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Evaluating The Olfactory Fossa Depth and KEROS Classification in Kashmiri Population.

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Abstract:

Background: KEROS classification is a means of classifying the depth of the olfactory fossa The olfactory fossa is shallow depression in the anterior cranial fossa whose floor is formed by medial lamella of cribriform plate located within ethmoid bone, lateral boundary by lateral lamella which is a thin plate like bone and is susceptible to injury during functional endoscopic sinus surgery, especially when fossa is deep/asymmetric. Functional endoscopic sinus surgery (FESS) although considered the gold standard technique to treat various nasal and paranasal sinus disorders but detailed anatomical study of the paranasal sinuses, olfactory fossa and adjacent anatomical structures during surgery is the necessity to avoid the complications like cerebrospinal fluid leak, periorbital and orbital hematoma, and blindness. Computed tomography(CT) is a frequently used imaging method in the evaluation of the paranasal sinuses, nasal cavity and nasopharynx.

Objective: The purpose of the study was to evaluate the depth of olfactory fossa and ethmoid bone using computed tomography in kashmiri population and distributing Kashmir people on the basis of KEROS classification.

Methods: In this observational study, PNS CT scan images of 396 patients including 234 males and 162 females between the age group of 17 and 75 years were examined in the Department of Radiodiagnosis, GMC Srinagar.

Results: The average depth of the total 792 olfactory fossa (OF) examined was 5.05 mm with a standard deviation (SD) calculated of ±1.51. Statistically, no significant difference was found between males and females in mean OF depth ($p>0.05$). According to KEROS classification in kashmiri population, 192(24.2%) had type I, 518 sides (65.50%) had type II and 82 sides (10.30%) had type III among 792 olfactory fossa.

Keyword: KEROS 1, Olfactory Fossa 2, Cribriform plate 3, Kashmiri population 4.

Introduction:

Functional endoscopic sinus surgery (FESS) although considered the gold standard technique to treat various nasal and paranasal sinus disorders but detailed anatomical study of the paranasal sinuses, olfactory zone, anterior skull base and adjacent anatomical structures during surgery is the necessity to avoid the complications like cerebrospinal fluid leak, periorbital and orbital hematoma, and blindness and to get optimum results.

The complex and delicate ethmoid bone that lies in the midline of facial skeleton is the key bone in FESS.[1]It consists of a midline perpendicular plate and crista galli and two lateral labyrinths of air cells connected to each other superiorly by the cribriform plate. The labyrinths are covered laterally by the lamina papyracea in the medial wall of the orbit and medially by cribriform plate which together forms the roof of the ethmoid labyrinth along with the portion of the frontal bone that covers and closes the ethmoid cells superiorly in the fovea ethmoidalis[2-5].It has been seen that levels of the ethmoid roof and cribriform plate can vary even in the same person; depending on the vertical extent of the lateral lamina. The olfactory fossa (OF) is the thinnest and an extremely variable part of the anterior skull base. After the analysis of 450 cadaveric skulls, Keros reported three main forms of the OF, depending on the level of the ethmoid roof. Keros characterizes the depth of the OF to be 1-3 mm in type I; 4-7 mm in type II and type III with 8-16 mm. Keros type III is called 'dangerous ethmoid' due to the high incidence of complications associated with its presence during surgeries in this region[6,7]. In Keros' III, the OF is extending deep into the nasal cavity and the bone is thin. Keros' classification provides an objective assessment of anterior skull base anatomy and can therefore guide the surgeon to the superior bony extent of the medial orbital wall during orbital decompression[9]. Keros also has described the width of the ethmoid labyrinth and OF at different points with gradual enlargement of its width posteriorly[7].

Preoperative imaging with high resolution CT has provided a boon for surgeons in identifying the marginal thickness of the cribriform plate, various anatomical variants of the Olfactory fossa and ethmoid roof. Imaging modalities like Computerised Tomographic (CT) scans and Digital Volume Tomography (DVT) can evaluate the bony configuration of the OF. Good attention to the anatomy of this region would help in preventing serious consequences such as CSF rhinorrhoea, meningitis, anosmia and brain abscesses and CSF rhinorhoea.[8] It has been reported that 30.1% of CSF leaks are due to Iatrogenic causes.[9]

After Keros, there were various studies conducted on ethmoid roof and Olfactory fossa based on Keros classification among various populations. The ethmoid roof configuration varies between different racial populations. There is a scarity of data about Keros classification in Indian context and no data to the best of our knowledge has been published regarding Kashmiri population. Thus, our study aims to measure the variation in olfactory fossa and ethmoid among population of Kashmir (A division in State of Jammu and Kashmir) using Keros classification.

Materials And Methods:

Study Design: This was an observational study that was carried out using PNS CT scan images of 396 patients including 234 males and 162 females between the age group of 17 and 75 years in the Department of Radiology, GMC Srinagar.Committee.

Inclusion Criteria: All adult patients hailing from Kashmir who were directed by the otolaryngology clinic and who underwent non-contrast paranasal sinus CT examination in the Department of Radiodiagnosis, GMC Srinagar from December 2021 and June 2022 were included in the study.

Exclusion Criteria: Patients with contraindications to CT Scan (e.g congenital facial anomaly, sinonasal polyposis, tumor, nasal-paranasal trauma, infection involving bone destruction, surgical history, pregnancy) and age <17 years were excluded.

Statistical analysis:

Statistical analysis of the data was performed using SPSS Statistics software (IBM SPSS ver 24.0, IBM, Armonk, NY, USA). Independent sample t-test was used to compare categorical variables and a value of $p<0.05$ considered statistically significant.

Results:

PNS CT scans of 396 subjects were included in the study. Among 396 subjects, 234 were males (59.1%) and 162 were females (41.9%). The youngest subject was 17 years and the eldest was of 75 years of age. The mean age [±standard deviation (SD)] of the study group was 32.08 ±13.21 years (Table 1)

Table 1. Age Statistics

	Gender	N	Mean(yrs)	Std. Deviation (yrs)	Std. Error Mean
Age	M	234	32.4615	11.97891	0.78
	F	162	31.6914	14.44685	1.13
			32.08	13.21	0.95

The depth of Olfactory Fossa ranged from 2 to 9 mm. The mean depth of the total 792 OF studied was 5.05 mm with an SD of 1.51. The mean depth of OF on the right side was 5.05 mm with an SD of 1.54 and the mean depth on the left side was 5.03 mm with an SD of 1.49 (Table 2).

Table 2: Olfactory Fossa Depth

Depth	Gender	Number	Mean(mm)	Std. Deviation(mm)
Right	M	234	5.13	1.54
	F	162	4.97	1.54
Left	M	234	5.08	1.52
	F	162	4.98	1.46
Combined	Both	792	5.05	1.51

Using independent sample t-test, P value was 0.7; no significant statistical difference was seen between the mean depth of Olfactory Fossa on both sides. The mean depth of Olfactory Fossa in males (including both sides) was 5.10 mm with an SD of 1.5 and that in females was 4.98 mm with an SD of 1.5. Using independent sample t-test, P value was 0.669. Statistically, no significant difference was present in the mean depth of Olfactory Fossa between males and females. Among the total 792 sides, Keros type I was seen in 192 (24.2%), type II (plate 1) in 518 (65.5%), and type III (plate 3) in 82 sides (10.3%). On the right side, 98(24.7%) OF were Keros type I, 258 (65.1%) were type II, and 40 (10.1 %) were type III. On the left side, 94 (23.7%) OF were Keros type I, 260 (65.6 %) were type II, and 42 (10.6 %) were type III. Among males, OF was Keros type I among 120 subjects (25.6 %), type II among 302 (64.5 %), and type III among 46 (9.8 %) on the both sides combined. Among females, OF was type I among 72 (22.2%), type II among 216(66.6 %), and type III among 36 (11.1%) on the both sides combined [Table 3a,b,c].

Table 3a; Distribution of KEROS Classification on Right side							
				Keros Classification on Right			Total
				I	II	III	
Gender	**F**	Number		36	108	18	162
	M	Number		62	150	22	234
Total				**98**	**258**	**40**	**396**

Table 3b; Distribution of KEROS Classification Left side							
				Keros Classification on Left			Total
				I	II	III	
Gender	**F**	Number		36	108	18	162
	M	Number		58	152	24	234
Total		**Number**		**94**	**260**	**42**	**396**

Table 3c; Distribution of KEROS Classification on both sides							
				Keros Classification on both sides			Total
				I	II	III	
Gender	**F**	Number		72	216	36	324
	M	Number		120	302	46	468
Total				**192**	**518**	**82**	**792**

Association between sex and Keros type on the both sides were compared using Chi-square test, P value was 0.023 (<0.05), and therefore, significant association between sex and Keros type was found.

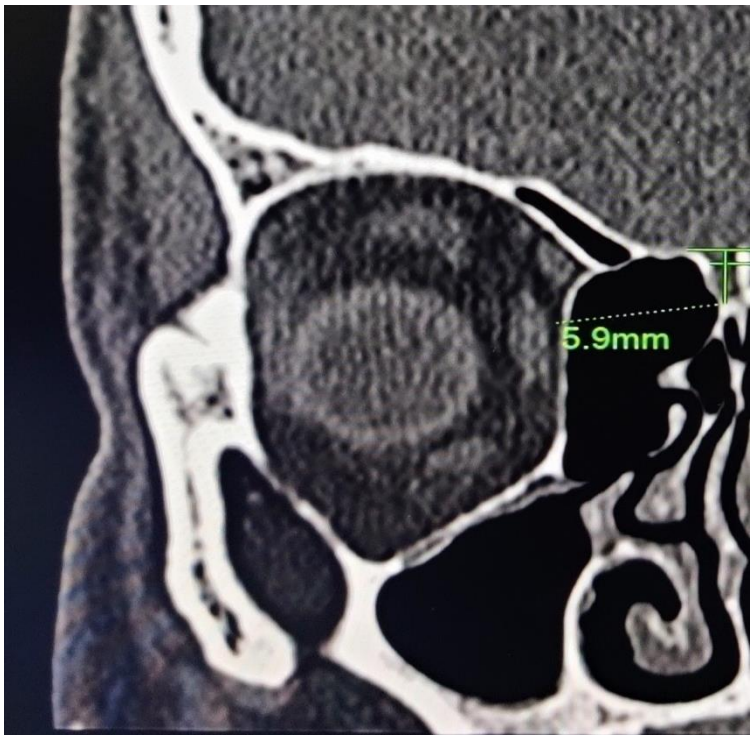

Plate 1 Showing KEROS type II on Right side.

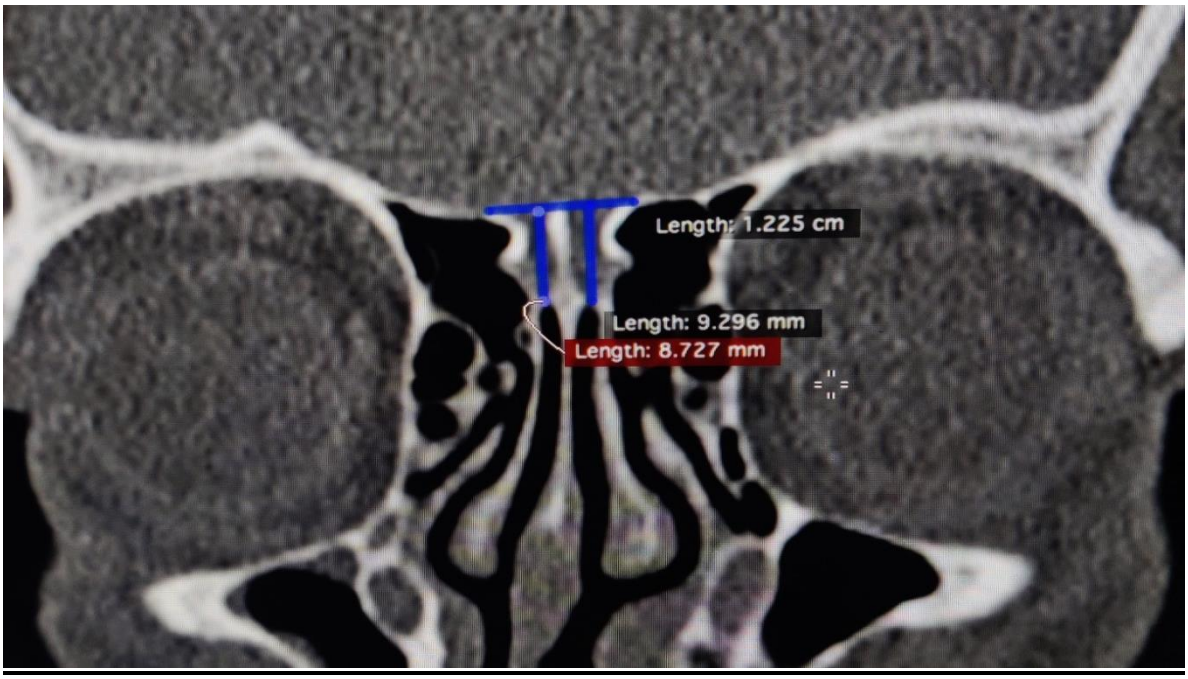

Plate 2 Showing KEROS type III on both sides.

Discussion:

With wide use of Multidetector CT particularly to visualize PNS anatomy particularly before FESS surgery, it becomes necessary for surgeon to know about various important anatomical structures particularly Keros morphology to optimise surgical approach and reduce complications for the patient. There is paucity of data on olfactory fossa depth particularly North India, barring a few, however in Kashmir no large scale study has been conducted till date. A study conducted by Salroo *et al*. had sample size as compared to our study and they didn't study right and left side olfactory depth seperately. In our study, we have analysed Keros morphology type in both the sexes and individually characterised it on left and right side. This study evaluates around 396 subjects and total of 792 olfactory fossa depth. Among the total 792 sides, Keros type I was seen in 192 (24.2%), type II in 518 (65.5%), and type III in 82 sides (10.3%). Comparison with other studies it was seen that there exists diversity in the distribution of configuration among different racial populations across the world and Indian states and is shown in (Table 4). Statistically significant association was seen between sex and Keros type in our study which was comparable to study done by Babuet al[10].The dangerous type III Keros was seen less on the right (10.1%) compared to the left (10.6%) side, more in females (11.1%) than females (9.8 %). Salroo *et al*., no statistically significant difference was observed in the distribution of Keros classification between males and females[11].

The mean depth of olfactory Fossa in our study was 5.05 mm. The mean depth in the studies by Jacob et al. and Salroo *et al*. was 5.08 and 4.9 mm, respectively [6,11]. No significant difference was seen in the mean depth of Olfactory Fossa between right and left sides in this study. Jacob et al. also observed no significant difference in Olfactory Fossa depth between the sides [6]. Conversely, the study by Salroo *et al*. showed significant difference between the sides [11]. A study by Pawar *et al*. also showed statistically significant difference in OF depth between the right and left sides but only in males [12].

In our study left olfactory fossa was deeper than Right in females and males had deeper right Fossa than left. In the study by Pawar *et al*. also, right-sided OF was deeper than the left in males **[12].** But in the studies by Jacob *et al*. and Salroo *et al*., OF was shallower on the right side **[6,11].**

Table 4: KEROS distribution in Various Indian State according to previous studies								
	Our Study	Babu*et al*	Salroo *et al*	Pawar *et al*	Satish Nair	Ali *et al*	Gupta *et al*	Jacob *et al*
Type I	24.2%	17.5%	29%	18.5%	17.2%	20%	39%	23.44%
Type II	65.5%	74.6%	61%	74.5%	77.2%	78.7%	59%	70.8%
Type III	10.3%.	7.9%.	10%	7%	5.6%	1.3%	2%	5.73%

Conclusion:

Keros classification is important for surgeon prior to FESS, it's a guide to avoid dreaded complications (CSF rhinorhea) associated with FESS. Based on Keros the surgical planning can be done accordingly, keeping in view other factors as well. The most prevalent type of Olfactory Fossa among our regional population was Keros type II. Even though the prevalence of the dangerous type III OF was low thus should be well documented in order to avoid Iatrogenic complications. Therefore, preoperative assessment of KEROS morphology along with other factors should be done.

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Conflicts of interest:

There are no conflicts of interest.

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Autobiography:

Author is PG Resident in Department of Radiodiagnosis, GMC Srinagar.

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