ORIGINAL ARTICLE

Olfactory Fossa Depth Assessment Based on Keros Classification using Computed Tomography

Mubina Lakhani[1], Nuzhat Hassan[2], Arsalan Manzoor[3], Muhammad Ali[4], Madeeha Sadiq[5]

ABSTRACT:

Objective: To evaluate the olfactory fossa depth and to categorize it according to Keros classification.

Methodology: It was a cross sectional study done on 270 adults , 160 males and 110 females at Ziauddin University Hospital, Clifton, Karachi using CT Para nasal sinuses. The depth of olfactory fossa was evaluated by measuring the height of lateral lamina of cribriform plate.

Results: The mean and standard deviation(SD) of right olfactory fossa depth was greater than that of left 6.184±1.8237mm and 5.949 ±1.8003mm (p value 0.006) respectively. Mean ± (SD) for left olfactory fossa depth was greater in females (6.215±1.9271) than in males (5.766±1.6896) (p value 0.043).

Keros type II was found to be the most frequent on both right and left sides that is, in 69.26% and 72.96% individuals respectively followed by type III on right side in 18.15% and on left side in 15.19% subjects. Type I was found to be the least frequent in our population with a value of 12.59% on the right side and 11.85% on the left side.

Conclusion: Our study shows that most of the population falls in the high risk categories of Keros that is type II and type III thus emphasizing the need of preoperative radiological assessment.

Keywords: Keros classification, Paranasal sinuses, Olfactory fossa, Radiological assessment

INTRODUCTION:

Currently, functional endoscopic sinus surgery (FESS) is extensively used for the treatment of chronic rhinosinusitis which is resistant to medical treatment. It is also used in the treatment of many conditions such as mucocele, nasal polyposis, sellar and parasellar tumors, and optic nerve decompression[1]. Due to close proximity of sinuses to important structures such as orbits and brain, surgeons should have sound knowledge of sinonasal anatomy and associated variations. Therefore, a thorough knowledge of constant anatomical landmarks and their variations along with a preoperative CT evaluation is important for surgeons to securely traverse through paranasal sinus (PNS) region with minimal risk to patients[2]. Computed tomography (CT) scan has been considered the gold standard in the preoperative evaluation of PNS[3].

Although it is extensively performed, FESS is not devoid of complications. Some of the major complications include ocular/orbital injury, leakage of cerebrospinal fluid and intracranial injury[4], most of these complications are due to close proximity of ethmoidal cells with anterior cranial fossa. The ethmoid roof separates the ethmoidal cells from the anterior cranial fossa. It is formed by the fovea ethmoidalis (FE) of the frontal bone laterally and the cribriform plate (CP) of the ethmoid bone medially[5-7]. Ethmoid roof is critically important because it is most vulnerable to iatrogenic cerebrospinal fluid leaks. During FESS, injury can occur on the side where the position of the roof is relatively low[1,8,9]. Olfactory fossa is an interstice between the CP and the FE. CP is generally at a lower level than FE. The FE connects medially with lateral lamina of cribriform plate (LLCP). This lateral lamella (LL) is thinnest & most vulnerable in terms of complications during FESS. Also the anterior ethmoidal artery enters the olfactory fossa through LLCP. High variability exists in the relationship of anterior ethmoidal artery to the roof of the ethmoid and is at risk during FESS[10,11]. Depth of the olfactory fossa is determined by the height of the LLCP, which is part of the ethmoid bone. In 1962, Keros proposed a classification[12], which was based upon CP position in relation to the roof of ethmoid. This classification has a significant clinical relevance in FESS. As per this classification, type I ranges from 1–3mm. In this type, the LL is short and a significant portion of frontal bone is protecting the ethmoid roof thus, making the roof thick and the sinus less dangerous to operate within. Type II ranges from 4–7mm, so the

Dr. Mubina Lakhani
Senior Lecturer
Department of Anatomy
Ziauddin University
Karachi
E mail: mubina.lakhani@gmail.com
Dr. Nuzhat Hassan
Professor & Chairperson
Department of Anatomy
Ziauddin University
Karachi
Dr. Arsalan Manzoor
Assistant Professor
Department of Anatomy
Ziauddin University
Karachi
Dr. Muhammad Ali
Assistant Professor and Head
Department of Radiology
Ziauddin University Hospital
Karachi
Dr. Madeeha Sadiq
Assistant Professor
Department of Anatomy
Ziauddin University
Karachi
Received: 15-07-17
Revised: 01-08-17
Accepted: 15-08-17

ethmoid roof is formed by a considerable portion of the LL. And lastly type III has a range of 8–16mm. The LL becomes thin forming a larger component of the ethmoid roof, which is not protected by the thick frontal bone. Keros type III is therefore considered to be the most vulnerable type and has a considerable risk for iatrogenic trauma to CP. Proper knowledge of anatomical variations of ethmoid bone has been proved to be helpful in avoiding complications that may occur during FESS. With this background, present study was undertaken to assess depth of olfactory fossa on CT.

METHODOLOGY:

This cross sectional study was undertaken at the Radiology department of Ziauddin University hospital, Clifton, Karachi . Duration of study was 5 months that is January 2017 till May 2017after approval from ethics review committee, with a sample size of 270 individuals. Males and females between 21–60 years of age were included. Patients with sinonasal tumors, chronic rhino-sinusitis, prior sinus surgery, facial fracture, nasal polyposis and congenital craniofacial anomaly were excluded.

Study population comprised of adults coming for CT head & brain who did not have bony abnormality of sphenoid & ethmoid sinuses or adjacent structures. CT scan was performed and depth of olfactory fossa was assessed by measuring height of lateral lamella of cribriform plate (LLCP) on 16 slice Toshiba Alexion in which scanner's X-ray beam was rotated around the head and created a series of images from different angles. Sequential axial images were obtained and processed to form volume data. From volume data, multiplanar reconstructions were made in axial, coronal and sagittal planes. 3D volume rendered images in bone algorithm were also constructed. All images were evaluated in both coronal and axial planes. Analysis was performed as per Keros classification to categorize the height of lateral lamella of cribriform plate[13]. The coronal views of CT films were analyzed in bony windows and the results were reported in a data sheet.

Following standard anatomical landmarks were noted and used for measuring LLCP:

- Infraorbital nerve point
- Medial ethmoid roof point (MERP) (which corresponds to the medial end of the ethmoid roof that articulates with the LLCP)
- Cribriform plate point[1,13,14]

Vertical height from MERP (MERPs height) and vertical height from CP (CP height) to the horizontal plane through infraorbital foramen was measured on each slide (Figure-1).

The LLCP was calculated by subtracting CP height from MERP height (MERP-CP = LLCP)[18]

Measurements between 1 and less than 4mm were considered as type I Keros. Measurements more than 4mm and less than 8mm were considered as type II Keros. Type III Keros subjects showed measurements of 8mm and more. This was done to overcome the limitations in original Keros classification as measurements between 3 and 4mm as well as between 7 and 8mm were not described in Keros classification[15].

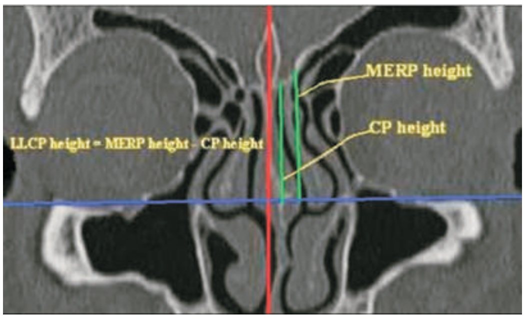


Figure-1: Showing LLCP measurement in a coronal paranasal sinus CT cross-section[1]

For statistical analysis, SPSS version 23 was used. Means ± SD were calculated for quantitative variables and compared using student t test for two groups. Qualitative variables were described as frequency and percentages, p-value less than 0.05 was taken as significant.

RESULTS:

The mean and SD of olfactory fossa depth was found to be significantly greater on right as compared to the left side (Table-1)

Table-1: Mean± Standard Deviation of Right and Left Olfactory Fossa Depth

Olfactory Fossa Depth	N	Mean (mm)	Std. Deviation (mm)	P value
Right Olfactory Fossa Depth	270	6.184	1.8237	0.006*
Left Olfactory Fossa Depth	270	5.949	1.8003	

*$p \leq 0.05$ was considered significant

Olfactory fossa depth was also studied according to gender. Mean and SD for right olfactory fossa depth in females was insignificantly greater than that in males, while the result was significant on the left side (Table-2).

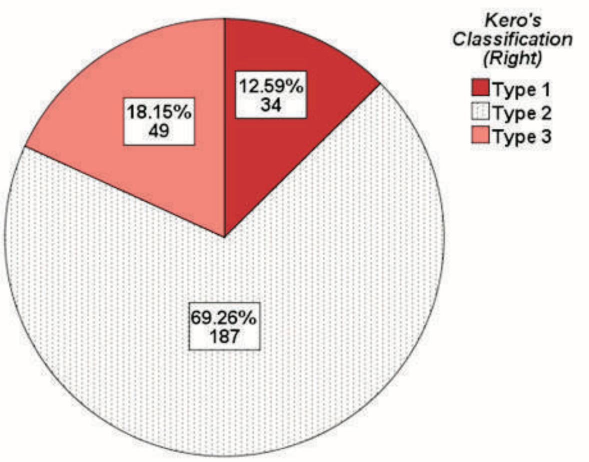
Table-2: Mean and Standard Deviation of Right and Left Olfactory Fossa Depth According to Gender

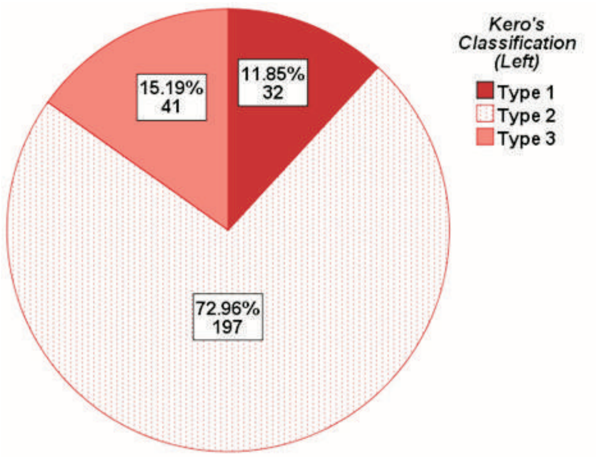
Olfactory Fossa Depth	GENDER	N	Mean(mm)	Std. Deviation	P value
Right Olfactory Fossa	Male	160	6.016	1.7804	0.069
	Female	110	6.427	1.8664	
Left Olfactory Fossa	Male	160	5.766	1.6896	0.043*
	Female	110	6.215	1.9271	

*p = 0.05 was considered significant

In the present study, the population was categorized according to Keros classification. Keros type II was found to be most frequent on both sides followed by type III. Type I was found to be the least frequent (Figure-2).

Figure-2: Frequency of subjects according to Keros classification on right and left side





DISCUSSION:

CT examination of the olfactory fossa is essential for pre-operative evaluation in FESS. Recent literature suggests that a comprehensive pre-operative radiological assessment is essential for determination of anatomic variations of paranasal sinuses to avoid possible complications[16]. Iatrogenic injuries have been linked to varying olfactory fossa depth[17]. Kero's classification is an extensively applied approach to classify olfactory fossa depth variations[3,5,15].

In our study we analyzed both right and left olfactory fossa of 270 adult males and females. The mean right and left olfactory fossa depth of our sample was comparable to that reported in some previous studies. In a study[14] from Pakistan in 2013, the mean depth of right and left olfactory fossa was reported to be 5.5±2.13 and 5.2 ±2.05 mm respectively. This retrospective study was done on a small sample size of 77 subjects and this was one of the limitations of the study. A SD of ±2.13 mm further depicted a considerable variation in a small sample size.

Our results were also in accordance with two studies on Turkish population[1,18] conducted in 2004 and 2013. However, a study from Philippines[3] and another from Egypt[15] have reported lower mean of right and left olfactory fossa depth. It is evident from literature that considerable variations in mean depths of olfactory fossa exist among different populations ranging from as low as 2.21 mm in Filipinos[3] to as high as 8.7 in Nigerians[19]. This may be attributed to the genetic variations in different populations.

On comparing the mean depths on both sides in our sample, we found a greater mean depth on the right side than on the left side, which was statistically significant. Kaplanoglu et al documented significantly greater depth on the left side as compared to the right[1]. In another retrospective study from India on 100 CT scans, a greater statistically significant mean for the left side was reported as compared to the right[20]. However, Shama and Montaser reported an insignificant difference between the two sides[15].

In the present study, the difference between the mean depths of males and females of left side was statistically significant. However, a study from India reported an insignificant depth difference between males and females[20]. This may be attributed to a smaller sample size in their study. Therefore, further studies on a larger sample size are required to elucidate the difference between the gender.

Keros type I, II and III was found in 12.59%, 69.26%, and 18.15% subjects on the right and 11.85%, 72.96%, 15.19% subjects on the left. A review of previous literature on ethmoidal roof variation reported higher frequencies of type II[1,5,12,18,21-23]. Adeel et al from Pakistan and Rathnakar et al from India also reported highest frequency of type II Keros in their samples which was in accordance with our results[14,20]. Our sample showed the least frequency of Type I Keros. However, a few studies had reported more frequency of type I[3,15,24-26]. Literature reported that individuals falling in this low depth range were least vulnerable to iatrogenic injuries[15]. The present study showed that most of the study subjects were present in the high risk categories of Keros. The frequency of Keros type III was reported to be the least in most studies[1,3,5,12,24-26]. In addition to racial variations, this variation could also be due to the fact that Keros classification is ambiguous in the ranges of 3-4mm and 7-8mm. Standardization of Keros classification and consideration of race in its calculation is recommended.

CONCLUSION:

It is concluded that most of the studied population was present in the high risk categories of Keros, that is type II and type III thus emphasizing the need of preoperative radiological assessment.

CONFLICT OF INTEREST:

The authors declare that there are no conflicts of interest.

REFERENCES:

1. Kaplanoglu H, Kaplanoglu V, Dilli A, Toprak U, Hekimoğ lu B. An analysis of the anatomic variations of the paranasal sinuses and ethmoid roof using computed tomography. The Eurasian journal of medicine. 2013;45(2):115-125
2. Salroo IN, Dar NH, Yousuf A, Lone KS. Computerised tomographic profile of ethmoid roof on basis of keros classification among ethnic Kashmiri's. International Journal of Otorhinolaryngology and Head and Neck Surgery. 2016; 2(1):1-5
3. Paber JEL, Cabato MSD, Villarta RL, Hernanadez JG. Radiographic analysis of the ethmoid roof based on Keros classification among Filipinos. Philippine Journal of Otolaryngology Head and Neck Surgery. 2008;23(1):15-9
4. McMains KC. Safety in endoscopic sinus surgery. Current opinion in otolaryngology & head and neck surgery. 2008; 16(3):247-51
5. Souza SA, Souza MMAd, Idagawa M, Wolosker ÂMB, Ajzen SA. Computed Tomography assessment of the ethmoid roof: a relevant region at risk in endoscopic sinus surgery. Radiologia Brasileira. 2008;41(3):143-7
6. Adeel M, Rajput MSA, Akhter S, Ikram M, Arain A, Khattak YJ. Anatomical variations of nose and para-nasal sinuses; CT scan review. Journal of the Pakistan Medical Association. 2013; 63(3):317-19
7. Cashman EC, MacMahon PJ, Smyth D. Computed tom-ography scans of paranasal sinuses before functional endoscopic sinus surgery. World J Radiol. 2011;3(8):199-204
8. Reddy UDMA, Dev B. Pictorial essay: Anatomical variations of paranasal sinuses on multidetector computed tomography-How does it help FESS surgeons? The Indian journal of radiology & imaging. 2012;22(4):317
9. Heskova G, Mellova Y, Holomanova A, Vybohova D, Kunertova L, Marcekova M, et al. Assessment of the relation of the optic nerve to the posterior ethmoid and sphenoid sinuses by computed tomography. Biomedical Papers. 2009;153(2):149-52
10. Souza SA, de Souza MMA, Gregório LC, Ajzen S. Anterior ethmoidal artery evaluation on coronal CT scans. Brazilian journal of otorhinolaryngology. 2009;75(1):101-6
11. Araujo Filho BC, Weber R, Neto CDP, Lessa MM, Voegels RL, Butugan O. Endoscopic anatomy of the anterior ethmoidal artery: a cadaveric dissection study. Brazilian journal of otorhinolaryngology.2006;72(3):303- 8
12. Keros P. On the practical value of differences in the level of the lamina cribrosa of the ethmoid. Zeitschrift fur Laryngologie, Rhinologie, Otologie und ihre Grenzgebiete. 1962;41:809
13. Alazzawi S, Omar R, Rahmat K, Alli K. Radiological analysis of the ethmoid roof in the Malaysian population. Auris Nasus Larynx. 2012;39(4):393-6
14. Adeel M, Ikram M, Rajput MSA, Arain A, Khattak YJ. Asymmetry of lateral lamella of the cribriform plate: a software-based analysis of coronal computed tomography and its clinical relevance in endoscopic sinus surgery. Surgical and Radiologic Anatomy. 2013;35(9):843-7
15. Shama SA, Montaser M. Variations of the height of the ethmoid roof among Egyptian adult population: MDCT study. The Egyptian Journal of Radiology and Nuclear Medicine. 2015;46(4):929-36
16. Emirzeoglu M, Sahin B, Bilgic S, Celebi M, Uzun A. Volumetric evaluation of the paranasal sinuses in normal subjects using computer tomography images: a stereological study. Auris Nasus Larynx. 2007;34(2):191-5
17. Ulualp SO. Complications of endoscopic sinus surgery: appropriate management of complications. Current opinion in otolaryngology & head and neck surgery. 2008;16(3):252-9
18. Erdem G, Erdem T, Miman MC, Ozturan O. A radiological anatomic study of the cribriform plate compared with constant structures. Rhinology. 2004;42(4):225-9
19. Ameye S, Amusa Y, Eziyi J, Famurewa O. Assessing the surgical anatomy of the ethmoid sinus in adult Nigerians using computerized tomography scan.International Journal of Medicine and Medical Sciences.2014;6(12):239-44
20. Rathnakar P, Shrinath D, Kamath P. Computed Tom -ographic study of depth of Anterior Skull Base in Dakshina Kannada population. International Journal of Anatomy and Research. 2016; 4(3):2738-42
21. Nitinavakarn B, Thanaviratananich S, Sangsilp N. Anatomical variations of the lateral nasal wall and paranasal sinuses: a CT study for endoscopic sinus surgery (ESS) in Thai patients. J Med Assoc Thai. 2005;88(6):763-8
22. Elwany S, Medanni A, Eid M, Aly A, El-Daly A, Ammar S. Radiological observations on the olfactory fossa and ethmoid roof. The Journal of Laryngology & Otology. 2010; 124(12): 1251-6
23. Şachin C, Yilmaz Y, Titiz A, Özcan M, Özlgedik S, Ünal A.Analysis of Ethmoid Roof and CranialBase in Turkish Population. KBB ve BBC Dergisi.2007;15:1-6
24. Solares CA, Lee WT, Batra PS, Citardi MJ. Lateral

lamella of the cribriform plate: software-enabled computed tomographic analysis and its clinical relevance in skull base surgery. Archives of Otolaryngology–Head & Neck Surgery. 2008;134(3):285-9

25. Nouraei S, Elisay A, Dimarco A, Abdi R, Majidi H, Madani S, et al. Variations in paranasal sinus anatomy: implications for the pathophysiology of chronic rhinosinusitis and safety of endoscopic sinus surgery. Journal of Otolaryngology-Head and Neck Surgery. 2009;38(1):324

26. Bista M, Maharjan M, Kafle P, Shrestha S. Computed tomographic assessment of lateral lamella of cribriform plate and comparison of depth of olfactory fossa. Journal