Evaluation of Olfactory Fossa Depth Using Computed Tomography

Sharma Paudel,[1] Ramswarth Sah,[1] Tekendra Budhathoki,[1] Ghanshyam Pandey[2]

[1]Department of Radiology, Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal, [2]Department of Public Health, Yeti Health Science Academy, Kathmandu, Nepal.

ABSTRACT

Background: Olfactory fossa is a depression in anterior cranial cavity whose floor is formed by cribriform plate of ethmoid bone and is susceptible to injury during functional endoscopic sinus surgery (FESS), especially when fossa is deep. Understanding of patient's ethmoid roof anatomy and its possible variations is crucial for countering possible complications during functional endoscopic sinus surgery. So, objective of this study was to evaluate olfactory fossa depth.

Methods: In this descriptive cross sectional study, olfactory fossa depth was measured on Computed Tomographic images of 280 patients in the Department of Radiology, Tribhuvan University Teaching Hospital. The data were grouped according to Keros classification and their distributions were analyzed according to side and gender. Association between olfactory fossa depth with different parameters were evaluated with descriptive statistics, independent t-test, ANOVA and Chi-square test.

Results: Among 280 participants, 144 were male and 136 female. The mean depth of right and left olfactory fossa was found 5.10 ± 1.58 mm and 5.28 ± 1.62 mm respectively. Keros type II was the most common, found in 209 cases (74.60%) on left side and 194 (69.30%) on right side while type III was the least common. The difference between left and right olfactory fossa depth was significant though it was insignificant between male and female. No significant association was found between Keros type with sides and with gender.

Conclusions: Variation in olfactory fossa depth was common. Thus, preoperative assessment of ethmoid roof and Keros type is cruicial for warning the surgeon to minimize the critical complications.

Key words: Computed Tomography; olfactory fossa depth; para nasal sinus.

INTRODUCTION

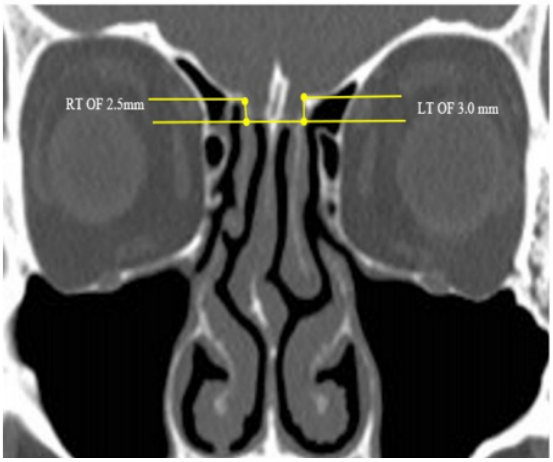
Olfactory fossa (OF) is a depression in anterior cranial cavity whose floor is formed by cribriform plate of ethmoid bone. It is bounded laterally by lateral lamella of cribriform plate and medially by crista galli.[1-3] The levels of cribriform plate may differ even in the same individual based on the vertical extent of the lateral lamella. The relationship between the OF and the ethmoid roof was studied by Keros and a three-category classification system for depth of the OF in relation to the ethmoid roof was developed.[1] Lateral lamella (the thinnest bone) is at the risk of injury during FESS (a common modality of treatment for diseases of paranasal sinuses) especially when fossa is deeper or uneven.[1,2] Therefore, preoperative evaluation by computed tomography (CT) examination provide a safer route during surgery and reduce postoperative complications.[4-6]

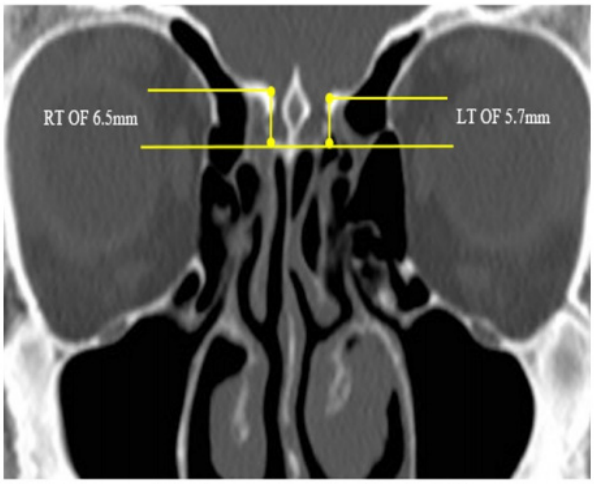
METHODS

This descriptive cross sectional study was conducted in Department of Radiology, Tribhuvan University Teaching Hospital, Institute of Medicine from August 2023 to January 2024. Ethical approval was obtained from the institutional review committee of Institute of Medicine, Kathmandu Ref: 66 (6-11) E2;080/081. After informed written consent and required clinical history, CT scans

Correspondence: Ramswarth Sah, Department of Radiology, Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal. Email: npshahiom@gmail.com, Phone: +977-9841380084

were performed in Somatom Definition AS+ 128 slice Multi detector CT, Siemens. Images were acquired with standard acquisition parameters (64 x 0.625 mm collimation, 230 effective mAs, 120kVp, pitch=0.891, 0.75 second rotation time, 512 X 512 Matrix). A total of 280 images of the adult Nepalese patients coming for CT scan for Paranasal sinuses (PNS) for the evaluation of sinonasal polyposis and chronic sinusitis were collected between August 2023 and January 2024. Patients with history of trauma, tumor and infection causing erosion at the olfactory fossa and images with significant artifacts were excluded. All the patients meeting the inclusion criteria during the study period were included. Depth of OF was measured as vertical height of the lateral lamella between two horizontal lines drawn along the cribriform plate and at the medial ethmoid roof point. All the measurements were taken on 1mm thick coronal reformatted image with window width 1500 and window level 400 to avoid intraobserver or interobserver variability in the measured value which would influence or impact the findings. (**figure 1**)The heights of both right and left lateral lamella were recorded separately.





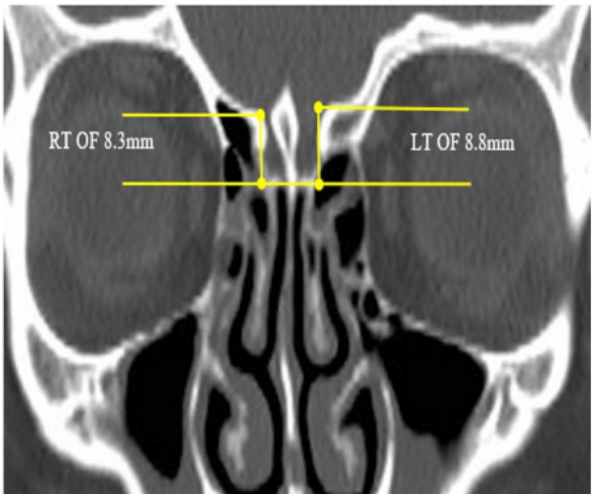


Figure 1. Measurement of olfactory fossa depth on coronal reformatted computed tomographic 1mm thick images (left: Keros I, middle: Keros II and right: Keros III).

Statistical Package for Social Science (SPSS) program, version 16 was used for the analysis of the data. Mean value and standard deviation (SD) were calculated for descriptive statistics. Categorical variables were presented as percentage. The level of significance was kept at $p < 0.05$. Independent t-test was used to compare left and right OF depth in male and female. One way analysis of variance (ANOVA) test was used to see the differences between left and right mean OF depth among various groups of age, height, weight and BMI. Association of OF depth with age, height, weight and BMI was tested with Karl Pearson's coefficient correlation test. Olfactory fossa depth of 1–3.9 mm was categorized as Keros type I, 4–7.9 mm as type II, and ≥8 mm as type III.[7]

RESULTS

Out of 280 participants, 144 were male and 136 were female. Participant's age ranged from 17 to 86 years with mean age was 47.61 ± 18.87 years. The average depth of right OF was found 5.10 ± 1.58 mm and that for left was found 5.28 ± 1.62 mm. Asymmetry in OF depth was seen in 99.64% of subjects and the difference between left and right OF depth was statistically significant ($t = 3.40$, $p = 0.01$). The depth of OF ranged from1.9mm to 8.9mm (mean value = 5.09 ± 1.66 mm) for right side and that ranged from 2.10mm to 8.90mm (mean value = 5.26 ± 1.65 mm) for left side of male while that for female was found 2.30mm to 9.40mm (mean value = 5.11 ± 1.50 mm) for right side and 1.90mm to 9.70mm (mean value = 5.30 ± 1.61 mm) for left side. Difference between depth of OF

was not statistically significant for any side (t=0.12, p = 0.09 for right side and t = 0.18, p = 0.85 for left side). (**Table 1**)

Table 1. Olfactory fossa depth according to gender and side.

Gender (No.)	OF depth (mean + SD mm)		OF depth (mean+ SD mm) Both left and right	t-value and p-value
	Right	Left		
Male (144)	5.09 ± 1.66	5.26 ± 1.65	5.17 ± 1.65	t = 2.44, p = 0.01
Female (136)	5.11 ± 1.50	5.30 ± 1.61	5.20 ± 1.55	t = 2.36, p = 0.02
t-value, p-value	t=0.12, p = 0.09	t = 0.18, p = 0.85		

The depth of OF measured in different age groups found increasing with increasing age and it was low in lower age group and higher in higher age group. The difference of the mean depth found for various age groups is statistically significant. (**Table 2**)

Table 2. Olfactory fossa depth according to age and side (n=280).

Age	No.	Right Olfactory Fossa depth in mm (mean ± S.D.)	Left Olfactory Fossa depth in mm (mean ± S.D.)	Olfactory Fossa depth in aggregate in mm (mean ± S.D.)
15-30	63	4.51±1.41	4.65±1.6	4.58±1.51
30-45	67	5.04±1.61	5.14±1.62	5.09±1.62
45-60	59	5.15±1.24	5.52±1.44	5.335±1.36
60-75	62	5.28±1.7	5.45±1.57	5.365±1.64
75+	29	6.02±1.85	6.12±1.76	6.07±1.81
F Value (p-value)		5.171 (<0.001)	5.212 (<0.001)	5.19 (<0.001)

Keros type II was the most common in both sexes and found on 403 sides (72.0%) followed by Keros type I in 118 sides (21.1%), and Keros type III only on 39 sides (6.9%). Keros type II was more on the left (74.6%) than right side (69.3%) and more in females 105 (37.5%) than males 104 (37.1%). No statistically significant association was found between the side (right or left) and Keros type (Chi-square value = 2.04 and p-value = 0.35). There was no statistically significant association between gender and Keros classification (Chi-Square value = 2.905; p-value = 0.234. (**Table 3**)

Table 3. Olfactory fossa depth according to age and side.

Keros type	Male			Female			Both Male and Female		
	Right count (%)	Left count (%)	Both right and left count (%)	Right count (%)	Left count (%)	Both right and left count (%)	Right count (%)	Left count (%)	Both right and left count (%)
Type I	36 (25.0)	29 (20.1)	65 (22.6)	28 (20.6)	25 (18.4)	53 (19.5)	64 (22.9)	54 (19.3)	118 (21.1)
Type II	95 (66.0)	104 (72.2)	199 (69.1)	99 (72.8)	105 (77.2)	204 (75.0)	194 (69.3)	209 (74.6)	403 (72.0)
Type III	13 (9.0)	11 (7.6)	24 (8.3)	9 (6.6)	6 (4.4)	15 (5.5)	22 (7.8)	17 (6.1)	39 (6.9)
Total	144	144	288	136	136	272	280	280	560
Chi-square value (p-value)	2.905 (0.234)						2.04 (p = 0.35)		

Distribution of Keros types in the olfactory fossa was not uniform across age groups. In the 15-30 years of age group, Keros type I was the most common while in the 45-60 age group, Keros type II was more prevalent and there was a significant association between age and Keros type (chi-square = 54.283 and p-value < 0.05). (**Table 4**)

Table 4. Distribution of Keros type according to age groups.

Age Groups	Keros Type of Olfactory Fossa					
	Keros type I		Keros type II		Keros type III	
	Count	Percentage	Count	Percentage	Count	Percentage
15-30	44	37.3	81	20.1	1	2.6
30-45	30	25.4	93	23.1	11	28.2
45 - 60	14	11.9	101	25.1	3	7.7
60 - 75	21	17.8	92	22.8	11	28.2
75+	9	7.6	36	8.9	13	33.3
Chi Square value (p-value)	54.283 (<0.001)					

There was a strong correlation between the depth of the right and left fossa (correlation coefficient = 0.848) and (p-value < 0.05), while the moderate positive correlations with age suggest some relationship between age and fossa depth. The correlation with sex was weak and was not significant.

DISCUSSION

Computed Tomography of paranasal sinuses (CT-PNS) is an essential part of preoperative evaluation for endoscopic sinus surgery. Along with clinical examination and nasal endoscopy, CT-PNS has crucial role for evaluating pathological changes and anatomic variations in nasal and paranasal sinuses for safe and better patient outcomes.

In this study, mean depth of left OF was found high (5.28mm) than that of right (5.10 mm) and the difference was statistically significant both in male and female (p-value < 0.05). Our results were slightly different from the study done by Pawar A et al. for Indian population where they found statistically significant asymmetry in OF depth in right and left side in males only, right being deeper.[8]

In our study, statistically insignificant differences in OF depth were found for both side (t=0.12, p = 0.09 for right side and t = 0.18, p = 0.85 for left side) between male and female (mean value = 5.09 ± 1.66 mm for right side and mean value = 5.26 ± 1.65 mm for left side of male while mean value = 5.11 ± 1.50 mm for right side and mean value = 5.30 ± 1.61 mm for left side in case of female) which is supported by the similar studies performed by Madani GA et al. and Pawar et al respectively.[3, 8] But higher height of lateral lamella was found in males than in females and more on right side in the similar study performed by Salroo I et al.[9]

The OF depth measured in different age groups were found increasing with increasing age and it was low in lower age group and higher in higher age group and the difference of the mean depth for various age group was statistically significant (p < 0.05) in this study. A similar result was also found in the study performed by Naaz S et al.[10]

Keros type II was the most common in both sexes followed by Keros type I and the least common was Keros type III in our study. Keros type II was more on the left (74.6%) than right side (69.3%), more in females 105 (37.5%) than males 104 (37.1%). Similar results were also found in the study performed by Pawar et al, Salroo IN et al, Naaz S et al, Shilpa D et al.[8-11]

In this study, no statistically significant association was found between the side (right or left) and Keros type (Chi-square value = 2.04 and p-value = 0.35) and gender and Keros classification (Chi-Square value = 2.905 and p-value = 0.234).

Distribution of Keros types in the olfactory fossa was not uniform across age groups because Keros type I was the most common in the 15-30 years age group, while Keros type II was more prevalent in the 45-60 years age group, and there was a significant association between age and Keros type (chi-square = 54.283 with p-value < 0.05). A similar trend was found in a study performed by Salroo IN et al.[9]

Preoperative evaluation of PNS by CT is mandatory for all patients undergoing functional endoscopic sinus surgery because it provides OF depth and Keros type accurately which ultimately warn the surgeon to reduce the complications by proving a roadmap during surgery.[4] Patients with Keros type III (deeper OF) are more prone to complication (injury to floor of OF).[1]

In our study, there was a strong correlation between the

depths of the right and left fossa (correlation coefficient = 0.848) and the association was highly significant (p-value < 0.05), while the moderate positive correlations with age suggested some relationship between age and fossa depth. The correlations with sex were weak and not significant.

CONCLUSIONS

This study evaluated the depth of olfactory fossa, Keros classification, and variation of OF depth on the basis of age, gender and laterality. Preoperative assessment of OF depth, Keros level and anatomy of ethmoid roof are essential for the surgeons to avoid iatrogenic injury while performing endoscopic sinus surgeries. Keros II was most prevalent in both male and female but height of lateral lamella was higher in female than male and more on left side. Therefore, extra care seems essential during surgeries on female.

ACKNOWLEDGEMENTS

None

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Tony George Jacob, J.M. Kaul, Morphology of the olfactory fossa – A new look, Journal of the Anatomical Society of India, Volume 63, Issue 1, 2014, Pages 30-35.doi: https://doi.org/10.1016/j.jasi.2014.04.006

2. Erdem G, Erdem T, Miman MC, Ozturan O. A radiological anatomic study of the cribriform plate compared with constant structures. Rhinology. 2004 Dec 1;42(4):225-9. [PDF]

3. Madani GA, El-Mardi AS, El-Din WA. Analysis of the anatomic variations of the ethmoid roof among Saudi population: A radiological study. Eur J Anat. 2020;24(2):121-8.[Article]

4. Cashman EC, MacMahon PJ, Smyth D. Computed tomography scans of paranasal sinuses before functional endoscopic sinus surgery. World journal of radiology. 2011 Aug 8;3(8):199.[Article]

5. Souza SA, Souza MM, Idagawa M, Wolosker ÂM, Ajzen SA. Análise por tomografia computadorizada do teto etmoidal: importante área de risco em cirurgia endoscópica nasal. Radiologia Brasileira. 2008;41:143-7.[Article]

6. Karatay E, Avcı H. Evaluation of Olfactory Fossa Anatomy by Computed Tomography and the Place of Keros Classification in Functional Endoscopic Sinus Surgery. Southern Clinics of Istanbul Eurasia. 2021 Mar 1;32(1).[Article]

7. Babu AC, Nair MR, Kuriakose AM. Olfactory fossa depth: CT analysis of 1200 patients. Indian Journal of Radiology and Imaging. 2018 Oct;28(04):395-400. [Article]

8. Pawar A, Konde S, Bhole P. Assessment of depth of olfactory fossa in pre-functional endoscopic sinus surgery computed tomography scan of paranasal sinuses. Int J Otorhinolaryngol Head Neck Surg. 2017 Dec 22;4(1):83.[Article]

9. Salroo I, Dar NH, Yousuf A, Lone KS. Computerised tomographic profile of ethmoid roof on basis of keros classification among ethnic Kashmiri's. Int J Otorhinolaryngol Head Neck Surg. 2016 Jan 7;2(1):1-5.[Article]

10. Naaz S, Aramani A, Biradar BN, Jacob C. Assessment of ethmoid roof and olfactory fossa variations using Keros classification in a tertiary care hospital. The Egyptian Journal of Otolaryngology. 2022 Dec;38(1):112.[Article]

11. Shilpa D , Ismail M , Kumar P. Assessment of olfactory fossa depth on computed tomography in adults in a tertiary care hospital in India. International Journal of Academic Medicine and Pharmacy. 2022 Aug 6; 4(3); 215-218.[PDF]