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Evaluation of Olfactory Fossa Depth Using Computed Tomography in a Tertiary Center: A Retrospective Study

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Abstract

Introduction: Endoscopic sinus surgery is a common and effective method for addressing chronic sinonasal diseases. To minimize the risk of significant postoperative complications, a thorough understanding of the anatomical variations is crucial. The aim of this study was to evaluate the occurrence and classification of different Keros types by analyzing paranasal sinus CT scans, specifically focusing on the depth of the olfactory fossa in the population.

Methods: This retrospective, single-center analytical study was conducted on 127 patients who underwent non-enhanced paranasal sinus CT scans over a 1-year period. Ethical approval was granted by the Institutional Review Committee of Saraswathi Institute of Medical Science. The study utilized the SPSS statistical program (version 25) for data analysis.

Results: The average depth of the right olfactory fossa (OF) was 4.4±1.44 mm, while the left olfactory fossa had a mean depth of 4.5±1.5 mm. Based on the Keros classification, 15% of patients (19 out of 127) were classified as Keros I, 76% (97 patients) as Keros II, and 10% (13 patients) as Keros III for the right lateral lamella. For the left lateral lamella, 17.3% (22 patients) were classified as Keros I, 70.9% (90 patients) as Keros II, and 11.8% (15 patients) as Keros III.

Conclusions: Preoperative CT scans of the paranasal sinuses provide valuable insight into the architecture of the anterior skull base, which is essential for planning the surgical approach and preventing complications in endoscopic sinus surgery.

Keywords: Endoscopy; Paranasal Sinuses, Retrospective Studies, Skull

Introduction

The olfactory fossa (OF), which is visible as a dip in the anterior cerebral fossa, has an ethmoid bone structure called the cribriform plate that acts as its floor. This thin bone plate serves as a barrier between the nasal cavity and the anterior cerebral fossa. The medial and lateral boundaries of OF are formed by crista galli and the lateral lamella of the cribriform plate of the ethmoid, respectively. Olfactory bulbs and tracts are present in OF [1].

The depth of the olfactory fossa is determined by the size of the lateral lamella of the cribriform plate. After studying 450 cadaveric skulls, Keros categorized the olfactory fossa into three types based on the level of the ethmoid roof. In Keros Type I, the depth of the olfactory fossa ranges from 1 to 3 mm, in Type II, it ranges from 4 to 7 mm, and in Type III, it ranges from 8 to 16 mm. The term "dangerous ethmoid" was coined by Kainz and Stammberger and initially referred to olfactory fossa depth, specifically resembling Keros type III, which is associated with a higher risk of complications during procedures. Multidetector computed tomography (MDCT) is considered the gold standard for assessing the anatomy and conditions of the paranasal sinuses and nasal cavity. It enables simultaneous visualization of bone, soft tissue, and air [2, 3, 4, 5, 6, 7].

The depth and asymmetry of the olfactory fossa are important considerations during endoscopic sinus surgery (ESS), which is a commonly used surgical technique for treating chronic sinonasal disorders. Given the close proximity of the paranasal sinuses to the orbital spaces and the brain, it is crucial for surgeons to be knowledgeable about sinonasal anatomy and any variations that may exist. Therefore, this study aimed to evaluate the depth and asymmetry of the olfactory fossa, providing valuable information for surgeons performing ESS [8, 9].

Methods

This retrospective single-center analytical study was done in the Department of Radiodiagnosis, Saraswathi Institute of Medical Sciences. Ethical approval was taken from the Institutional Review Committee.

The study population was all the patients aged 18-90 years who attended the Department of Radiodiagnosis of Saraswathi Institute of Medical Science, Hapur and underwent non-contrast CT PNS over a period of one year. Patients with neoplastic lesions of PNS, fracture/trauma to the PNS, and congenital abnormalities of the face were excluded from the study.

CT scan images were obtained with a single multi- detector 128-slice CT scanner. Only coronal images were used for the study. The height of the lateral lamella was measured to determine the depth of the olfactory fossa. A line was drawn parallel to the highest point of the maxillary sinus at the level of bony boundaries of infraorbital foramina. Perpendicular lines were drawn up to the inferior and superior margins of the lateral lamella. The difference between these lines denoted the depth of the olfactory fossa as shown in Figure 1. The convenience consecutive sampling method was used. The data were then statistically analyzed using the Statistical Program for Social Science (SPSS) Version 25. Quantitative variables were analyzed using measures such as mean and standard deviation, while categorical variables were examined through frequency and proportion.

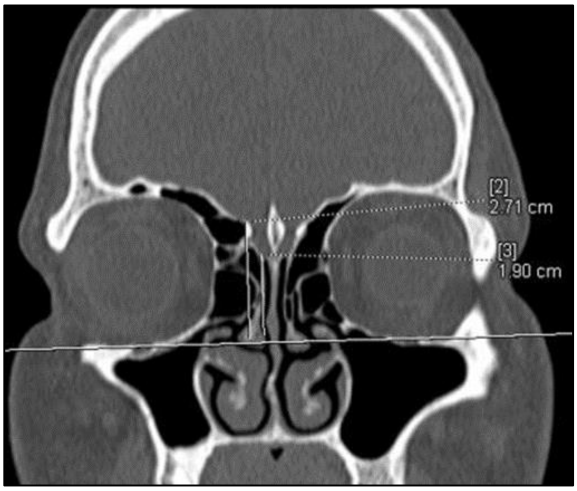

Fig 1: Measurement of olfactory fossa depth

Results

One hundred twenty-seven CT scans were analyzed, 125 (59.4%) were males, and 51 (40.6%) were females. The mean age of patients was 39±16.32 (SD) years. The mean OF depth on the right side was 4.4±1.44 mm and on the left side was 4.5±1.5 mm. The mean OF depth in females on the right side was slightly less than that of males (4.3±1.48 mm as compared to 4.5±1.41 mm) while that on the left was slightly more than that of males (4.5±1.53 mm as compared to 4.4±1.49 mm) (Table 1). The difference between right and left was statistically insignificant.

Table 1: Distribution of study population according to side and sex

Total	Right (mm)		Left (mm)	
	Female	**Male**	**Female**	**Male**
	51	76	51	76
Mean	4.303	4.574	4.551	1.5352
Std. Deviation	1.4857	1.4134	4.474	1.4950

Each CT scan was counted as two cases (right and left) for a total of 254 cases. On both sides (right and left), Fourty one cases (16.1%) were Keros I, 185 (73.4%) Keros II, and 26 (10.5%) Keros III (Table 2). Nineteen (18.5%) females were classified as Keros I, 72 (70.4%) were classified as KerosII and 12 females (11.1%) were classified as Keros

III. Twenty two males (14.6%) were classified as Keros I, 114 (75.5%) were Keros II, and 15 (9.9 %) were classified as Keros III (Table 3). 34 subjects (26.8%) showed different Keros types bilaterally.

Regarding the classification of Keros in types I, II, and III, it was found that there is no significant association between gender and the side (p-value >

0.05 in all types).

Table 2: Distribution of study population according to side and Keros type

Type	Right	Left	Total both sides
Type I	19 (15%)	22 (17.3%)	41(16.1%)
Type II	96 (76%)	90 (70.9%)	186(73.4%)
Type III	12 (9%)	15 (11.8%)	27(10.5%)
Total	127	127	254

Table 3: Distribution of study population according to sex and Keros type bilaterally

		I	II	III	Total
	Female	19 (18.5%)	73 (70.4%)	11 (11.1%)	103
Sex	Male	22 (14.6%)	114 (75.5%)	15 (9.9%)	151
Total		41	187	26	254

Discussion

Regarding the treatment and care of the paranasal sinuses, the use of endoscopy can pose a risk of perforation during surgical procedures. To prevent iatrogenic complications, it is crucial to evaluate the ethmoid roof using CT scans, as emphasized in several studies. Studies conducted in different countries have revealed that ethnic populations exhibit diverse configurations of the olfactory fossa. Therefore, it is important to have an understanding of the configuration and symmetry of the olfactory fossae specific to the ethnic population residing in a particular geographical area [8, 10, 11,12, 13].

Our study has shown that type II (74.5%) olfactory fossa was the commonest. This was followed by type I (18.5%) and type III (7%). This is in concurrence with the study done by Salroo *et al*. for the north Indian population. This is also in agreement with studies conducted among the Saudi, Jordanian, Indian, Brazilian, and Turkish populations.14 Many Indian studies also reported Keros Type II as the common OF type. Studies by Babu *et al*. and Salroo *et al*.

reported Keros II in 61%, 74.6% Keros I in 29%, and 17.5% in Kashmir and Kerala. Unlike our findings, the research conducted on the Egyptian and Filipino populations revealed that the majority of participants examined were categorized as Keros type I, followed by type II, and finally type III [13, 14, 15].

Regarding gender, Type II olfactory fossa was common in both males and females followed by Type I and Type II. In our study, the mean OF depth on the right side was 4.4±1.44 mm, and on the left side was 4.5±1.5 mm. A study by Shama and Montaser conducted on Egyptians revealed mean OF depth on the right side of 4.87±1.71mm and 4.91±1.66mm on the left side. Furthermore, various studies have indicated that the average depth is lower on the right side compared to the left side. Our study showed 68 subjects (26.8%) have different Keros types on both sides. In a study by Pawar *et al*., 11.5% of the subjects showed asymmetry in Keros types. Therefore, there is no consistency in the anterior skull base depth, and frequent anatomical variation can be observed [11, 16, 17, 18].

Endoscopic sinus surgeries can result in a range of complications, which can be classified as minor or major. Minor complications are observed in 1.1- 20.8% of cases. Major complications, while rare, occur in 0-1.5% of such surgeries, and can include bleeding, cerebrospinal fluid leakage, ocular injury, ocular infection, and intracranial injury (involving the brain or major blood vessels). Thus, possessing a thorough comprehension of the structure of the paranasal sinuses and common anatomical variations in this region is crucial in preventing such complications [19, 20].

The major limitations of our study are the small sample size, taking measurements by a single radiologist and since all participants in the study were adults aged 18 and above, the findings may not be applicable or representative of children or adolescents.

Conclusion

This study has shown that the majority of the participants were under Keros Type II, followed by Type I and Type III. Adequate data on the variability of the anatomy of the olfactory area are very helpful in the preoperative workup of patients with diseases of the nose and paranasal sinuses. Inadequate attention to the anatomy of this area can lead to damage of the cribriform plate and subsequent major and minor complications. We recommend a larger sample size and more than one radiologist to take the measurements to increase the reliability of the results.

Conflict of Interest

None

Sources of Funding

None

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