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# ANALYSIS OF ETHMOID ROOF BASED ON KEROS CLASSIFICATION

**Anatomy**

**Dr Samreen Siraj Bala** Demonstrator, Department Of Anatomy, GMC, Srinagar, J&k

**Dr Shaheen Shahdad** Professor, Department Of Anatomy, GMC, Srinagar, J&k

**Dr Fozia Nazir*** Demonstrator, Department Of Anatomy, GMC, Srinagar, J&k *Corresponding Author

## ABSTRACT

**OBJECTIVE:** To evaluate the olfactory fossae depth according to the Keros classification and determine the incidence and degree of asymmetry in the height on computer tomography scan(CT Scan).

**MATERIALAND METHOD:** Cross sectional observational study was done on 200 CT scans of 3mm slice thickness in coronal plane. The results were classified according to their Keros classification. Any asymmetries in the ethmoid roof depth and fovea ethmoidalis configuration were examined.

**RESULTS:** In present study, depth of olfactory fossa was measured and classified as per Keros classification.Majority of cases i.e. 137 (68.5%) were of type II, 52 (26%) were of type I, 3 (1.50%) were of type III. 8(4%) cases were having asymmetric ethmoid roof with different classification type on either side of crista galli.

**CONCLUSION:** To minimize probable complications and to avoid major complications, anatomic variations particularly in the base of the skull, should be properly understood.

## KEYWORDS

Computed tomography, Olfactory fossa, Anatomical variations, Keros classification.

## INTRODUCTION

Paranasal sinuses carry high risk for injuries and consequential intraoperative complications, with the ethmoid and frontal sinuses being most frequently affected. Anatomical variations in association with their inherent conditions, are added to such risks. The type of cribriform plate is important in predicting the intra operative complications during FESS(functional endoscopic sinus surgery). The ethmoid roof is formed by the fovea ethmoidalis, an extension of the orbital plate of the frontal bone. The vertical lamella of the middle turbinate divides the anterior skull base into the cribriform plate medially and the roof of the ethmoid or fovea ethmoidalis laterally. The ethmoid labyrinth of air cells lies lateral to the middle turbinate and terminates at the paper-thin bone forming the medial orbital wall, called the lamina papyracea. The roof of the ethmoid is composed of a thicker horizontal portion called orbital plate of the frontal bone, and a thinner vertical portion called the lateral cribriform plate lamella (LCPL). The orbital plate comprises most of the ethmoid roof, with the LCPL forming a small medial portion. The height of the LCPL defines the depth of the olfactory cleft, where duramater is closely adherent to the bone. Increasing depths of the olfactory cleft correlate with a greater risk of inadvertent injury during surgery. The Keros classification divides the ethmoid roof into 3 configurations: shallow type I (1-3 mm), medium type II (4-7 mm), and deep type III (8-16 mm).[1] The type III configuration, being the deepest, is at greatest risk for complications during endoscopic endonasal surgery. An even greater risk of inadvertent injury exists if the surgeon perceives the thinner orbital plate to be part of a superior ethmoid cell, rather than the actual skull base.[2]Cross-sectional imaging has proven to be a valuable tool for preoperative planning.[3]The coronal plane is considered to be the best orientation for evaluation of relationship of the brain to ethmoidal roof and correlates closely with the surgical orientation.[4]

## MATERIALAND METHOD

This cross sectional observational study was conducted by Postgraduate Department of Anatomy in collaboration with Department of Radiodiagnosis and Imaging, Government Medical College, Srinagar for a period of 1 year .Study was done on 200 cases. Cases having pathology or disease enough to obscure the regional anatomy,age less than 20,history of surgery in region were excluded from the study. Patient was kept in supine position. Non-contrast CT scan Nose and Paranasal sinuses (NCCT Nose &PNS) was done and data was acquired in axial plane. Reconstruction was done in coronal plane using 3mm slice thickness. Depth of olfactory fossa was measured and classified as per Keros classification: shallow type I (1-3 mm), medium type II (4-7 mm), and deep type III (8-16 mm).1

## RESULTS

**TABLE-I: KEROS CLASSIFICATION ON NCCT NOSE & PNS (N=200)**

| Keros Classification | No. of cases | Percent(%) |
|---|---|---|
| Type I | 52 | 26.00 |
| Type II | 137 | 68.50 |
| Type III | 3 | 1.50 |
| Asymmetric roof | 8 | 4.00 |
| Total | 200 | 100 |
| Mean=4.44; Standard Deviation (SD)=1.61; Minimum =1; Maximum =10 | | |

In our study of 200 cases, depth of olfactory fossa was measured and classified as per Keros classification. Majority of cases i.e. 137 (68.5%) were of type II, 52 (26%) were of type I, 3 (1.50%) were of type III and 8 (4.00%) cases were having asymmetric roof as shown in table No. I.

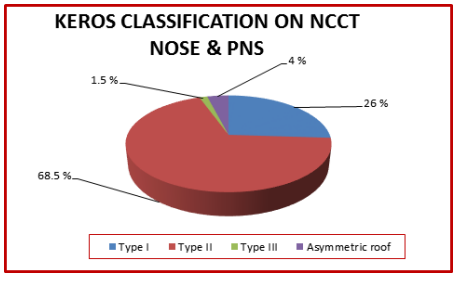
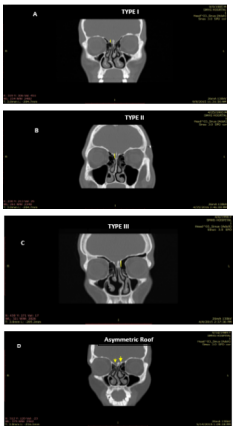



**TABLE-II: KEROS CLASSIFICATION WITH ASSYMERY OF ETHMOID ROOF ON NCCT NOSE & PNS (N=200)**

| | | Keros classification left | | | Total |
|---|---|---|---|---|---|
| | | TypeI | TypeII | TypeII | |
| Keros classification right | Type I | 52 | 5 | 0 | 57 |
| | Type II | 2 | 137 | 0 | 139 |
| | Type III | 0 | 1 | 3 | 4 |
| Total | | 54 | 143 | 3 | 200 |

As shown in table No. II, 8 cases were having asymmetric ethmoid roof with different classification type on either side of crista galli. 5 cases had right type I and left type II, 2 cases had right type II and left type I whereas 1 case had right type III and left type II.




A, B, C coronal computed tomography (CT) scan showing Kero's classification type I, II, III and D, shows asymmetry of ethmoid roof with arrows.

## DISCUSSION

Coronal images can particularly be considered as maps in the evaluation of the anatomy that is variable even between the two sides of a same individual, demonstrating areas potentially at risk for complications in the planning of endoscopic nasal surgeries. [5,6,7] There may be complications during endoscopic sinus surgery because it is performed in a complex region. The major complications are cerebrospinal fluid leakage, ocular traumatization, meningitis or intracranial vascular traumatization; these complications are found in 0-1.5% of cases.[8,9,10] The fovea ethmoidalis and lateral lamella are the most important parts of the skull base in terms of the risk of complication development during ESS(endoscopic sinus surgery) .[11,12] In present study, as shown in table no.I and II; depth of olfactory fossa was measured and classified as per Keros classification.Majority of cases i.e. 137 (68.5%) were of type II, 52 (26%) were of type I, 3 (1.50%) were of type III. 8(4%) cases were having asymmetric ethmoid roof with different classification type on either side of crista galli. 5 Cases had right type I and left type II, 2 cases had right type II and left type I whereas 1 case had right type III and left type II. Mean value was 4.44 and SD calculated was 1.61. Souza SA et al (2008)[13] evaluated the olfactory fossa depth according to the Kero's classification in Brazilian population in their retrospective study and reported olfactory fossa type II in majority i.e. 73.3% of cases followed by type I in 26.3% and type III in 0.5% of cases. Asymmetry in the ethmoid roof height was found in 12% of cases. Hatice Kaplanoglu et al (2013)[14] studied 500 CT scans retrospectively in Turkish population and found Keros Type I in 13.4%,Keros Type II in 76.1%, and Keros Type III in 10.5%. The mean height of the lateral lamella cribriform plate (LLCP) was 4.92±1.70 mm.

An Indian study by Satish Nair (2012)[15] analyzed 180 CT scans of paranasal sinuses and found olfactory fossa was Keros type I in 31(17.2%) cases, Keros type II in 139(77.2%) and Keros type III in 10 (5.6%) cases. In 21 (11.7%) cases asymmetry of height was reported.The observations noted in our study are consistent to observations recorded by above mentioned authors following similar trend of keros Type II>Type I>TypeIII.

The Keros type III is the most vulnerable one, considering the major risk for iatrogenic lesion of the lateral lamella of the cribriform plate.[16,17]Asymmetry in the anterior of the skull base and especially in the ethmoid roof is important for ESS. If asymmetry is present, the height of the ethmoid roof varies, and the fovea ethmoidalis of the two sides may be at different levels. Intracranial complications appear more frequently on the side in which the ethmoid roof is low. This low-hanging roof may cause cerebrospinal fluid fistula and recurrent meningitis postoperatively.[18,19] Thus ,the knowledge about the complex skull base anatomy and anatomical relations, including the fovea ethmoidalis and lateral lamella of the cribriform plate is essential in the prevention of complications in endoscopic nasal surgeries.

## CONCLUSION

Evaluation of anatomical findings may determine a higher intraoperative safety during surgeries in the frontoethmoidal region, giving the surgeon knowledge about the configuration of the ethmoidal roof and depth of olfactory fossae. Thus, study of Keros classification may be useful in determining the risk of inadvertent intracranial entry during endoscopic sinus surgery and consequently avoid post-operative complications.

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