Original Article

Anita GC[1], Arun KC[1], Prakash Bahadur Thapa[1], Hariom Joshi[2], Prashant Khatiwada[2], Dhiraj Bisankha[1]

[1]Department of Otolaryngology and Head and Surgery, Bir Hospital, NAMS, Kathamandu Nepal

[2]Department of Radiology, Bir Hospital, NAMS, Kathamandu Nepal

Corresponding Author

Dr. Anita GC, Department of Otolaryngology and Head and Surgery, Bir Hospital, NAMS, Kathamandu Nepal

Email: gcanita222@gmail.com

EVALUATION OF OLFACTORY FOSSA DEPTH: OUR INSTITUTIONAL EXPERIENCE

ABSTRACT

Aims and Objectives: The objective of the study is to find the depth of the olfactory fossa in Nepalese population.

Methods: It is a retrospective study carried at department of Otolaryngology and Head & Neck Surgery at a tertiary hospital. The clinical case records of all the patients who have undergone CT imaging of paranasal sinuses (PNS) from 1 February to 25 September 2024 were taken from the CT archives of radiology department. The depth of the Olfactory fossa was measured on coronal CT images according to Keros classification, based on the vertical height of the lateral lamella of the cribriform plate.

Results: The total number of CT scans studied were 87 out of which 50 were males and 37 were females. The mean length of the olfactory fossa on the right side was 3.74±1.41mm and on the left side was 3.30±1.34 mm. The maximum depth of olfactory fossa was 7.39 mm which was on the right side. Our study shows Keros type I was the commonest (65.5%) followed by Keros type II (35.5%) and there were no Keros type III.

Conclusion: The majority of Olfactory fossa depth in our study fall in Keros type I category(0-4mm). There was a significant difference in the depth of the two sides where the right side was longer than the left side. (p value =0.015)

Keywords: Keros type, Lateral lamella cribriform plate, Olfactory fossa depth

INTRODUCTION

Preoperative knowledge of olfactory fossa depth is one of the pre-requisites in a patient planned for Functional Endoscopic Sinus surgery (FESS). It is one of the common procedures for various sino-nasal diseases. Because of the complexity of the paranasal sinuses and their location adjacent to the orbital spaces and the brain, the surgeon should be aware of sinonasal anatomy and associated variations.[1] The olfactory fossa (OF) and the area around the ethmoid cells are called the 'dangerous zone', if the depth and anatomical variations of the olfactory fossa are not considered in preoperative imaging, complications may occur more frequently during surgery.[2] The olfactory fossa is bordered medially by crista galli, laterally by the lateral lamella of the cribriform plate (LLCP), and inferiorly by the fragile cribriform plate of the ethmoid bone.[3] The LLCP is the thinnest bone in the entire anterior skull base, hence it is the region most at risk of the OF (lesions occur commonly).[3] A variable segment of the LLCP is vulnerable during FESS, specifically during dissection of the fronto-ethmoidal region.[4] The depth of the olfactory fossa is determined by the height of the lateral lamella of the cribriform plate. According to the classification made by Keros in 1962, the depth of the olfactory fossa is evaluated in three categories: type 1, 1-3 mm; type 2, 4-7 mm; and type 3, 8-16 mm.[5] Type 3 is the most dangerous type where cribriform is very thin, low lying and at most risk for injury during surgery.[6]

Computed tomography of the nose and paranasal sinuses is a frequently used imaging modality for anatomical and disease evaluation. Preoperative evaluation of the anatomy of the ethmoid roof, anterior cranial fossa and related bone structures adjacent to the olfactory fossa will provide a safer route during surgery and reduce postoperative complications. Therefore, paranasal sinus CT is very valuable before endoscopic sinus surgery.[7,8]

Our hospital, National Academy of Medical Sciences, Bir Hospital is a central government hospital and people from all over the country come to our outpatient department for various surgical and non-surgical cases. Thus, our sample represents a Nepalese population from various parts of the country.

The aim of the study is to examine the CT scans of the nose and the paranasal sinuses and determine the depth of the olfactory fossa as per Keros classification in Nepalese population.

METHODS

This was a retrospective study, wherein the clinical case records of all the patients who have undergone CT imaging of paranasal sinuses (PNS) from 1 February 2024 to 25 September 2024 were taken from the CT archives of radiology department at our institution.

The inclusion criteria for scan selection were as follows: scans with slice thickness ≤1 mm, patients ≥18 years of age, benign sinonasal diseases. The exclusion criteria were previous history of surgery, road traffic injury and suspected malignancy and revision nasal surgery.

Figure.1 shows the normal anatomical structures in the anterior skull base namely crista galli (CG), olfactory fossa (OF), fovea ethmoidalis (FE), lateral lamella of the cribriform plate(LLCP), perpendicular plate of the ethmoid bone(PPEB), vertical plate of the middle turbinate(VPMT)

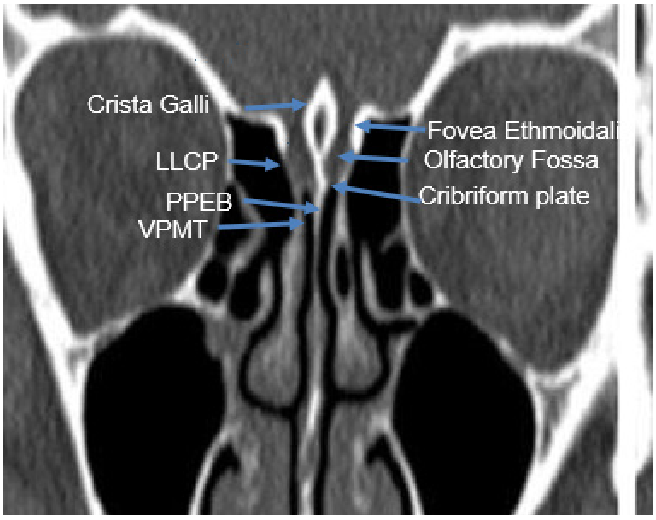

Figure 1. The different anatomical structures of the ethmoid roof and olfactory fossa in coronal view CT scan.CG-crista galli, OF-olfactory fossa, FE-fovea ethmoidalis, LLCP-lateral lamella of the cribriform plate, PPEB-perpendicular plate of ethmoid bone, VPMT-vertical plate of middle turbinate[5]

Imaging protocol:

Non-contrast coronal and axial CT scans of the paranasal sinuses (PNS) were performed using a 128-slice Philips CT scanner. Images were reconstructed with a slice thickness of 1 mm using a bone algorithm to assess the olfactory fossa and surrounding structures.

Assessment Olfactory fossa depth

The depth of the olfactory fossa was measured on coronal CT images according to Keros classification based on the vertical height of the lateral lamella of the cribriform plate. Measurements were performed bilaterally by two independent radiologists with discrepancies resolved by consensus. In the CT scan the coronal scan showing the maximum depth of the olfactory fossa was obtained in the bone film. Line A, which is the horizontal line connecting the most superior bony boundaries of the inferior orbital foramina on both sides. Line B was drawn from the most medial aspect of the orbital plate of the frontal bone forming the orbital roof (fovea ethmoidalis) which is connected to the lateral aspect of the lateral lamella of the cribriform plate of the ethmoid bone (LLCP) as a direct vertical line connecting to line A. Line C was drawn as a direct vertical line connecting line A to the most lateral bony boundary of the cribriform plate of the ethmoid bone at its communication with the lateral lamella. Line B was representing the medial ethmoid roof height while line C was representing cribriform plate height (Figure. 2). The depth of the olfactory fossa is formulated by d=Line B-Line C.

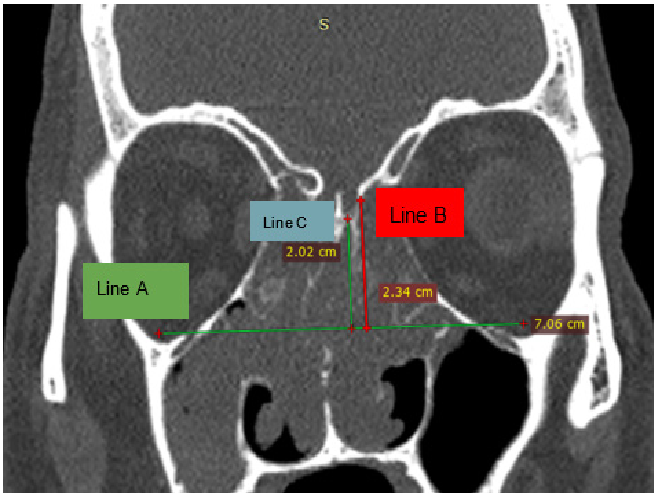

Figure 2. Lines A, B and C used for measurements are demonstrated. The depth of the olfactory fossa is formulated by d=Line B-Line C i.e. 0.32mm=2.34-2.02.

SPSS 20.0 was for statistical analysis. The collected data were evaluated using the descriptive statistical methods (the mean, standard deviation and median). Measurements between the right and left sides were compared. The results were categorized according to Keros classification which was modified to type I(0-3.99mm), type II(4.0-7.99mm) and type III(8.0-16mm) as in the original classification >3 to <4 mm and >7 to <8 mm which were not included in any types. Their distributions were analyzed according to gender and the sides (right and left).

RESULT

The total number of CT scans studied were 87 out of which 50 were males and 37 were females. The male to female ratio was 1.35. The patients included were 18 and above and the oldest patient was 84 years old. The mean age was 37.2 years. The mean length of the olfactory fossa on the right side was 3.74±1.41mm and on the left side was 3.30±1.34 mm. The maximum length of olfactory fossa was 7.39 mm which was on the right side. Our study shows type I was the commonest (65.5%) followed by type II (35.5%) and there was no type III.

Table 1. Mean age

	Male(n=50)	Female(n=37)
Age(mean) (years)	38.5	35.67

Table 2. Relation between Keros type and gender

Keros type	Overall (n=174)	Male (n=100)	Female (n=74)
Type I(1-3.9)	114(65.5%)	67(67%)	47(63.5%)
Type II(4-7.9)	60(34.5%)	33(33%)	27(36.5%)
Type III(8-12)	0	0	0

Table 3. Relation between gender and depth of olfactory fossa

Side	Sex	Olfactory fossa depth(mm) Mean±SD
Right	Males	3.69±1.35
	Females	3.82±1.51
	Total	3.74±1.41
Left	Male	3.20±1.26
	Female	3.43±1.44
	Total	3.30±1.34

DISCUSSION

The PNS area is a complicated anatomical structure with several important structures within a closed space. Therefore, a detail anatomical knowledge of the area is vital to avoid complications

and for good surgical outcome. The thin-section paranasal sinus CT also provides an important guide for the diagnosis and treatment of paranasal sinus disease and also identification of any anatomical variations. There is always the probability of facing complications during FESS in spite of good anatomical knowledge and CT scans as it is a complex anatomical space. The major complications are cerebrospinal fluid leakage, meningitis or intracranial vascular trauma. There may be anterior ethmoidal artery trauma which may result into orbital hematoma and these complications are established in 0-1.5% of cases while the minor complications, including bleeding, infection, crusting, synechiae, ostial stenosis, and recurrence of the disease, occur in 1.1-20.8% of functional endoscopic sinus surgery cases[9-10]. Regarding the risk of complication development during ESS, the fovea ethmoidalis and lateral lamella are the most important parts of the skull base.[10]

In the literature there are different findings of depth of the olfactory fossa in different parts of the world which are shown in table 4 and table 5.

Table 4. Studies where Keros' type I was common

Authors	Country	Keros' Type I (%)	Keros' Type II (%)	Keros' Type III (%)
Paber et al.[11]	Phillipines	81.8	17.7	0.5
Solares et al.[12]	USA	83.0	15.0	2.0
Alazzani et al.[13]	Malaysia	80.0	20.0	0
Bista et al .[14]	Nepal	86	2	2

Table 5. Studies where Keros' type II was common

Authors	Country	Keros' Type I (%)	Keros' Type II (%)	Keros' Type III (%)
Jacob et al.[6]	India	23.44	70.83	5.73
Keros P.[5]	Germany	26.3	73.3	0.5
Kaplanoglu et al.[10]	Turkey	13.4	76.1	10.5
Souza et al.[4]	Brazil	26.3	73.3	0.5

One of the oldest known studies on the olfactory fossa is the cadaveric study published by Keros P. in 1962, type I has a depth of 1-3mm and is seen in 12% patients, type II has a depth of 4-7mm and is seen in 70% patients, whereas type III has a depth of 8-16mm and is seen in 18% patients.[5] Our findings are similar to other studies done in Nepal, Bista et al[14] had the finding of 86.0%,12.0% and 2.0%. Whereas in study done by Keros[5], Kaplanoglu et al.[10] and Souza et al.[5] Keros type II was the commonest variation. So, there is marked variation in Keros' types in the literature.

The thin-section paranasal sinus CT also provides an important guide for the diagnosis and treatment of paranasal sinus disease[11] and also identification of any anatomical variations. There is always the probability of facing complications during FESS in spite of good anatomical knowledge and CT scans as it a closed and complex anatomical space. The major complications are cerebrospinal fluid leakage, meningitis or intracranial vascular traumatization, and anterior ethmoidal artery trauma which may result into orbital hematoma, these complications are established in 0-1.5% of cases while the minor complications, including bleeding, infection, crusting, synechiae, ostial stenosis, and recurrence of the disease, occur in 1.1-20.8% of functional endoscopic sinus surgery cases.[15] Regarding the risk of complication development during ESS, the fovea ethmoidalis and lateral lamella are the most important parts of the skull base.[14] One of the oldest known studies on the olfactory fossa is the cadaveric study published by Keros P. in 1962, type I has a depth of 1-3mm and is seen in 12% patients, type II has a depth of 4-7mm and is seen in 70% patients, whereas type III has a depth of 8-16mm and is seen in 18% patients.[5] Our study shows type I was the commonest (65.5%) followed by type II(35.5%) and there were no type III. Our findings are similar to other studies done in Nepal, Bista et al[14] had the finding of 86.0%(I),12.0%(II) and 2.0%(III). Whereas in study done by Keros[5], Kaplanoglu et al.[10] and Souza et al.[4] Keros type II was the commonest variation. So, there is marked variation in Keros' types in the literature.Our study showed that the height of LLCP on right side was 3.74±1.41mm, whereas on left side, it was 3.28±1.34mm. In this study there was statistical difference i.e., the $p<0.05$ between the mean values of olfactory fossa depth in the right and the left side (p value: 0.015).

There was only one case of symmetry in the depth of olfactory fossa depth. It showed that the depth of the olfactory fossa was more on right side in both males and in females. The literature has also shown variation in depth of olfactory fossa either on left or right side with no consistency[15].The overall depth of olfactory fossa was more on the right side (66.6%) in our study. The literature shows that there is more of skull base injury on the right side during the endoscopic sinus surgery[1,5]. In our study the type I Keros' variation was the most common which is relatively safe for endoscopic sinus surgery. A larger multi-institutional study is recommended in various parts of the country for a better statistical finding of olfactory fossa.

CONCLUSION

In our study, Keros' type I is the most common type and Keros' type III was the least. The depth of the olfactory fossa was deeper on the right side in our sample population.

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