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Assessment of olfactory fossa depth using computed tomography imaging in a tertiary care setting

Shantala Sawkar[1], Adarsh AD[2], Anil Kumar Sakalecha[3], Mahima Kale R[4], Soumya Z Chincholikar[5]

[1,5]Postgraduate Resident, [2]Professor, [3]Professor and Head, [4]Senior Resident, Department of Radio-diagnosis, Sri Devaraj Urs Medical College, Kolar, Karnataka, India

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ABSTRACT

Background: Chronic sinonasal disorders are commonly treated surgically with endoscopic sinus surgery. Keros classifies the olfactory fossa (OF) into three groups according to the ethmoid roof level. The depth of the OF is determined by the size of the lateral lamella of the cribriform plate. Multidetector computed tomography is gold standard in evaluating the structure of the nasal cavity and paranasal sinuses (PNS). **Aims and Objectives:** The aim of the study was to examine non-enhanced computed tomography (CT) scans of the paranasal sinus and analyze the depth of the OF to identify and categorize different Keros types and to evaluate anatomical variances to prevent major surgical complications. **Materials and Methods:** IM was a prospective study and 160 patients were enrolled for the study. The study was undertaken in the Department of Radiodiagnosis at Sri Devaraj Urs Medical College in Tamaka, Kolar. Patient with chronic sinonasal disorders undergoing pre-operative non-enhanced CT PNS study was enrolled in the study. The depth of the OF was measured and categorized into three groups according to Keros classification. **Results:** Out of 160 participants, 115 (71.8%) were male. The depth of the OF on the right (P=0.28) or left (P=0.66) did not differ significantly between genders. In men, the most prevalent (n=92, 57.5%) was Type-II Keros on the right, with 80 (50%) patients on the left. Type-1 Keros was more common in females on the right side (18 patients, 11.2%), whereas Type-II Keros was more common on the left side (20 patients, 12.5%). The proportion of different types of Keros differed significantly across genders (P<0.001). **Conclusion:** This study reveals that Keros Type-II was the most prevalent among participants. Comprehensive insights into the anatomical variability of the olfactory region are pivotal for through pre-operative assessment of patients with nasal and PNS disorders in preventing significant surgical complications.

Key words: Functional endoscopic sinus surgery; Keros classification; Paranasal sinus

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INTRODUCTION

Functional endoscopic sinus surgery (FESS) is a common surgical technique, and its important to understand the anatomy of the paranasal sinuses (PNS), olfactory fossa (OF), and adjacent anatomical structures during surgery. Because the PNS are close to the orbital spaces and the brain, the surgeon should be familiar with sinonasal anatomy and its associated variations.[1-3]

The OF, situated within the anterior cranial fossa, is structurally defined by the cribriform plate of the ethmoid bone, which acts as its floor and separates it from the cranial cavity. Its boundaries are marked by the crista galli medially and the lateral lamella of the cribriform plate laterally. This anatomical region houses the olfactory bulbs and tracts. The depth of the OF is determined by the height of the lateral lamella of the cribriform plate[4] (Figure 1).

Address for Correspondence:
Dr. Adarsh AD, Professor, Department of Radio-diagnosis, Department of Radiodiagnosis, Sri Devaraj Urs Medical College, Kolar, Karnataka, India. **Mobile:** +91-9894705836. **E-mail:** adarsh.7@gmail.com

Keros classified the OF into three categories according to the depth defined by the lateral lamella of the cribriform plate (Figure 2):

- Type I (1.0–3.0 mm)
- Type II (4.0–7.0 mm)
- Type III (8.0–16 mm).

The phrase "dangerous ethmoid" was coined to refer to Type III, which has higher surgical risks due to its depth.[5]

Paranasal sinus computed tomography (CT) is the most commonly used investigation technique in the assessment of the PNS, nasopharynx, and nasal cavity. Furthermore, the ability to capture pictures in both axial and coronal planes allows for effective evaluation of bone structures.[1-3]

Pre-operative evaluation of the anatomy of the ethmoid roof, anterior cranial fossa, and associated bone structures around the OF will result in a safer surgical path and fewer post-operative complications. As a result, a CT scan of PNS is very valuable before endoscopic sinus surgery.[3,6,7]

Aims and objectives

The objectives of the study are as follows:

1. Examine non-enhanced CT scans of the paranasal sinus and analyze the depth of the OF to identify and categorize different Keros types
2. Evaluate anatomical variances to prevent major surgical complications.

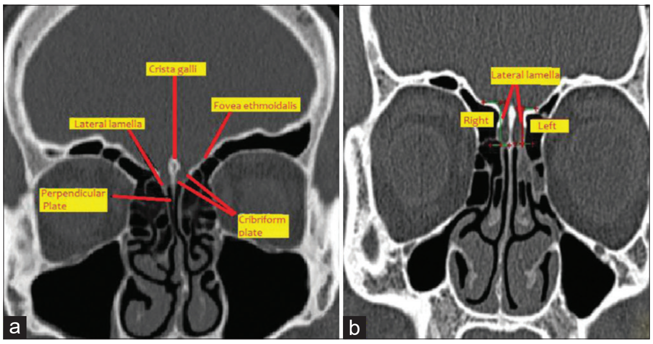

Figure 1: Reformatted coronal computed tomography scan showing: (a) Normal anatomy, (b) Lateral lamella utilized to measure olfactory fossa depth

MATERIALS AND METHODS

Hospital-based prospective study that included 160 patients and the study was conducted for 3 months in the Department of Radiodiagnosis at Sri Devaraj Urs Medical College from May 2024 to July 2024. Institutional Human Ethical Committee clearance was obtained and informed written consents were signed by all participants. CT scan images were captured using a multi-detector 128-slice CT scanner (Siemens Somatom go TOP). Coronal images were used in patients who matched the inclusion criteria. The depth of the OF was estimated by measuring the height of the lateral lamella. A line was drawn parallel to the highest point of the maxillary sinus at the bony boundaries of the infraorbital foramina. Perpendicular lines were drawn to the inferior and superior borders of the lateral lamella. The distance between these lines denoted the depth of the OF (Figure 3). The Keros classification was used to divide the OF into three groups based on the level of the ethmoid roof. The study populations gender and age distribution is described in Table 1.

Inclusion criteria

- Patient in the age group of 18–90 years undergoing non-enhanced CT PNS study was included in the study.

Exclusion criteria

The following criteria were excluded from the study:

- Patients with fracture/trauma to the PNS
- Patients with neoplastic lesions
- Congenital abnormalities of the face will not be included in the study.

Statistical analysis

- Data were entered into Microsoft Excel data sheet and was analyzed using SPSS 22 version software. Categorical data were represented in the form of Frequencies and proportions. Chi-square test or Fischer's exact test (for 2×2 tables only) was used as

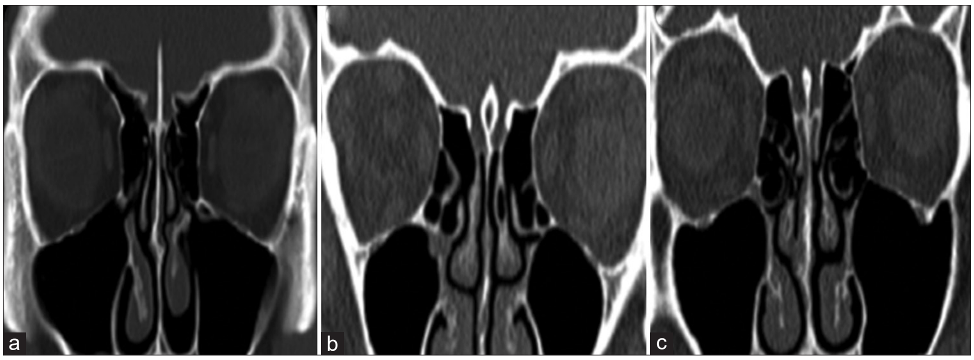

Figure 2: Computed tomography scan showing the Keros classification; (a) Keros Type I (b) Keros Type II (c) Keros Type III

test of significance for qualitative data.
- Continuous data were represented as mean and standard deviation. Independent t-test was used as test of significance to identify the mean difference between two quantitative variables.
- Graphical representation of data: MS Excel and MS Word was used to obtain various types of graphs
- P-value (Probability that the result is true) of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.
- Statistical software: MS Excel, SPSS version 22 (IBM SPSS Statistics, Somers NY, USA) was used to analyze data.

RESULTS

In our study, we had 160 patients among which 115 (71.8%) were male and 45 (28%) were females.

DISCUSSION

The PNS area is a complicated anatomical structure with several variants. These variances make FESS surgery a difficult operation. To avoid difficulties, one must be aware of anatomical variances, with the OF being one of the most susceptible areas. The integrity of the lamina papyracea may be compromised during surgery. The optic nerve is adjacent to both the sphenoid and ethmoid sinuses and can be damaged directly during posterior ethmoidectomy and sphenoidectomy. Cerebrospinal fluid (CSF) leak, intraparenchymal hematoma, subarachnoid hemorrhage, cerebritis, abscess, pneumocephalus, and meningoencephalocele are some of the intracranial complications. As the depth of the lateral plate of the cribriform plate increases, the OF narrows and deepens, and the roof of the ethmoid becomes lower and hangs, increasing the chances of surgical injury (Tables 2 and 3).[8]

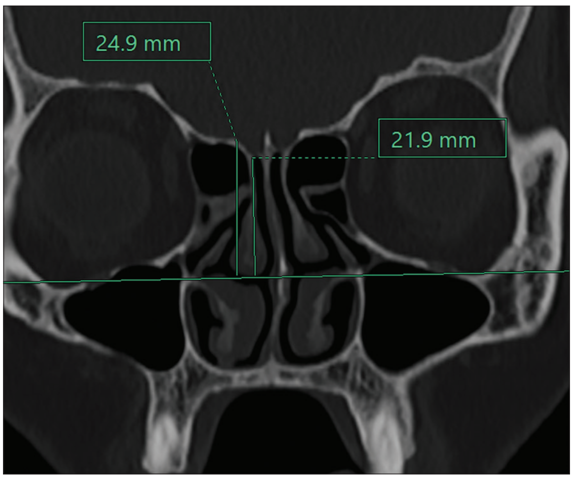

Figure 3: Reformatted coronal computed tomography scan showing measurement of olfactory fossa depth. A line was drawn parallel to the highest point of the maxillary sinus at the bony boundaries of the infraorbital foramina. Perpendicular lines were drawn to the inferior (arrow) and superior borders (arrowhead) of the lateral lamella. The distance between these lines is 3.0 mm (type I keros)

In the context of paranasal sinus treatment and care, the use of endoscopy carries inherent risks of perforation during surgical interventions. To reduce these iatrogenic complications, thorough evaluation of the ethmoid roof through CT scan is essential, as explained in various researches[9,10]

In the present study, 43.56 years was the mean±SD age among the study group. According to a study conducted by Kaplanoglu et al., out of a total of 500 cases, the mean age of the patients was 39.41 years with a median value of 38 years (Age range: 18–81 years).[11]

In our current study, it was observed that Keros Type-II (65.3%) was the most common OF type, followed by Type-I (24.3%) and Type-III (10.3%). These findings align with research conducted by Pawar et al., where Type-2 (74.5%) OF type was the most common among the group.[12] Similar findings were observed in the study by Babu et al.,[13] with a sample size of 1200 subjects, Type 2 Keros was the most common (74.6%), followed by Type 1 (17.5%) and type 3 (7.9%).

In the present study, mean±SD OF depth on the right side (5.32±1.62 mm) and left side (5.28±1.65 mm) with no

Table 1: Comparing the depth of olfactory fossa between males and females

Side	Olfactory fossa depth (mm) (Mean±SD)		P-value
Right	Males	5.41±1.21	0.288
	Females	5.17±1.45	
	Total	5.32±1.62	
Left	Males	5.38±1.34	0.665
	Females	5.25±1.73	
	Total	5.28±1.65	

Table 2: The table depicts the study population's gender and age distribution

Gender	n (%)
Males	115 (71.8)
Females	45 (28.2)
Age groups	**n (%)**
<30 years	50 (31.25)
31–40 years	39 (24.37)
41–50 years	29 (18.13)
51–60 years	21 (13.12)
>60 years	21 (13.12)

Table 3: Distribution of Keros types among the different age groups

Age group (Years)	Keros types					
	Type-1		Type-2		Type-3	
	Right n (%)	Left n (%)	Right n (%)	Left n (%)	Right n (%)	Left n (%)
<30	12 (24)	14 (28)	35 (70)	34 (68)	3 (6)	2 (4)
31–40	7 (17.9)	8 (20.5)	27 (69.2)	28 (71.8)	5 (12.8)	4 (10.2)
41–50	7 (24)	8 (27.5)	17 (58.6)	18 (62)	5 (17.2)	3 (10.3)
51–60	5 (23)	5 (23.8)	14 (66.7)	11 (52.3)	2 (9.5)	4 (19)
>60	4 (19)	8 (38.1)	16 (76.1)	9 (42.8)	1 (4.7)	4 (19)

significant difference in the depth of OF between the two sides. In a study by Babu et al.,[13] mean OF depth on the right side and on the left side was 5.27 mm and 5.25 mm, respectively. In an another study by Srivastava et al.,[14] the mean OF depth on the right side (5.17 mm) and left (5.15 mm) with no significant variation between the two sides (Table 4).

In the present study where a total of 320 sides was considered, Type-I was seen in 78 (24.3%) sides, Type-II was seen in 209 (65.3%) sides, and Type-III was seen in 33 sides (10.3%). On the right side, Type-I was seen in 35 (21.8%) patients, Type II was seen in 109 (68.1%) patients, and Keros Type III was seen in 16 (10%) patients. On the left side, 43 (26.8%) patients were Keros Type I, 100 (62.5%) patients were Type II, and 17 (10.6%) patients were Type III. Among a total of 115 males, on the right side, Keros Type I was seen in 17 (10.6%) patients, Type II was seen in 92 (57.5%) patients, and Type III was seen in 6 (3.75%) patients (Table 5). Among a total of 45 females, Keros Type I was seen in 18 (11.2%) patients, Type II was seen in 17 (10.6%) patients, and Type III was seen in 10 (6.25%) patients (Table 5). Using the Chi-square test, P<0.001. Among men, on the left side, Keros Type I was seen in 27 (16.8%) patients, Type II was in 80 (50%) patients, and Type III was seen in 8 (5.0%) patients. Among women, on the left side, Type I was seen in 16 (10%) patients, Type II was seen in 20 (12.5%) patients, and Type III was seen in 9 (5.6%) patients (Table 5). Using the Chi-square test, P-value obtained as <0.001.

In a study by Pawar et al.,[12] there was a statistically significant asymmetry in the depth of right and left OF in males, the right being deeper, and no statistically significant asymmetry was seen in females. In the current investigation, there was no significant correlation between sex and the distribution of symmetric and asymmetric OF.

In contrast to previous research by Karatay and Avcı[15] and Naidu et al.,[16] there was no statistically significant variation in OF depth between males and females on both the right and left sides.

Table 4: Comparing the current study's Keros categorization to other research

Studies	N	Type I (%)	Type II (%)	Type III (%)
Souza et al.[17]	400	26.3	73.3	0.5
Jang et al.[18]	205	30.5	69.5	None
Pawar et al.[12]	200	18.5	74.5	7
Nitinavakarn et al.[19]	88	11.9	68.8	19.3
Adeel et al.[20]	77	29.9	49.4	20.8
Basak et al.[21]	64	9	53	38
Babu et al.[13]	1200	17.5	74.6	7.9
Current study	160	24.3	65.3	10.3

Table 5: Keros type distribution in males and females

Keros types	Right		Left	
	Males n (%)	Females n (%)	Males n (%)	Females n (%)
Type 1	17 (14.7)	18 (40)	27 (23.4)	16 (35.5)
Type 2	92 (80)	17 (37.7)	80 (69.5)	20 (44.5)
Type 3	6 (5.3)	10 (22.3)	8 (6.9)	9 (20)
Total	115 (100)	45 (100)	115 (100)	45 (100)
P-value	<0.001*		<0.001*	

*Correlation is significant (P<0.001)

Endoscopic sinus surgeries carry risks ranging from minimal complications, noticed in 1.1–20.8% of cases, serious major complications can happen including hemorrhage, CSF leakage, infection, ocular trauma, and intracranial injury.[8] Understanding the subtleties of paranasal sinus structure and anatomical variations is critical for reducing these risks and improving surgical outcomes.

Limitations of the study

Our study had a modest sample size, but subsequent studies with larger sample size will improve the categorization of Keros in regular reporting of CT scans. A single radiologist did the measurements. Furthermore, because all participants were adults aged >18, the applicability of our findings to children and adolescents may be limited. There has been no prospective comparison of the incidence of injuries during surgery, surgeon difficulty level while operating, and OF depth. As the study institution was done in a tertiary care center, there is a possibility of centripetal bias.

CONCLUSIONS

This study found that Keros Type II was the most prevalent among participants, followed by Types I and III. The depth of the OF differs on the right and left sides, as the majority of people exhibit asymmetry. There was no significant difference in OF depth between males and females. Based on the most common kind of Keros, males are deemed to have an intermediate risk of injury during surgery because Type 2 Keros occurs on both sides. Females have a lower risk on the right side than the left side because Type 1 Keros is more frequent on the right side in females. The proportion of dangerous Type 3 Keros is more common in females than in males, placing them at a greater risk of injury during surgery. Prospective studies that include intraoperative information from the surgeon can provide additional information on the efficacy of the Keros grade and help risk stratify patients. Furthermore, there is some discordance in the results of numerous research published around the world, which might be attributed to differences in population composition due to ethnicity and race.

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SS- Definition of intellectual content, literature survey, prepared the first draft of manuscript, implementation of the study protocol, data collection, data analysis, manuscript preparation and submission of article; **AAD**- Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **AKS**- Design of study, statistical analysis, and interpretation; **MKR**- Literature survey and preparation of figures; **SZC**- Literature survey and preparation of figures.

Work attributed to:
Sri Devaraj Urs Medical College, Tamaka, Kolar, Karnataka, India.

Orcid ID:
Dr. Shantala Sawkar - https://orcid.org/0009-0008-8171-5118
Dr. Adarsh AD - https://orcid.org/0009-0000-9062-1107
Dr. Anil Kumar Sakalecha - https://orcid.org/0000-0003-2957-4908
Dr. Mahima Kale R - https://orcid.org/0000-0002-2372-6205
Dr. Soumya Z Chincholikar - https://orcid.org/0009-0005-1735-6219

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