12–16]. The delicate area in the skull base is where the anterior ethmoidal artery goes into the cranial cavity [17, 18].

The fovea ethmoidalis is a continuation of the orbital plate of frontal bone and forms the roof of the ethmoid. This forms a boundary between the ethmoidal cells and the anterior cranial fossa [19]. It is connected to the lateral lamella of the cribriform plate medially [10, 20].

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The height of lateral lamella of the cribriform plate governs the depth of the olfactory fossa. Based on its depth, Keros categorized the olfactory fossa into three types as follows: Keros type 1 (< 3 mm), type 2 (4–7 mm) and type 3 (8–16 mm). An inconsistent section of the lateral wall of the olfactory fossa will be bare during ESS in the frontoethmoidal region based on the type of Keros. The type 3 Keros is more at risk of injuring the lateral lamella of the cribriform plate during ESS [21, 22].

### Aim

To assess the anatomical variations of type of ethmoid roof and depth of olfactory fossa as per Keros classification.

### Methods

This was a retrospective observational descriptive study, wherein the clinical case records of all the patients who have undergone CT imaging of paranasal sinuses (PNS) from 29 September 2018 to 20 May 2020 were taken from the CT archives of radiology department at our institution, using a predesigned validated observation checklist. Ethics approval was obtained from the institution ethics committee vide number FMIEC/CCM/100/2020. The datasets generated and/or analysed during the current study are available in the RISC PACKS repository. The patients' data was kept completely confidential, and the personal identifiers were never revealed in any form while reporting results. The clinical case records of all the patients who underwent a computed tomography study of paranasal sinuses, from September 2018 to May 2020, were included. Patients with malignancy of nose and PNS, road traffic accident cases and revision nasal surgery cases were excluded from the study. The sample size obtained was 256. Each CT scan was assessed jointly by one radiologist and three rhinologists. The consensus findings of all the 4 researchers were entered into the Excel sheet for analysis.

All CT scans were obtained with GE BrightSpeed 16 slice. After obtaining the scout projection, the area of scanning was defined to include the region from anterior wall of frontal sinus until the sphenoid sinus for coronal sections. Axial sections were performed with the patient in the supine position. The plane of data acquisition was parallel to the hard palate. The sections were taken with slice thickness of 2.5 mm, and the images were reconstructed to 1.25 mm. Scanning parameters included 150 mas and 120 kvp. Coronal sections were performed with the patients in the prone position with extended neck and the plane perpendicular to the axial plane. The scan parameters were the same as in axial plane.

### Availability of data and materials

The datasets generated and/or analysed during the current study are available in the RISC PACKS repository

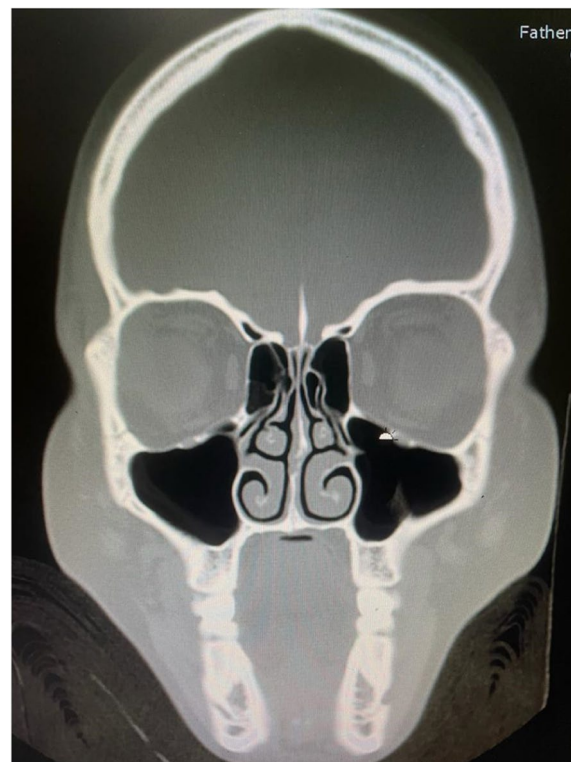
### Results

In our study, the CT scans of 256 patients were studied. A total of 54.3% of the patients constituted of males, and 45.7% were females respectively.

The age group of patients ranged between 7 and 83 years. We found that 9.7% of patients were normal, 41.8% patients had sinusitis, 23% patients had DNS, 5.9% patients had DNS with sinusitis, 18% patients had polyposis, 1.2% patients had sinusitis with polyposis, and 0.4% patients had DNS with polyposis.

Type 2 Keros (Fig. 1) was the commonest in the CT scans studied in our study (Table 1). Type 2 Keros was proportionately higher in the people aged between 27 and 46 years. (Table 2). A significantly higher proportion of type 3 Keros (Fig. 2) was seen in males on the right side (Table 2) ( $\chi^2$  6.04, *df* 2, *p*-value 0.049).

The majority of the patients had the same type of Keros on both sides (Table 3). Asymmetry in the olfactory fossa was found in 104 (40.6%) patients, and pneumatization of crista galli was seen in 15 (5.9%) patients



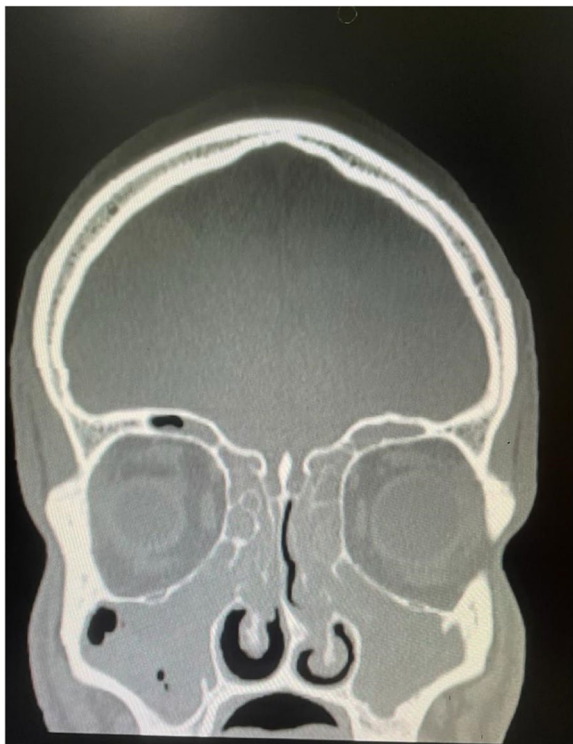
**Fig. 1** Showing Keros variation type 2

**Table 1** Distribution of Keros classification according to sides

Right						Left					
Type 1		Type 2		Type 3		Type 1		Type 2		Type 3	
N	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>
33	12.9	210	82.0	13	5.1	38	14.9	209	81.6	9	3.5

<sup>a</sup> Row percentages**Table 2** Distribution of Keros classification according to the sides and age and sex of the patients

		Right						Left					
		Type 1		Type 2		Type 3		Type 1		Type 2		Type 3	
		n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>	n	n% <sup>a</sup>
Age (in years)	7–26	5	15.2	60	28.6	4	30.7	10	26.3	57	27.3	2	22.2
	27–46	17	51.5	83	39.5	6	46.2	16	42.1	83	39.7	7	77.8
	47–66	11	33.3	51	24.3	3	23.1	11	29.0	54	25.8	0	0.0
	67–86	0	0	16	7.6	0	0.0	1	2.6	15	7.2	0	0.0
Sex	Male	20	60.6	108	51.4	11	84.6	20	52.6	114	54.5	5	55.6
	Female	13	39.4	102	48.6	2	15.4	18	47.4	95	45.5	4	44.4

<sup>a</sup> Column percentages**Fig. 2** Showing Keros variation type 3 bilaterally**Table 3** Distribution of Keros type on both sides according to the sex of the patients

		Keros type on both sides			
		Same		Different	
		n	n <sup>a</sup>	n	n <sup>a</sup>
Sex	Male	115	82.7	24	17.3
	Female	98	83.8	19	16.2

<sup>a</sup> Row percentages

## Discussion

Computed tomography of the paranasal sinuses is vital in the preoperative evaluation of a FESS candidate. The familiarity concerning lateral lamella asymmetries and the olfactory fossa variants is indispensable to the endoscopic surgeon while performing FESS as it may lead to grave problems. Thus, radiographic assessment of the ethmoid roof is imperative to deliver a safe outcome to the patient.

In our study, type 2 Keros was the commonest, followed by type 1 and type 3. In our study, 82% patients had type 2 Keros on both sides, 12.9% patients (right side) and 14.8% patients (left side) had type 1 Keros,

and 5.1% patients (right side) and 3.5% patients (left side) had type 3 Keros. Murthy A. et al. [23] also found that majority of the patients (71.5%) had Keros type 2.

A higher proportion of male and female patients had Keros type 2 on both the sides (Table 2). Elwany S. et al. [24] in their study on radiologic inspection of ethmoid roof and olfactory fossa found that 68% male patients had Keros type 2 on right side, and 65.3% male patients had Keros type 2 on left side, while 52% female patients had Keros type 1 on right side and 54% on the left side, respectively. Type 3 Keros was seen significantly higher in males compared to females, but no reason could be identified for the differences observed.

Different Keros types of olfactory fossa on either side were observed in 16.8% of our study patients, whereas Babu A. C. et al. [14] observed a higher discordance of Keros (Fig. 3) type on either side 21.7%. and Pawar et al. [4] found asymmetry in types of Keros on either side in only 11.5% patients.

In our study, we found that the height of the lateral lamella between left and right was symmetrical in 59.4% and asymmetrical in 40.6% patients. The study by Souza S. A. et al. [25] on radiologic evaluation of the ethmoid roof showed that the height of the lateral lamellas

between left and right sides was symmetrical in 88%, while 5.5% had lower lateral lamella on left side, and 6.5% had lower lamella on right side.

A total of 6% of the patients had pneumatized crista galli in our study whereas Som P. M. et al. [26] observed pneumatisation of crista galli in CT scans of 13% of patients.

## Conclusion

This study evaluated the depth categorization of the ethmoid roof, and its variations on the basis of age and gender were examined. In our study, the leading and most common type was Keros type 2, but there was a noteworthy difference between the two sides in the same individual. Therefore, extra care must be taken during surgery to note the type of Keros on each side.

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## Authors' contributions

SN worked on gathering data and analysing the data and helped in manuscript writing. AA helped in analyzing data and major contributor in manuscript writing. BB helped in accessing the data and interpretation of data. CJ helped in reviewing the manuscript. The authors read and approved the final manuscript.

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## Availability of data and materials

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Ethics approval was obtained from the Father Muller Institution ethics committee vide number FMIEC/CCM/100/2020. Consent to participate is not applicable as it is a retrospective study

### Consent for publication

Not applicable

### Competing interests

The authors declare that they have no competing interests.

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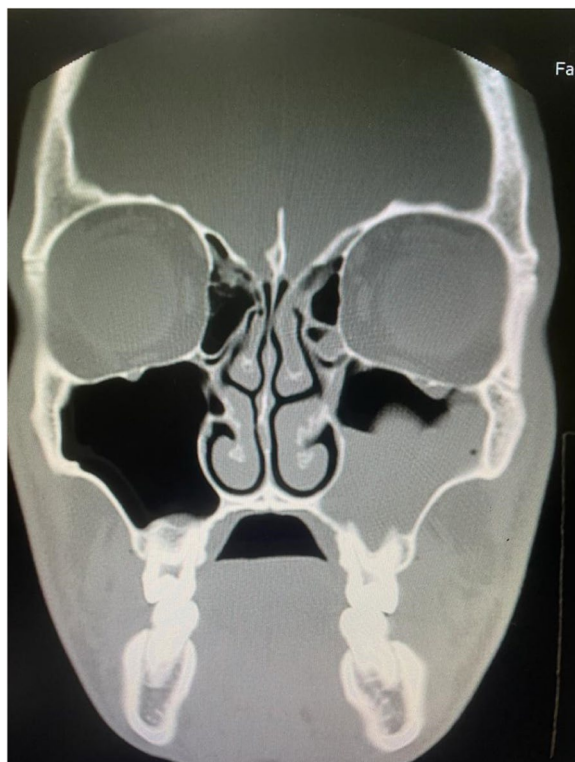
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**Fig. 3** Showing Keros variation type 2 on right side and type 1 on left side



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