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## **Olfactory fossa depth: A radiological analysis and its surgical significance**

**Dr Vikaashini Devi B B**

Postgraduate final year MS ENT, Department of ENT, Vinayaka Mission Kirupananda Variyar Medical college and hospital Salem

**Dr Shivakumar S**

Professor and HOD, Department of ENT, Vinayaka Mission Kirupananda Variyar Medical college and hospital Salem

**Abstract**---Introduction: Functional endoscopic sinus surgery (FESS) has become most preferred procedure in treatment of diseases of the nose and paranasal sinuses. The purpose of this study is to discuss the incidence of skull base injury during surgery and radiologically analyse the depth of the olfactory fossa and the length of the lateral lamella in a CT PNS scan using the Keros classification, to determine the age and gender distribution, and to discuss its significance in surgical practice. Methodology: This is a retrospective study which was conducted among 200 patients above 10 years of age who visited ENT department in the past one year and had undergone CT PNS scan in radiology in VMKVMCH, Salem for sinusitis, headache, sinonasal polyposis and deviated nasal septum and those undergoing surgery. Scans of patients with previous history of surgery or trauma to nose and PNS and congenital anomalies of face were excluded. The results correlated with surgical relevance in FESS. Results: There were about 17% in Keros classification I, 78% Keros classification II and 6% Keros classification III. There are about 61% symmetric type of olfactory fossa between right and left sides based on Keros type and 39% asymmetric type of olfactory fossa between right and left sides based on Keros type. Mean depth right Olfactory with Keros Classification I  $3.17 \pm 0.50$  mm, Keros classification II  $5.65 \pm 1.13$  mm and Keros classification III  $8.33 \pm 0.32$  mm. Mean depth left Olfactory with Keros Classification I  $3.24 \pm 0.49$  mm, Keros classification II  $5.77 \pm 0.96$  mm and Keros classification III  $8.27 \pm 0.32$  mm. Conclusion: Type II is the most common Keros' type in our study, and type III is the least common. In our population, a deep olfactory fossa is more common on the right than on the left and incidence of skull base injury is higher with type 3 Keros.

**Keywords**---cribriform plate, ethmoidal roof, lateral lamella cribriform plate, olfactory fossa depth.

## Introduction

The functional endoscopic sinus surgery (FESS) has excellent outcomes with few complications when performed with a thorough understanding of endoscopic anatomy and anatomic variations in the nose and paranasal sinuses, which provides the necessary anatomy and pathology of disease condition.<sup>1</sup> The olfactory fossa depth and lateral lamella length are critical in FESS among all important parameters in the preoperative CT evaluation. The cribriform plate of the ethmoid forms the floor of the olfactory fossa, and its lateral boundary is a thin plate of bone called the lateral lamella. The depth of the fossa can be measured in two ways: by drawing horizontal lines along the cribriform plate and meeting point of the ethmoid roof with the lateral lamella of the cribriform plate and measuring the vertical height between them, or by measuring the depth relative to a plane passing through the two infraorbital foramen.

Endoscopic sinus surgery (ESS) is a common procedure that is not only used to treat chronic rhinosinusitis that has not responded to medical treatment, but also to treat a variety of conditions and approaches such as nasal polyposis, mucocoele, sellar and parasellar tumours, optic nerve decompression, and other intracranial lesions.<sup>1</sup> Although ESS is widely used, it is not without complications. These are classified as minor and major complications. In 1.1–20.8 percent of functional endoscopic sinus surgery cases, minor complications occur.<sup>2</sup> These symptoms include bleeding, infection, crusting, synechiae formation, ostial stenosis, tooth or lip numbness, and disease recurrence.<sup>2</sup> In 0–1.5 percent of such operations, major complications occur. Cerebrospinal fluid leak, ocular injury (herniation of orbital fat, extraocular muscle injury, ocular motility dysfunction, optic nerve injury, and peri-orbital hematoma or periorbital emphysema), and intracranial injury are examples of these (brain or major blood vessels injury).<sup>2,3</sup> The purpose of this research is to assess variations in these parameters and their surgical significance during endoscopic sinus surgery.<sup>2-5</sup>

## Methodology

This is a retrospective study which was conducted among 200 patients above 10 years of age who visited ENT department in the past one year and had undergone CT PNS scan in radiology in VMKVMCH, Salem for sinusitis, headache, sinonasal polyposis and deviated nasal septum and those undergoing surgery. Scans of patients with previous history of surgery or trauma to nose and PNS and congenital anomalies of face were excluded. The olfactory fossa depth was measured by the vertical height of the lateral lamella of cribriform plate. It is the height of cribriform plate with respect to the roof of ethmoid. The depth is classified according to Keros. The parameters studied in coronal sections of CT where cristagalli is evident. The results correlated with surgical relevance in FESS.

The data are reported as the mean +/- SD or the median, depending on their distribution. Frequencies are expressed in percentages. The differences in

quantitative variables between groups were assessed by means of the unpaired t test. Comparison between groups was made by the Non parametric Mann - whitney test ANOVA was used to assess the mean depth with Kerosclassification. The chi square test was used to assess differences in categoric variables between groups Wilcoxon matched pair signed rank test is applied to see the significant difference between the depth of right and left fossa. A p value of <0.05 using a two-tailed test was taken as being of significance for all statistical tests. All data were analysed with a statistical software package.

## Results

The mean age of the study participants were  $40.42 \pm 14.02$  years. There were about 5% in the age group of 11-20 years followed by 28% 21-30 years, 20% 31-40 years, 22% 41-50 years, 16% 51-60 years and 11% 61-70. There were about 58% males and 42% females. There were about 3% males in 11-20 years, 15% 21-30 years, 13% 31-40 years, 12% 41-50 years, 10% 51-60 years and 7% 61-70 years of age group. There were about 2% females in 11-20 years, 13% 21-30 years, 8% 31-40 years, 10% 41-50 years, 6% 51-60 years and 5% 61-70 years of age group (Table 1). There were about 17% in Keros classification I, 78% Keros classification II and 6% Keros classification III. Around 17.5% of right sided patients and 16% of left sided patients are on Keros classification I; 76% of right sided patients and 79.5% of left sided patients have Keros classification II; 6.5% of right sided patients and 4.5% of left sided patients have Keros classification III (Table 2). There are about 61% symmetric type of olfactory fossa between right and left sides based on keros type and 39% asymmetric type of olfactory fossa between right and left sides based on keros type (Table 3).

Table 1: Distribution of age and gender among the study participants (N = 200)

Slno	Age group (years)	Males	%	Females	%
1	11-20	6	3%	3	2%
2	21-30	29	15%	26	13%
3	31-40	25	13%	15	8%
4	41-50	24	12%	19	10%
5	51-60	19	10%	12	6%
6	61-70	13	7%	9	5%
Total		116	58%	84	42%

Table 2: Distribution of Keros classification between right and left sides of total patients based on Keros type (N = 200)

Slno	Keros classification	On Right Side	Percentage %	On Left side	Frequency
1	I	35	17.5%	32	16.0%
2	II	152	76.0%	159	79.5%
3	III	13	6.5%	9	4.5%
Total		200	100.0%	200	100.0%

Table 3: Asymmetrical distribution rates of olfactory fossae based on Keros type between right and left sides (N = 200)

Slno	Type of olfactory fossa between right and left sides based on keros type	Frequency	Percentage %
1	Symmetric	122	61.0%
2	Asymmetric	78	39.0%
Total		200	100.0%

Table 4: Mean Depth Right Olfactory with Keros Classification

Slno	Keros classification	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	Sig
					Lower	Upper			
1	I	3.17	0.50	0.09	3.00	3.34	2.51	3.99	
2	II	5.65	1.13	0.09	5.47	5.83	4.01	8.59	<0.001
3	III	8.33	0.32	0.09	8.13	8.52	8.01	9.05	
Total		5.39	1.58	0.11	5.17	5.61	2.51	9.05	

Mean depth right Olfactory with Keros Classification I  $3.17 \pm 0.50$ mm, Keros classification II  $5.65 \pm 1.13$ mm and Keros classification III  $8.33 \pm 0.32$ mm (Table 4). Mean depth left Olfactory with Keros Classification I  $3.24 \pm 0.49$ mm, Keros classification II  $5.77 \pm 0.96$ mm and Keros classification III  $8.27 \pm 0.32$ mm (Table 4).

Table 5: Mean Depth Left Olfactory with Keros Classification

Slno	Keros classification	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	Sig
					Lower	Upper			
1	I	3.24	0.49	0.09	3.06	3.41	2.51	3.98	
2	II	5.77	0.96	0.08	5.62	5.92	2.81	8.59	<0.001
3	III	8.27	0.32	0.11	8.03	8.52	8.01	8.96	
Total		5.48	1.42	0.10	5.28	5.68	2.51	8.96	

## Discussion

Endoscopic sinus surgery is performed primarily to remove disease from the paranasal sinuses and improve ventilation. This method of disease eradication is widely used. The risk of iatrogenic injury to the skull base area during surgery is always present, and the most vulnerable area is the LLCP due to its thinness. 10 As a result, it is critical to use CT imaging of the nose and paranasal sinuses to determine the LLCP and olfactory fossa depth. A coronal cut CT scan provides the best surgical anatomy. We conducted our research in accordance with the variations proposed by Keros in 1962.<sup>6</sup>

In a study by Shreshta et al Type I has a depth of 1-3mm and is seen in 12% of patients, type II has a depth of 4-7mm and is seen in 70% of patients, and type III has a depth of 8-16mm and is seen in 18% of patients, according to Keros' study of 450 skulls.<sup>7</sup> whereas In EmrahKaratay et al, type 1 seen in 30.85%, type II in

66.75% and type III in 2.4%. In our study there were about 17% in Keros classification I, 78% Keros classification II and 6% Keros classification III. Around 17.5% of right sided patients and 16% of left sided patients are on Keros classification I; 76% of right sided patients and 79.5% of left sided patients have Keros classification II; 6.5% of right sided patients and 4.5% of left sided patients have Keros classification III. There are about 61% symmetric type of olfactory fossa between right and left sides based on keros type and 39% asymmetric type of olfactory fossa between right and left sides based on keros type. Iatrogenic skull base injury occurred in 3 patients with type 2 keros and 8 patients with type 3 keros.

In our study the mean age of the study participants were  $40.42 \pm 14.02$  years. There were about 5% in the age group of 11-20 years followed by 28% 21-30 years, 20% 31-40 years, 22% 41-50 years, 16% 51-60 years and 11% 61-70. There were about 58% males and 42% females. There were about 3% males in 11-20 years, 15% 21-30 years, 13% 31-40 years, 12% 41-50 years, 10% 51-60 years and 7% 61-70 years of age group. There were about 2% females in 11-20 years, 13% 21-30 years, 8% 31-40 years, 10% 41-50 years, 6% 51-60 years and 5% 61-70 years of age group.

In our study the mean depth right Olfactory with Keros Classification I  $3.17 \pm 0.50$ mm, Keros classification II  $5.65 \pm 1.13$ mm and Keros classification III  $8.33 \pm 0.32$ mm. Mean depth left Olfactory with Keros Classification I  $3.24 \pm 0.49$ mm, Keros classification II  $5.77 \pm 0.96$ mm and Keros classification III  $8.27 \pm 0.32$ mm. The difference in height could be due to variations in ethmoidal roof configuration among different populations, or it could be due to the use of different measurement methods. We used the infraorbital foramen as a reference point in our research. This reference point has been suggested in the literature as having anatomic value during endoscopic middle meatal antrostomy because it aids in determining the position of the ethmoidal roof. Our research also revealed that the depth of the olfactory fossa in males was greater on the right side, whereas it was greater on the left side in females. We couldn't figure out why it was happening. However, hormonal factors may play a role in the development of craniofacial asymmetry. The literature also shows a variation in the depth of the olfactory fossa, either on the left or right side, with no consistency.<sup>8,17, 23-25</sup>

However, in our study, the overall depth of the olfactory fossa was on the higher side. The significance of our findings revealed that when endoscopic sinus surgery is performed on the right side, skull base injury with cerebrospinal fluid leaks occur more frequently, as previously reported in the literature. As a result, we must exercise extreme caution when performing surgery on the right side. The type II Keros' variation was the most common in our study. As a result, performing endoscopic sinus surgery in a type II population like ours is safer for the surgeon because the iatrogenic risk of skull base injury is low.

## **Conclusion**

The purpose of the research on variations of Keros' classification is to avoid injury to the ethmoidal roof during sinus surgery. Type II is the most common Keros' type in our study, and type III is the least common but with higher risk of skull

base injury.. In our population, a deep olfactory fossa is more common on the right than on the left. Prior to sinus surgery, a careful and precise assessment of the CT nose and PNS is required to avoid serious iatrogenic injury.

### Recommendation

The type II Keros' variation is the most common, type III keros had higher iatrogenic injury and a deep olfactory fossa on the right is more common than on the left. However, because this is a single-institutional study, we recommend a multi-institutional study in different regions to give clear idea about the surgical complications and necessary precautions.

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