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MULTIDETECTOR COMPUTED TOMOGRAPHY VALUATION OF OLFACTORY FOSSA DEPTH REGARDING FUNCTIONAL SINUS ENDOSCOPIC SURGERY IN EGYPTIAN PATIENTS

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Abstract

Background: functional endoscopic sinus surgery is widely performed for many disease of nose and sinuses diseases and some of its complications related to olfactory fossa anatomical varieties.

Our study aim is to evaluate the olfactory fossae depth, dimensions, and morphology according to the Keros' classification on pre functional endoscopic sinus surgery (pre-FESS) and determine the incidence and degree of asymmetry in the height of the ethmoid roof in the Egyptian population.

Methods: Cross section analysis of 50 patients multidetector CT skull base studies (100 sides) was performed and the depth of OF was measured from vertical height of lateral lamella. in between 2022 - 2023. Statistical Methods: Results were analyzed according to gender and laterality using independent sample T-test and Chi-square test.

Results: According to the Keros classification, the incidence of different types of olfactory fossae was as follows: **Type I** olfactory fossa was found in 34 sides (34%), of which 18 (19%) were found on right side and 15 (15%) on the left side. **Type II** olfactory fossa was found in 61 sides (61%), of which 29 (29%) were found on right side and 32 (32%) on the left side. **Type III** olfactory fossa was found in 5 sides (5%), of which 2 (2%) were found on right side and 3(3%) on the left side. Asymmetry in the ethmoid roof we found in 17 cases (34**%).**

Conclusions: Keros' type II was the commonest followed by type I and type III. There was asymmetry in the depth of the olfactory fossae in 17 (34%) cases. There was no significant gender predilection as far as type and asymmetry were considered.

Keywords: Olfactory fossa; cribriform plate; endoscopic sinus surgery; Keros classification; lateral lamella; crista galli.

1. INTRODUCTION

Chronic rhinosinusitis is a very common disease; regrettably, it does not improve completely by medical treatment. Functional endoscopic sinus surgery (FESS) is the main line of surgical treatment for this disorder. [1] Functional Endoscopic sinus surgery is a surgery which is widely performed for the surgical treatment of many diseases other than chronic rhinosinusitis such as mucoceles, nasal polyps, sellar/parasellar tumors as well as decompression of optic nerve.[2] There are many variations

in sinus anatomy, and to be safer in performing FESS, surgeons should pay attention to these different variations. No way to fully describe these variations better than computed tomography (CT). [3] The ethmoidal notch is the site where the olfactory fossa (OF) is settled at the frontal bone at the center of its horizontal part. The olfactory fossa floor is formed by the cribriform plate of the ethmoid and is limited laterally by the lateral lamella. The ethmoid roof lies inferior to frontal bone and is not usually in line with frontal bone. The distance between the ethmoid roof and the frontal bone is the depth of the olfactory fossa, Keros in (1962) [4] classified depth of olfactory fossa into three categories: Keros I, OF depth measures from 1 to 3mm; Keros II, OF depth measures from 4 to 7 mm; and Keros III : OF depth measures from 8 to 16mm. According to Keros classification type II variation is the most common, followed by type III and, lastly, type I[5] .

The thinnest part of the skull base is the lateral lamella cribriform plate (LLCP) of the OF for this it is the site of maximum risk for iatrogenic lesion at the skull base. In cases with increase height of LLCP, the olfactory fossa will be more susceptible to injury because it is narrower and deeper; the ethmoid roof will be in more down position. The hanged low down ethmoid roof will increase the risk of LLCP iatrogenic disastrous injury. LLCP injury complications that range from infection and bleeding up to leak of cerebrospinal fluid as well as intracranial injury[5] .

The microdebrider and the endoscope should be kept away from the thinnest and vulnerable bone of the base of the skull LLCP all the time of surgery to avoid serious injury to the base of the skull . [2]

Although of the great advancement as regarding to techniques and instruments in the procedure of (FESS), serious complications during this surgery are not uncommon, preoperative CT assessment of the paranasal sinuses particularly the olfactory fossa and its relation to skull base is a very important study to avoid serious complications even fatal outcome may be disastrous complications even in the best hands[6] .

Our study aims to evaluate Keros types and their incidence by evaluating the OF depth according to the Keros Classification, distribution of Keros types, age and gender differences on a paranasal sinus MDCT scan in the Egyptian patient.

To measure the variations in depth and morphology of olfactory fossa of Egyptian patients to assess the risk possibility of endoscopic sinus surgery for this ethnic group using paranasal sinuses multidetector computed tomography.

Materials And Methods

This cross-section study was conducted in Alzahraa University Hospital, Cairo Egypt, through the period January 2022 and January 2023.

This study was recruited as a convenience sample 0f 50 patients (26 female and 24 male) undergoing 160-slice CT without contrast enhancement to diagnose any pathological lesion obscure of anatomy the evaluation of anatomical variations of olfactory fossa, depth, dimensions and morphology as risk factors of endoscopic sinus surgery. This was done by consultant radiology using PACS software .

Our inclusion criteria in this study were performing study on Egyptian patients to overcome the ethnic problem of olfactory fossa configuration ethnic varieties. All our patients were adults not less than 18 years old with paranasal sinusitis based on clinical assessment, both males and females are non-selectively included in the study .

Exclusion criteria were patients less than 18 years old, pregnant patients are excluded for issue of risk of fetal radiation effects as well as patients with significant trauma, operations or tumors affecting the region of olfactory recess and olfactory fossa were excluded from the study as these pathologies disturbed the visualization of the skull base .

Patients were subjected to full history taking (age, sex, complain and duration of the disease) then the patients were subjected to paranasal CT study with 160 slices multidetector computed tomography machine in the radiology department of Al Zahraa University hospital for measuring depth and morphology of olfactory fossa. All CT exams were with no contrast enhancement. Soft tissue and

bone windows were included in the study. Coronal, axial and sagittal views are checked; however, the measures are mainly based on coronal bone window view.

Ethical Considerations:
The study was conducted according to declaration of Helsinki 2013 and was revised and approved by research ethics committee, faculty of medicine for girls, Al-Azhar University with number (1555), (12-10-2022).

During the study, the patients were informed about the examination and instructed not to move during the study and advised to follow the voice instructions, the patients were lying down supine with head supported. A scout lateral view was first taken to plan axial views on it with no tilt with acquisition of tomographic imaging technical parameters included tube voltage 120 KV, effective mAs 160, rotation time 1 s, section thickness 4mm and a field of view 15 cm. Axial images were reconstructed using soft tissue and high-resolution bone filter which then transferred to the workstation to generate multi-planer reformation (MPR) in different planes.

The measurement of both right and left lateral lamellae in the coronal views was recorded. The height of the lateral lamella was measured to determine the depth of the olfactory fossa. At CT coronal view, a line was drawn along lower bony orbital margins and from this line two perpendicular lines were drawn up to the inferior and superior margin of the lateral lamella. Difference between these last two lines denoted the depth of the olfactory fossa. The olfactory fossae were then grouped according to Keros' classification (Fig. 1). The distribution was then analyzed according to gender and laterality[7] .

The Keros classification is widely used to evaluate the nasal roof depth. [8] As stated in the Keros classification, the depth of the olfactory fossa is estimated in three categories: type 1 (1-3 mm), type 2 (4-7 mm), and type 3 (8-16 mm). [9] Type 3 is the most dangerous and important type of endoscopic sinus surgery and has a very thin cribriform plate. [10] The imbalance of the depth of both sides' olfactory fossa or the height of the ethmoidal roof may lead to a greater risk of intracranial infiltration during endoscopic sinus surgery.[11,12]

The depth of the olfactory fossa was measured and classified as per the Keros classification: type 1 (1-3 mm), type 2 (4-7 mm), and type 3 (8-16 mm) (Figure 1) [9].

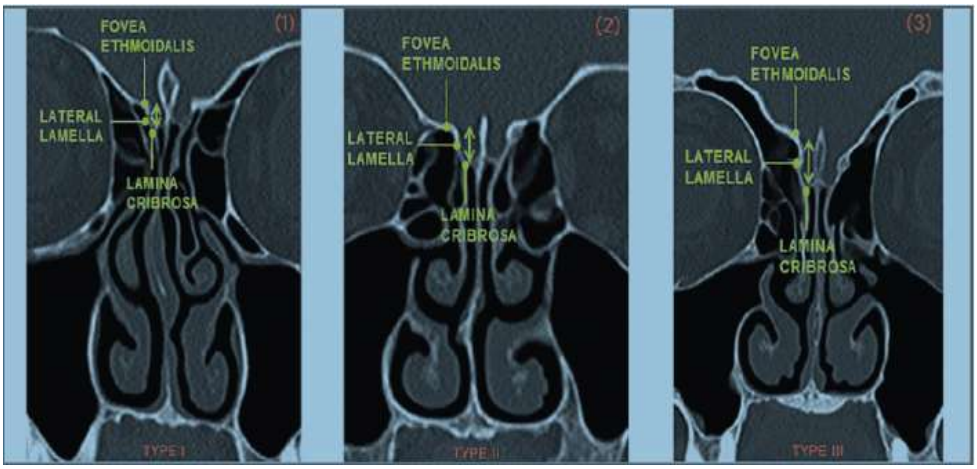


Figure 1: MSCT Coronal reformate showing the Keros classification

RESULTS

We included valid cases; 26 females (52%) and 24 were males (48%). The oldest patient in males was 84 -years old and 78 -years-old in females while the youngest was 18-year-old in males and 20 -year-old in females. The average age of the male and females' patients were 33, 29 years respectively.

Table1 A: distribution of olfactory fossa according to the side and Keros types classification and sex

Right KEROS TYPES * Gender Crosstabulation			Gender		Total
			Male	Female	
Right KEROS TYPES	type 1	Count	13	6	19
		%	54.2%	23.1%	38.0%
	type 2	Count	11	18	29
		%	45.8%	69.2%	58.0%
	type 3	Count	0	2	2
		%	0.0%	7.7%	4.0%
Total		Count	24	26	50
		%	100.0%	100.0%	100.0%

Pearson Chi-Square =6.199** (p_value= 0.045) i.e.(There is a relationship between the two variables)
Spearman Correlation = 0.346 (p_value= 0.014)

There is medium correlation between the two variables *gender and the right Keros types.

Table 1 B: distribution of olfactory fossa according to the side and Keros types classification and sex

Left KEROS TYPES * Gender Crosstabulation			Gender		Total
			Male	Female	
Left KEROS TYPES	type 1	Count	6	9	15
		%	25.0%	34.6%	30.0%
	type 2	Count	17	15	32
		%	70.8%	57.7%	64.0%
	type 3	Count	1	2	3
		%	4.2%	7.7%	6.0%
Total		Count	24	26	50
		%	100.0%	100.0%	100.0%

Pearson Chi-Square =0.960** (p_value= 0.613) i.e.(There is NO relationship between the two variables) Spearman Correlation = -0.067 (p_value= 0.642)
There is no correlation between the two variables *gender and the left Keros types.

According to the Keros classification, Type 1 olfactory fossa was found in 34 sides (34%), of which 19 (19%) were found on right side and 15 (15%) on the left side. Type 2 olfactory fossa was found in 61 sides (61%), of which 29 (29%) were found on right side and 32 (32%) on the left side. Type 3 olfactory fossa was found in 4 patients (4%), of which 2 (2%) were found on the right side and 3 (3%) on the left side. The most common type is type 2 seen at the left side and type 1 seen at the right side and the least one was type 3 seen at left side. The sex–wise distribution to the Keros classification type 1, seen at 19 males and 15 females and Keros Type 2 seen at 28 males, 33 females, Keros type 3 seen at 1 male and 4 in females.

Table 2: Using the "Mann Whitney U Test" is a non-parametric statistical test to compare two groups of sex (male/female) applied to see the significant difference between male and female Keros types has revealed significant statistical difference of the right OF depth and gender.

	Gender	N	Mean Rank	Z	Sig.
Right OF Depth	Male	24	19.71	-2.701	0.007
	Female	26	30.85		
	Total	50			
Left OF Depth	Male	24	26.54	-0.486	0.627
	Female	26	24.54		
	Total	50			
Right KEROS TYPES	Male	24	21.00	-2.421	0.015
	Female	26	29.65		
	Total	50			
Left KEROS TYPES	Male	24	26.35	-0.472	0.637
	Female	26	24.71		
	Total	50			

Table 3: Correlation between sex and 4 variables

Spearman's rho		KEROS TYPES right	KEROS TYPES left	R OF Depth	L OF Depth
Gender	Correlation Coefficient	.346*	-0.067	.386**	-0.069
	Sig. (2-tailed)	0.014	0.642	0.006	0.632

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

There is statistically significant between the sex and right-side olfactory fossa and no significant at the left side and sex.
Using Cross tabulation, the relationship analysis between Keros type right and left and patient sex. The chi-square test was used to test the Hypothesis Study: The null and alternative hypotheses for a $\chi 2$ test are:

- *H_0: No relationship. The two variables are statistically independent.* (O=E)
- *H_1: There is a relationship. The two variables are not statistically independent (*O≠E*) where.*
- *O=observed frequency for each cell*
- *E=expected frequency for each cell*

Table 4 (A). Asymmetry in the depth of the olfactory fossae.

Types	Number	Percentage (%)	Gender
Same type	33 patients	66%	16 M-17F
Asymmetry	17 patients	34%	9 M-8F
Higher subtype on right	10 from 17 patients	20%	6 M-4F
Higher subtype on left	7 from 17 patients	14%	3 M-4F

Symmetry was found in 33 patients (66%) with the same Keros type for both right and left sides to the same patient seen at 16 male and 17 female patients.

Asymmetry for the keros type with sides right and left fall in different types was found in 17 patients (34%) 9 male and 8 female patients, of these, the right olfactory fossa was of a higher subtype in 10 patients (20%) and left olfactory fossa was of a higher subtype in 7 patients (14%) (Table 4A).

Table 4 (B). Asymmetry of the olfactory fossae depth

Types	Number	Percentage (%)
Same subtype	33	66%
Asymmetry	17	34%
-Asymmetry 1-2	9	18%
- Asymmetry 1-3	3	6%
-Asymmetry 2-3	5	10%

Asymmetry for the anatomical subtype to fall in asymmetry 1-2 was found in 9 patients (18%), 1-3 was found in 3 patients (6%) and 2-3 was found in 5 patients (10%) (Table 4-B).

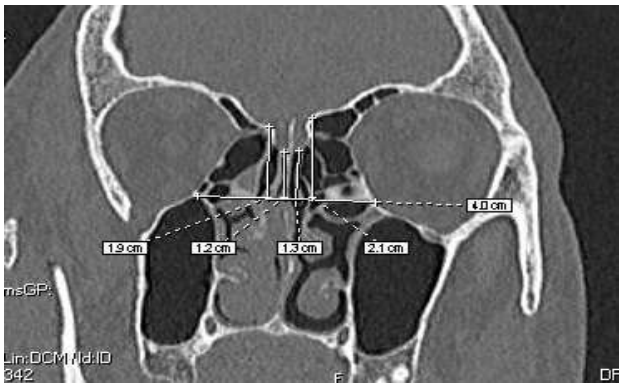
Table 4. Patient age distribution at both patient sexes

Patient Age	Females	Males
17- 30 (yrs)	10	17
30- 45 (yrs)	8	2
> 45 (yrs)	6	5
Total	26	24

Age distribution at both patient sex, age between 18-30 years old were 10 female and 17 males , 30-45 years old were 8 female and 2 males and > 45 years old were 6 female and 5 males (Table).

Selected Cases

Case No 1

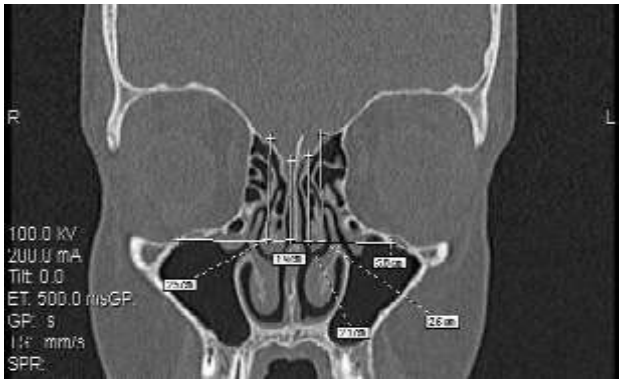


MSCT coronal reformate paranasal sinuses obtained in bone window showing symmetry in the depth of OF on both sides (Type III)

Case No 2

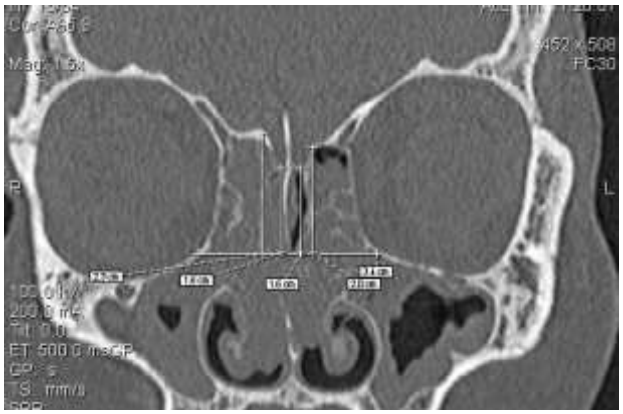
MSCT coronal reformate paranasal sinuses obtained in bone window showing symmetry in the depth of OF on both sides (Type II)

Case No 3



MSCT coronal reformate paranasal sinuses obtained in bone window showing asymmetry in the depth of OF on either side. Both sides have different Keros type OF (type III on right and type II on left side)

Case No 4



MSCT coronal reformate paranasal sinuses obtained in bone window showing asymmetry in the depth of OF on either side. Both sides have different Keros type OF (type III on right and type II on left side) with diffuse mucoperiosteal thickening of the paranasal sinuses.

DISCUSSION

Development of multi-slice technology, exposing the anatomical details in the best way, the thin-section paranasal sinus CT also provides an important aim for the diagnosis and treatment of paranasal sinus disease. [13] Coronal images can specifically be considered as maps in the assessment of the anatomy that is variable even between the two sides of the same person; there is a possibility of demonstrating areas at risk for complications in the arrangement of endoscopic nasal surgeries ,14] . [16 ,15

The olfactory fossa is a depression in the anterior cranial cavity; its floor is formed by cribriform plate of ethmoids which is a fragile bone that separates anterior cranial cavity from nasal cavity. The lateral boundary of olfactory fossa is formed by lateral lamella of the cribriform plate and the medial boundary is formed by crista galli. [10] At olfactory fossa, the olfactory bulbs and tracts are present. The lateral lamella is the thinnest bone in the anterior skull base, and it is dehiscent in about 14% of patients. [17] Within the same patient, based on vertical height of lateral lamella, variation in the levels of the cribriform plate, ethmoid roof, and fovea ethmoidalis may be noted[18] .

ESS is now the most common line for treatment of chronic sinonasal diseases. As a result of this detailed anatomical skull base knowledge is of great importance, to avoid serious surgical hazards. Therefore, before surgery, anatomical variations are obligatory to be diagnosed before surgery and should be examined precisely for every patient. Assessment of depth of olfactory fossa is widely depends on Keros classification and pre-operative assessment should be done, otherwise operative procedures without enough knowledge of anatomical variations may lead to serious complications and life-threatening problems[19] .

There are many endoscopic sinus surgery complications that can be divided into minor and major complications. Minor complications are more common, which is about 1.1–20.8% of cases undergoing functional endoscopic sinus surgery. Major complications are rare, occurring in 0–1.5% of such surgeries. Major complications include the risk of cerebrospinal fluid leak, orbital/ocular injury (orbital fat herniation, injury of extra-ocular muscles, dysfunction of ocular motility, injury of optic nerve as well as periorbital hematoma or emphysema) and intracranial injury (injury of brain or major blood vessels). [20] For this reason an understanding of the fine anatomical details and anatomical variations of the paranasal sinuses and the olfactory fossa region is mandatory. Asymmetry of the olfactory fossa, fovea ethmoidal as well as lateral lamella anatomical variants are all very important issues in FESS since knowledge lack of it can result in operative iatrogenic injury. As a result, before every FESS, a preoperative computed tomography (CT) scan is required [12] .

Complications that occur with FESS are more pronounced with the hazardous procedure of surgical ethmoidectomy according to the study done by Dessi et al. [21] Many studies, highpoint the relation of the assessment of the ethmoidal roof and its role in the avoidance of endoscopic surgery hazards. A study done by Gray and Wu, (2013) [22] and Souza et al. (2008) [23] in evaluation of skull base, lateral lamella of cribriform plate commonly subjected to iatrogenic lesions during FESS.

The vertical height of the lateral lamella of the cribriform plate determines the depth of olfactory fossa height. In 1962, Keros, defined lateral lamella height and classified the olfactory fossa depth into 3 types followed by its name: Keros type I (height less than3 mm), Keros type II (height from 4-7 mm) and Keros type III (height from 8-16 mm). Based on the Keros type, during the dissection of the fronto ethmoidal region, there is expose to a variable segment of the olfactory fossa lateral wall. The deepest olfactory fossa Keros type is type III and therefore is the most susceptible to iatrogenic injury. Type I olfactory fossa is shallow and therefore is the least susceptible to iatrogenic injury and so considered relatively safe and less hazardous to perform FESS[24] .

In our study we found that According to the Keros classification; Type 1 olfactory fossa was found in 34 sides (34%), of which 19 (19%) were found on right side and 15 (15%) on the left side. Type 2 olfactory fossa was found in 61 sides (61%), of which 29 (29%) were found on right side and 32 (32%) on the left side. Type 3 olfactory fossa was found in 4 patients (4%), of which 2 (2%) were found on right side and 3 (3%) on the left side. Type 2 is the most common type according to Keros classification then type I and the last type was type III. These results are agreed with Gimsa et al 2020 [25] for studies conducted among the Saudi, Jordanian, Egyptian, Indian, Brazilian, and Turkish Populations and match also with Salroo et al, Pawar et al, Satish nair, Ali et al and Gupta et al studies in Indian patients (26, 27, 28, 29 and 30). In contrast to this result, the studies performed by Gimsa et al among the Egyptian and Filipino populations demonstrated that the majority of studied subjects were classified as Keros type I, followed by type II and then type III

There is Statistically significant association was seen between sex and Keros type in our study especially on the right side, The sex–wise distribution of the depth of olfactory fossae I, it was 26 females and 24 males. The subtypes of the females it was 7 right and 7 left was type I of keros' classification, 20 right and 14 left type II and 3 right and 1 left type III. The subtype of the males it was 11 right and 7 left type I, 13 right and 17 left type II there is no patients in type III in males' olfactory fossae. this does not match with the study by Salroo et al. (26), no statistically significant difference was observed in the distribution of Keros classification between males and females.

In this study, various parameters of asymmetry were analyzed in detail, but no significant association was seen between sex and any of these. In this study, 20 patients (34%) of the subjects showed

asymmetry in the OF depth, 10 patients (20%) at the right and 7 patients 14% at the left sides and its prevalence was almost similar in males (52.94%) and females (47.06%). This in agree with studies by Satish Nair and Ali et al., 11.7% and 14.6% of patients, respectively, had asymmetry[29& 28] .

In this study, there is no significant difference was seen in the mean depth of OF between right and left sides. This in match with study done by Jacob et al. also observed no significant difference in OF depth between the sides.[31] Conversely, the study by Salroo et al. showed significant difference between the sides.[26] A study by Pawar et al. also showed statistically significant difference in OF depth between the right and left sides but only in males[24].

CONCLUSION:

Computerized tomography paranasal sinuses scan imaging and Keros classification has allowed detailed evaluation of the sinonasal diseases and assessment of anterior skull base anatomy. Understanding the fine detailed anatomic relationship of ethmoid roof and its anatomic variants is critical to avoid FESS vulnerable intracranial complications. So, evaluation of the depth of the olfactory fossae and asymmetry of ethmoidal roof represents a crucial duty in tomographic studies and should be highlighted in the routine description of CT paranasal sinuses reports especially in preoperative CT assessment, otherwise, iatrogenic life-threatening hazards may occur.

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