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Original Article

Computed tomography assessment of the ethmoid roof based on Keros classification in Iraqi patients undergoing functional endoscopic sinus surgery

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Abstract

Background: Among the most popular methods employed to classify the depth of the olfactory fossa is Keros classification. This study aims to assess Keros classification of the ethmoid roof, any possible association between Keros types and gender, and the incidence of asymmetry between right and left sides among Iraqi patients.

Methods: A retrospective cross-sectional study was conducted at Al-Shaheed Gazi Al-Hariri Teaching Hospital, Medical City, Baghdad, Iraq. The archived reports and the CT scans images (nose and paranasal sinuses) of 126 patients who have undergone functional endoscopic sinus surgery between January 2019 and January 2020 were reviewed. Univariate and bivariate statistical analysis was performed using SPSS version 24. The statistically significant was considered at less than 0.05.

Results: More than half of patients were females (54.0%) with a mean age of 31.52 ± 11.38 (SD) years (range: 10-57 years). Among the total patients, the mean depth of olfactory fossa (OF) was 3.58 ± 0.02 mm. Results showed that Keros type I was the most common type (71.0%), followed by type II (27.4%) and type III (1.6%) respectively. The difference in the olfactory fossa depth between the right and left sides was ≥ 1 mm in 16 (12.7%) patients and < 1 mm in 110 (87.3%) patients. Moreover, there was no significant relation between symmetry/asymmetry and gender (p-value > 0.05).

Conclusion: Keros type I was the most common type, which carries the lowest risk of inadvertent intracranial injury during endoscopic sinus surgery; besides the relatively low percentage of asymmetry in the depth of the two olfactory fossae among patients, surgeons should always be cautious during surgery to avoid iatrogenic injury concerning the thin lateral lamella of the cribriform plate.

Keywords: Keros Classification, CT Scan, Ethmoid Roof, Lateral Lamella, Endoscopic Sinus Surgery, Iraq

Background

The importance of computed tomography (CT) scan of the paranasal sinuses, both in the diagnosis and preoperative planning, has increased during the last thirty years, especially with the growing popularity of different functional endoscopic sinus surgery (FESS). Its value as a road map for surgeons in the preoperative assessment of patients undergoing FESS is not questionable [1-4]. CT scan has been “the gold standard in providing information on the anatomy and extent of pathology in chronic rhinosinusitis” [4]. Its precision and relevance in the radiographic assessment of the ethmoid roof have been documented in the literature for more than 20 years [5,6]. CT scan should be used to evaluate the paranasal sinuses in the preoperative period as it will guide the surgeon to avoid intraoperative complications [7]. The term ‘dangerous ethmoid’ was first introduced by Kainz and Stammberger and defined it depending on the depth of the olfactory fossa, as in Keros type III [8]. “The olfactory fossa depth is determined by the height of the lateral lamella of the cribriform plate”. In 1962, Keros classified the olfactory fossa depth into three types, Keros type I (1- 3 mm), type II (4–7 mm), and type III (8–16 mm) [9]. A variable segment of the lateral wall of the olfactory fossa, (depending on the olfactory fossa depth) will be exposed during the endoscopic dissection of the ethmoid region where Keros type III being the most exposed one, besides the fact that the thinnest bone of the entire skull base is the lateral lamella of the cribriform plate [10,11], leading it to be at a higher risk for iatrogenic injury during endoscopic ethmoid procedures [8, 12, 5, 13]. Badia et al. [14] found that the anatomical variations of the paranasal sinuses might differ radiologically in their prevalence between different ethnic groups.

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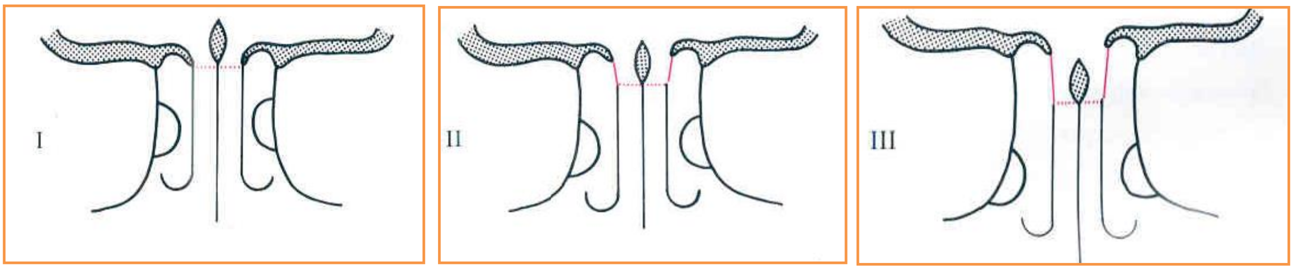

Figure 1: Schematic drawing shows the three different types of olfactory fossa according to Keros classification. The length of the lateral lamellae of the cribriform plate increases from type I to III. (Modified from Stammberger) [12].

Jang et al [15] noted that there is no significant difference between the age group of children and the group of adults in the incidence of bony defect in the sinuses. Paber and his team [16] concluded that there was no significant difference in the height of the lateral plate and the distribution of keros classification among Filipinos of the age group younger than and older than 14 years.

Functional endoscopic sinus surgery has developed in Iraq over the past two decades. The prevalence of ear, nose, and throat (ENT) specialists interested in nasal diseases has significantly increased. Therefore, concerns about the anatomical and radiological variants of the paranasal sinuses have raised among Iraqi patients in order to minimize the risk of complications during these operations. This study aims to assess Keros classification of the ethmoid roof, any possible association between Keros types and gender, and incidence of asymmetry between right and left sides among Iraqi patients.

Methods

Study population and sample

A cross-sectional study designed to analyses retrospective data retrieved from the archive of Al-Shaheed Gazi Al-Hariri Teaching Hospital, Medical City, Baghdad, Iraq. A total of 126 archived reports and CT scans images of the nose and paranasal sinuses were reviewed for patients undergoing functional endoscopic sinus surgery between January 2019 and January 2020.

Inclusion criteria

All patients underwent a CT scan of the nose and paranasal sinuses using the same CT system and protocol in the hospital. The same senior radiologist evaluated all scans, and the images were reconstructed using the software Somaris/7 Syngo CT 2012B, a registered trademark of Siemens AG.

Exclusion criteria

All patients having a history of previous trauma, previous sinus surgery, sinonasal tumor, cerebrospinal fluid leak, aged less than 14 years, and any poor resolution CT scan images in which the patient was rotated or tilted were excluded from the study.

CT imaging and technical measurements

CT scan images were obtained with a single multi-detector 64-slice CT scanner (Siemens SOMATOM Definition AS, Germany); the technical parameters were as follows (kVp 100; effective mAs caredose 130; rotation time 1.0 sec; collimation64 X 0.6 mm; scan direction = caudocranial; reconstruction spacing = 0.5 – 3 mm; window width and level = 2500/500; Coronal and sagittal image reconstructions are also performed). To measure the height of the lateral lamella of the cribriform plate (LLCP), a horizontal line was drawn between the infraorbital foramina on the floor of the orbital cavities. Further, two parallel, perpendicular lines were drawn from the medial ethmoid roof point and another line from the lowest point of the cribriform plate. The length of these two lines was measured, and then the result of their subtraction was considered the height of the lateral lamella, as shown in figure (2). The lateral lamella height measurements ranging between 1 – 3.99 mm, 4 – 7.99 mm, and 8 – 16 mm were categorized as Keros type I, II, and III, respectively.

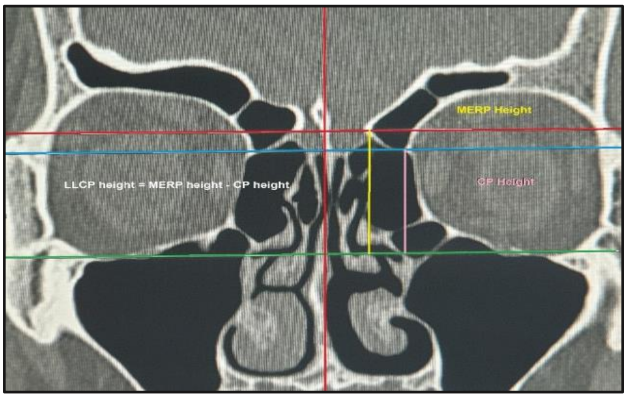

Figure 2: Measurement of the depth of the lateral lamella in a coronal paranasal sinus CT cross-section. Greenline = Infraorbital foramina (reference point), Yellow line = Medial ethmoid roof point height, Pink line = cribriform plate height; LLCP height = MERP height – CP height.

Statistical analyses

The data were sorted in Excel software and analyzed in SPSS software (version 24.0) (SPSS Inc., Chicago, IL, USA). Results of univariate analysis were expressed as the mean and standard deviation (SD), frequencies and proportion. Cross tabulation recruiting the Chi-square test was performed to check the differences in the distribution of nominal variables. P-values less than 0.05 were considered significant.

Results

One hundred twenty-six CT scans were analyzed, 58 (46%) were males, and 68 (54%) were females. The mean age of patients was 31.52 ± 11.38 (SD) years (Range: 10-57 years). Each CT scan was counted as two cases (right and left) for a total of 252 cases. The mean height of the lateral lamella of the cribriform plate (LLCP) on the right side was 3.59 ± 1.03 mm, and on the left side, it was 3.56 ± 1.09 and overall, it was 3.58 ± 0.02 mm. Table 1 presents the distribution of 126 olfactory fossae according to their side and Keros classification. Among the studied sample eighty-nine patients (70.6%) were Keros I, 35 (27.8%) Keros II, and 2 (1.6%) Keros III for the right lateral lamella (N=126). Ninety (71.4%), thirty-four (27.0%) and two (1.6%) patients were classified as Keros I, II,III respectively, for the left lateral lamella (N=126) (Table 1). According to Keros classification the LLCP height for both sides (Right and Left) was 0-3.99 mm (Type I) in 179 (71.0%) sides, 4-7 mm (Type II) in 69 (27.4%) sides, and more than 7 mm (Type III) in 4 (1.6%) sides. There was no statistically significant difference in relation between Keros type and the side (p-value > 0.05) (Table 1).

Table 1: Distribution of 126 olfactory fossae according to their side and Keros classification

Keros Types	Right side N(%)	Left side N(%)	Total (both sides) N(%)	p-value
I	89 (70.6)	90 (71.4)	179 (71)	0.990
II	35 (27.8)	34 (27)	69 (27.4)	
III	2 (1.6)	2 (1.6)	4 (1.6)	
Total	126 (100)	126 (100)	252 (100)	

In both sides (right and left), one hundred (39.7%) females were classified as Keros I and 33 (13.1%) were classified as Keros II and three females (1.2%) were classified as Keros III. Seventy-nine males (31.3%) were classified as Keros I, 36 (14.3%) were Keros II, and 1 (0.4%) was classified as Keros III (Table 2). Regarding the classification of Keros in type I, II, III, it was found that there is no association between the gender and the side (p-value > 0.05 in all types), as shown in Table (3). The difference in the olfactory fossa depth between the right and left sides were ≥ 1 mm in only 16 (12.7%) patients and < 1 mm in 110 (87.3%) patients. The statistical analysis showed no significant relationship between symmetry/asymmetry with gender, p-value > 0.05 (Table 4).

Table 2: Distribution of Keros classification with gender

Keros type	Total (both sides)	Female N(%)	Male N(%)
Observation	N=252	136(54.0)	116(46.0)
I	179(71.0)	100 (39.7%)	79(31.3%)
II	69(27.4)	33(13.1%)	36(14.3%)
III	4(1.6)	3(1.2%)	1(0.4%)

Table 3: Distribution of patients by their Keros type according to gender stratified by Ethmoid roof side (n=126)

Keros type	Right side [a] N (%)		Total	p-value	Left side [b] N (%)		Total	p-value
	Female	Male		0.356	Female	Male		0.853
Observation	68	58	126		68	58	126	
I	50 (56.2)	39 (43.8)	89		50 (55.6)	40 (44.4)	90	
II	16(45.7)	19 (54.3)	35		17(50)	17(50)	34	
III	2(100)	-	2		1(50)	1(50)	2	

Table 4: Right and left olfactory fossa depth differences by gender (n=126)

Difference between two sides	Gender		Total
	Males N(%)	Females N(%)	
Observations	58(46.0)	68(54.0)	126
< 1 mm	50 (45.5)	60(54.5)	110
≥ 1 mm	8(50.0)	8(50.0)	16

Discussion

To our knowledge, this study is the first to investigate Keros classification distribution among Iraqi patients undergoing endoscopic sinus surgery. The protocol of CT scan of the paranasal sinuses in this study using the caudocranial (axial) direction with reconstruction and reformation of the coronal and sagittal sections might look different from the usual direct coronal scan direction used in CT scanning of the paranasal sinuses. Such protocol can be followed after the advent of the multi-slice CT (MSCT) which has been shown to provide an equal or even better imaging quality than the single slice CT (SSCT) because of the absence of dental metal artifacts [17]. Keros [9] in his study classified the ethmoid roof into three types according to the LLCP height. He found that type II constituted 73.3% of the specimens, followed by Type I (26.3%) and Type III (0.5%). Similar findings to Keros's study have been reported in in various countries such as South Korea [15], Turkey [18], Turkey [19], Turkey [20], Turkey [21], Turkey [22] , Thailand [23], Brazil [10], Germany [24], Egypt [25], Pakistan [26], Poland [27], Saudi Arabia [28], India [29], India [30] , and Iran [31]. Unlike to Keros study [9], and similar studies [10, 15, 18-31] our findings showed that Type I is the most common type (71.0%), followed by Type II (27.4%) and the Type III (1.6%) of the cases, respectively. However, our findings inline to results reported in studies from Philippine [16], USA [32], UK [33], Nepal [34], Malaysia [35], and Egypt [36] which confirms that the Keros type I is the most common. Moreover, two studies from UK [37] and UK [38] found that Keros type III was the most common. Details about the country of study, year of publication, sample size, and percentages for each species in the virus classification for a set of previous studies are shown in Table 5. These variations in Keros classification among patients from different countries might be attributed to the different racial and genetic factors in these populations and races [14].

Likewise to several studies conducted in Turkey [19, [22], Poland [27], and Iran [31], our study found no statistically significant difference between males and females in all Keros types on both sides. In contrast, other studies from Philippine [16], Malaysia [35] and India [30] found a statistically significant difference in Keros types II between males and females and some other studies from Egypt [25], Saudi Arabia [28], and Pakistan [26] found a statistically significant difference between males and females in Keros type I.

Our findings reported asymmetry in the olfactory fossa depth of ≥ 1 mm in sixteen patients (12.7%) compared to 110 patients (87.3%) with a difference of < 1 mm. Similar results have seen in studies from Thailand [23], Brazil [10] , Poland [27], India

[29], and USA [39] with the percentages of asymmetry of 30.7%, 12.0%, 20.0%, 23.0%, and 9.5% of patients, respectively. Furthermore, other two studies conducted in India [30], and Malaysia [35], showed different results, and asymmetry in the olfactory fossa depth was more common than symmetry between right and left sides with asymmetry percentages of 75.0% and 92.7%, respectively. Comparing the difference in olfactory fossa depth between both sides, it was found that the right side was more in-depth than the left side in 8 patients (> 1mm), and in a similar number of patients, the left side was more in-depth than the right side. Previous studies from Brazil [10], Turkey [19], India [28] [29], USA [32], and Nepal [34], showed that the right side was more in-depth than the left side with the percentages of 56.0%, 54.2%, 69.57%, 54.0%, 56.0% of asymmetric cases, respectively. The left side was deeper in other studies conducted in Malaysia [35], and Egypt [36] with the percentage of the deeper left side was 51.0%, 58.1% of asymmetric cases, respectively.

Conclusion

The Keros type I was the most common type among the Iraq patients. Keros type I carries the lowest risk of inadvertent intracranial injury during endoscopic sinus surgery. In addition to the relatively low percentage of asymmetry in the depth of the two olfactory fossae among patients, however, the surgeons should always be cautious during surgery to avoid iatrogenic injury concerning the thin lateral lamella of the cribriform plate. original version of fcv-19s was developed by Ahorsu et al. [16]. The total score was calculated by adding each item score (from 7 to 35). The higher the score, the greater the fear of COVID-19.

Table 5: Keros classification among different studies sorted according to the year of publication of the study

Study (Authors)	Country	Year	No.	Type I (%)	Type 2 (%)	Type 3 (%)
Keros P. [9]	Germany	1962	450	26.3	73.3	0.5
Jang et al. [17]	South Korea	1999	205	30.5	69.5	None
Erdem et al. [18]	Turkey	2004	136	8.1	59.6	32.3
Nitinavakarn et al. [23]	Thailand	2005	88	11.9	68.8	19.3
Gauba et al. [37]	UK	2006	32	34.4	28.1	37.5
Souza et al. [10]	Brazil	2008	200	26.2	73.3	0.5
Paber et al. [16]	Philippine	2008	109	81.6	17.9	0.5
Solares et al. [32]	USA	2008	50	83	15.0	2.0
Savvateeva et al. [24]	Germany	2009	111	11.25	68.1	20.7
Nouraei et al. [33]	UK	2009	278	92	7.0	1.0
Bista et al. [34]	Nepal	2010	50	86	12.0	2.0
Elwany et al. [25]	Egypt	2010	300	42.5	56.8	0.6
Alazzawi et al. [35]	Malaysia	2011	150	80	20.0	None
Kaplanoglu et al. [19]	Turkey	2012	500	13.4	76.1	10.5
Guler et al. [20]	Turkey	2012	300	26	66.0	8.0
Adeel et al. [26]	Pakistan	2013	77	29.8	48.7	21.4
Al-Abri et al. [38]	Oman	2014	360	30	34.0	36.0
Shama & Montaser [36]	Egypt	2015	100	56.5	40.5	3.0
Erdogan et al. [21]	Turkey	2015	110	10	67.7	22.3
Skorek et al. [27]	Poland	2016	120	9.2	75.8	15.0
Alrumaih et al. [28]	Saudi Arabia	2016	121	6.6	52.9	29.8
Murthy& Santosh [29]	India	2017	100	19.5	71.5	9.0
Sari et al. [22]	Turkey	2017	516	20.3	51.9	27.7
Babu et al. [30]	India	2018	1200	17.5	74.6	7.9
Moradi & Dalili [31]	Iran	2020	600	36.7	50.5	12.8
Current study	Iraq	2021	126	71	27.4	1.6

Abbreviation

OF: Olfactory Fossa; CT: Computed Tomography; FESS: Functional Endoscopic Sinus Surgery; ENT: Ear, Nose, And Throat; LLCP: Lateral Lamella of the Cribriform Plate; SD: Standard Deviation; MSCT: Multi-Slice CT; SSCT: Single Slice CT

Declaration

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Availability of data and materials

Data will be available by emailing bnaltaee@gmail.com

Authors' contributions

Authors are equally participated in the concept, design, writing, reviewing, editing, and approving the manuscript in its final form. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

We conducted the research following the Declaration of Helsinki, and the protocol was approved by The Ethical Committee of College of Medicine, Al-Iraqia University, Baghdad, Iraq (Reference No: KTSH/285 on 31 December 2019).

Consent for publication

Not applicable

Competing interest

The authors declare that they have no competing interests.

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