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ARAŞTIRMA YAZISI / RESEARCH ARTICLE

ENDOSKOPİK CERRAHİ İÇİN OLFAKTÖR FOSSANIN BİLGİSAYARLI TOMOGRAFİ İLE DEĞERLENDİRİLMESİ

EVALUATION OF THE OLFACTORY FOSSA WITH COMPUTED TOMOGRAPHY FOR ENDOSCOPIC SURGERY

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ÖZET

AMAÇ: Bu vaka-kontrol çalışmasının amacı, klinik ve radyolojik olarak sinüzit tanısı alan hastalar ve kontrol grubunun bilgisayarlı tomografi (BT) görüntülerinde olfaktor fossa (OF) anatomisinin değerlendirilmesidir.

GEREÇ VE YÖNTEM: BT taraması için sevk edilen klinik ve radyolojik kronik sinüzit tanılı 100 hasta ile sinüzit tanısı olmayan 100 hasta dahil edildi. OF tipleri Keros sınıflamasına göre kaydedildi. Medial etmoid çatı noktası (MEÇN) yüksekliği, kribriform plate (KP) yüksekliği ve genişliği, OF derinliği ve genişliği, lateral lamel-Kribriform plate açısı (LLKPA) da ölçüldü.

BULGULAR: Ortalama OF derinliği sağ ve sol tarafta sırasıyla 5,9 mm ve 6,1 mm idi. Sağ ve sol tarafta en sık görülen tip Tip 2 idi. MEÇN'nin ortalama yüksekliği sağ ve sol tarafta 27,9 mm idi. Ortalama KP yüksekliği sağ ve sol tarafta sırasıyla 22,0 mm ve 21,8 mm idi. Ortalama OF genişliği sağ ve sol tarafta sırasıyla 4,1 mm ve 3,4 mm idi. Ortalama KP genişliği sağ ve sol tarafta sırasıyla 2.8 mm ve 2.4 mm idi. Ortalama sağ ve sol LLKPA sırasıyla 77.6° ve 79.1° olarak bulundu. Sinüziti olan ve olmayan hasta gruplarında parametreler arasında anlamlı fark yoktu.

SONUÇ: Sonuçlara göre, sinüzit varlığının OF anatomisine herhangi bir etkisi yoktur. Ancak bu bölgenin anatomisinin preoperatif değerlendirilmesi fonksiyonel endoskopik sinüs cerrahisi (FESC) sırasında oluşabilecek komplikasyonları en aza indirmede çok önemlidir.

ANAHTAR KELİMELER: Anatomi, Bilgisayarlı tomografi, Kafa tabanı, Etmoid sinüs.

ABSTRACT

OBJECTIVE: The aim of this case-control study is to assess the olfactory fossa (OF) anatomy in computed tomography (CT) images of patients with clinical and radiological diagnoses of sinusitis as well as those of patients of a control group.

MATERIAL AND METHODS: 100 patients without sinusitis and 100 patients with a clinical and radiological diagnosis of chronic sinusitis who were referred for CT scans were included. The OF types were recorded according to the Keros classification. Medial ethmoid roof point (MERP) height, cribriform plate (CP) height and width, OF depth and width, and angle of lateral lamella-cribriform plate (ALLCP) were also measured.

RESULTS: The mean depth of OF was 5.9 mm and 6.1 mm on the right and left sides, respectively. The most common type was type 2 on the right (51%) and left (45.5%) sides. The mean height of the MERP was 27.9 mm in both the right and left sides. The mean height of CP was 22.0 mm and 21.8 mm on the right and left sides, respectively. The mean width of the OF was 4.1 mm and 3.4 mm on the right and left sides, respectively. The mean width of CP was 2.8 mm and 2.4 mm on the right and left sides, respectively.The mean right and left ALLCP were 77.6° and 79.1°, respectively. No significant difference was found between the parameters in the case and control groups.

CONCLUSIONS: According to the results, the presence of sinusitis has no effect on the anatomy of the OF. However, preoperative evaluation of the OF anatomy is very important in minimizing complications that may occur during functional endoscopic sinus surgery (FESS).

KEYWORDS: Anatomy, Computed tomography, Cranial base, Ethmoid sinus.

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INTRODUCTION

With the development of technological advances in medicine, functional endoscopic sinus surgery (FESS) is frequently used during surgery in the paranasal sinus region of Ear-Nose-Throat practice. With this method, all sinus ostia can be reached. However, the nasal cavity is very close to the intracranial and orbital fossa in terms of localization and anatomy. Moreover, the nasal cavity and paranasal sinuses show a great deal of variation among individuals. Therefore, a number of complications of FESS surgeries have been described and classified as minor and major complications. Major complications are observed at a rate of 0–1.5% and have been defined as cerebrospinal fistulae, orbital complications, and intracranial injuries (1). Minor complications include bleeding, ostial stenosis, infection, insensitivity of the teeth or lips, and recurrence. Anatomical formations and possible variations in the skull base should be thoroughly investigated and identified to minimize the risk and to prevent complications (2). The ethmoidal roof separates ethmoid cells from the anterior cranial fossa. Fovea ethmoidalis (part of the frontal bone) forms the roof of the ethmoid labyrinth and fuses with the lateral lamella of the cribriform plate (LLCP)(3). LLCP is located in the lateral part of the olfactory fossa (OF), which is a depression in the anterior cranial cavity and the crista galli in the medial part. The OF depth is identified by the height of the LLCP (4). According to the Keros classification in 1962, OF depth is evaluated as three types.Depths between 1–3 mm, 4–7 mm, and 8–16 mm were defined as types 1, 2, and 3, respectively (5). Type 3, which has a very thin cribriform plate (CP), is the most dangerous and important type to encounter during FESS (6). Computed tomography (CT) is used to detect the type and extent of anatomical distortions in the nose and paranasal sinus (7). The aim of this study is to assess and compare the OF anatomy in CT images of patients with clinical and radiological diagnoses of sinusitis as well as those of a control group.

MATERIALS AND METHODS

Patient Selection and Evaluation Criteria: Paranasal sinus CT images taken between December 2021 and April 2022 of patients at Hatay Education and Research Hospital were evaluated. The control group and the case group with clinically and radiologically confirmed diagnoses of chronic sinusitis were included. The presence of craniofacial deformity or syndrome, nasal masses causing bone erosion, history of trauma, cleft lip-palate, history of nasal surgery, images of patients younger than 18 years of age, and low-quality images were excluded from the study. CT images of 200 patients who met the inclusion criteria were selected using the random sampling method; 100 patients with clinical and radiological diagnoses of sinusitis and 100 patients without sinusitis were evaluated retrospectively. CT images of all patients were obtained using a 128-slice CT scanner (GE Revolution EVO CT Scanner, GEMedical Systems, Milwaukee, WI, USA). The parameters were 100 kV, 20 mAs, section thickness 0.625 mm, and field of view (FOV) 20 cm. The OF was evaluated according to the Keros classification (5), which divides it into three types according to the difference in height between the ethmoid roof and the CP **(Figure 1)**:

Type 1: 1–3 mm deep
Type 2: 4–7 mm deep
Type 3: more than 7 mm deep.

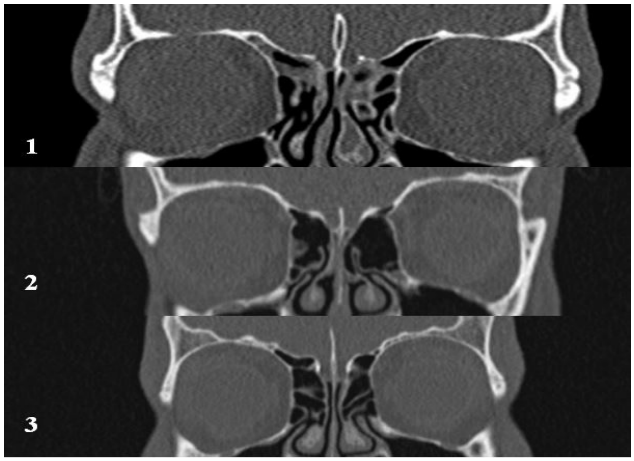

Figure 1: Olfactory fossa types according to Keros classification (5)

Measurements were made from coronal sections in which the infraorbital nerve was visible based on the study of Özeren Keşkek and Aytuğar (8). Vertical height from the medial ethmoid roof point (MERP) and vertical height from CP to the horizontal plane through the infraorbital foramen were measured bilaterally. To define OF depth, the LLCP was calculated by subtracting the CP height from the MERP height (MERP – CP = LLCP) (9 – 12). The following measurements were taken (8).

MERP and CP Height: The MERP is the point where the ethmoid roof medially meets the LLCP. A horizontal plane was created, passing through the infraorbital nerves on both sides. The vertical distance between this horizontal plane and the MERP was defined as the MERP height, and the vertical distance between the CP and this horizontal plane was defined as the CP height.

OF and CP Width: The horizontal width of the CP was measured bilaterally. The width of the OF was measured bilaterally from the midpoint of the MERP and the CP.

Angle of the Lateral Lamella-Cribriform Plate: The angle between the lateral lamella and the horizontal plane continuing from the CP was measured **(Figures 2, 3)**.

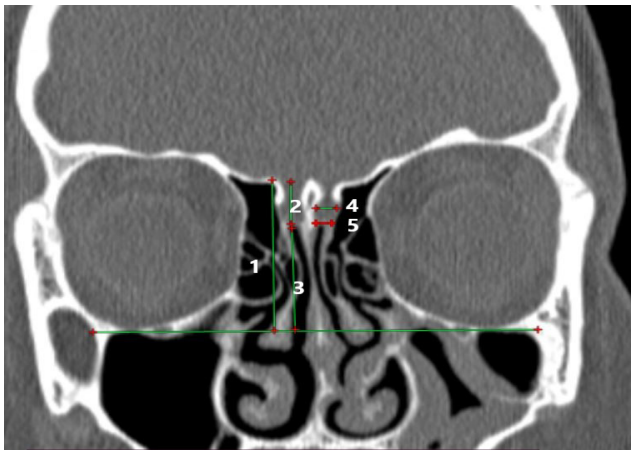

Figure 2: The radioanatomical measurements of olfactory fossa. 1= height of medial ethmoid roof point, 2= olfactory fossa depth, 3= cribriform plate height, 4= olfactory fossa width, 5= cribriform plate width

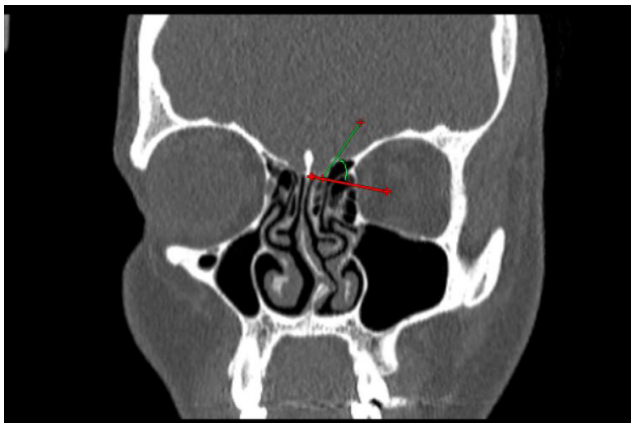

Figure 3: The measurement of angle of lateral lamella cribriform plate

Only coronal images were evaluated, and measurements were performed in the bone window. Paranasal sinus CT scans for each patient were assessed by a radiologist experienced in head and neck radiology. After a 15-day interval, all measurements were repeated for analysis of intraobserver reliability.

Ethical Committee

Ethical approval was obtained from the Hatay University, Non-Interventional Clinical Studies Ethical Committee (Decision No: 14, Date: 30.06.2022). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients included in the study.

Statistical Analysis

In the descriptive statistics of the data, mean, standard deviation, median minimum, maximum, frequency, and ratio values were used. The distribution of variables was analyzed using the Kolmogorov–Smirnov test. Independent sample t-test, Mann–Whitney U test, and Chi-squared test were used during the analysis of quantitative and qualitative independent data. Fisher's exact test was used when the Chi-squared test conditions were not met. Wilcoxon and McNemar tests were used in the analysis of dependent quantitative and qualitative data, respectively. Intraclass correlation (ICC) was used in the correlation analysis between observers. An ICC less than 0.40 is considered weak agreement, a value between 0.40 and 0.75 is considered fair, and a value greater than 0.75 is considered excellent (13). $P< 0.05$ indicated statistical significance. SPSS v28.0 (SPSS Inc., Chicago, IL, USA) software was used for the statistical analysis.

RESULTS

The reliability was estimated by intraclass correlations (ICC) for all observations. Tests revealed a strong correlation coefficient between the first and second readings by the same observer ($r = 1.00$; ICC 1.0). Evaluation of sinusitis and type distribution and all measurements did not differ significantly between the first and second readings ($p=1.000$). The anatomical evaluations of OF were made on the images of 200 patients aged 18–87 years (88 females; 112 males; mean age: 36.8 years). **Table 1** shows the incidence of OF types and the mean values of all parameters.

Table 1: The radioanatomical measurement values of parameters

		Min-Max	Median	Mean±ss/n-%
Age		18.0 - 87.0	34.0	36.8 ± 16.9
Gender	Female			88 44.0%
	Male			112 56.0%
Sinusitis	(-)			100 50.0%
	(+)			100 50.0%
Right olfactory fossa depth		1.9 - 14.0	5.9	5.9 ± 2.2
Right OF types	I			38 19.0%
	II			102 51.0%
	III			60 30.0%
Left olfactory fossa depth		1.9 - 17.4	6.0	6.1 ± 2.4
Left OF types	I			34 17.0%
	II			91 45.5%
	III			75 37.5%
Medial ethmoid roof point height				
Right		18.3 - 36.8	28.2	27.9 ± 3.7
Left		19.8 - 38.6	28.2	27.9 ± 3.6
Cribriform plate height				
Right		13.5 - 30.2	22.0	22.0 ± 3.2
Left		13.1 - 29.2	21.7	21.8 ± 3.1
Olfactory fossa width				
Right		1.8 - 14.7	3.8	4.1 ± 1.6
Left		1.3 - 16.0	3.0	3.4 ± 1.7
Cribriform plate width				
Right		1.2 - 5.1	2.6	2.8 ± 0.8
Left		1.2 - 7.3	2.3	2.4 ± 0.7
Angle of lateral lamella cribriform plate				
Right		44.5 - 99.3	77.4	77.6 ± 10.2
Left		42.5 - 99.9	79.8	79.1 ± 12.0

The age of the patients with sinusitis was significantly higher than the group without sinusitis (p=0.007). Gender distribution did not differ significantly between the groups with and without sinusitis (p=0.254). No statistical difference was found between all parameters, including OF types (for right side p=0.197, for left side=0.130);-MERP (for right side p=0.484, for left side=0.371) and CP height(for right side p=0.167, for left side=0.313);OF(for right side p=0.581, for left side=0.621) and CP width(for right side p=0.966, for left side=0.528);angle of lateral lamella-cribriform plate (ALLCP) (for right side p=0.608, for left side=0.843); and the groups with and without sinusitis **(Table 2)**.

Table 2: Difference in parameters between case and control groups

		Sinusitis (-)		Sinusitis (+)		p	
		Mean±ss/n-%	Median	Mean±ss/n-%	Median		
Age		33.7 ± 16.0	28.5	39.9 ± 17.2	36.5	***0.007***	m
Gender	Female	48 48.0%		40 40.0%		0.254	X^2
	Male	52 52.0%		60 60.0%			
Right olfactory fossa depth		6.0 ± 2.0	6.0	5.8 ± 2.4	5.6	0.527	t
Right OF types	I	14 14.0%		24 24.0%		0.197	X^2
	II	54 54.0%		48 48.0%			
	III	32 32.0%		28 28.0%			
Left olfactory fossa depth		6.1 ± 2.2	6.0	6.1 ± 2.5	6.1	0.966	t
Left OF types	I	13 13.0%		21 21.0%		0.130	X^2
	II	52 52.0%		39 39.0%			
	III	35 35.0%		40 40.0%			
Medial ethmoid roof point height							
Right		27.7 ± 3.7	28.2	28.1 ± 3.7	28.2	0.484	t
Left		27.7 ± 3.6	27.9	28.1 ± 3.6	28.3	0.371	t
Cribriform plate height							
Right		21.7 ± 3.2	21.8	22.4 ± 3.2	22.2	0.167	t
Left		21.6 ± 3.1	21.6	22.0 ± 3.1	21.9	0.313	t
Olfactory fossa width							
Right		4.0 ± 1.6	3.8	4.1 ± 1.5	3.9	0.581	m
Left		3.3 ± 1.5	3.0	3.5 ± 1.9	3.0	0.621	m
Cribriform plate width							
Right		2.8 ± 0.9	2.6	2.8 ± 0.8	2.6	0.966	m
Left		2.3 ± 0.8	2.3	2.4 ± 0.7	2.3	0.528	m
Angle of lateral lamella cribriform plate							
Right		77.2 ± 10.2	76.8	77.9 ± 10.3	78.2	0.608	t
Left		78.9 ± 11.4	78.7	79.3 ± 12.6	80.7	0.843	t

[t]Independent sample t test /[m] Mann-whitney u test / [X^2]Chi-Square test

DISCUSSION

The present study concluded no statistically significant difference in case and control groups in terms of all parameters, including OF types, MERP and CP height, OF and CP width, and ALLCP. The importance of OF evaluation (which includes the ethmoid roof and CP) in FESS is constantly increasing due to skull base damage caused by its highly fragile structure (14 – 16). Due to the close relationship of vital structures, such as the optic nerve and anterior ethmoid artery, FESS has also become a procedure with serious complications (17). CT has made a great contribution in the diagnosis and evaluation of sinonasal disease in order to minimize complications (18). In this study, CT is a reliable imaging method in the evaluation of OF anatomy due to its high intraobserver agreement. In addition, the high intraobserver agreement also revealed the consistency of OF typing and measurements.

OF Types According to Depth Measurements

In the present study, the most common OF type was type 2 on the right (51%) and left (45.5%) sides. Type 1 was more common in some studies (10,19–23), while type 2 was more common (61%–76.1%) in other studies, including the current study (2, 4, 8, 12, 14, 24 – 30). The highest incidence was reported in the study of Periyasamy et al. (28), but the incidence was found to be higher (80% and 83.3% on the right and left side of control group, respectively) because they divided 120 patients into 4 groups as the right and left, case (with sinusitis) and control groups, and calculated the incidence over 30 samples each. Elwany et al. (18) reported that type 2 OF was the most common type in males, while type 1 was most common in females. Murthy and Santosh (29) and Abdulhadi et al. (31) evaluated CT images of patients undergoing FESS and reported type 2 and type 1 as the most frequent types, respectively.In contrast, Gauba et al. (32) reported that type 3 was slightly high. Babu et al. (25) reported that the mean OF depths on the right and left sides were 5.27 mm and 5.25 mm, respectively. In the studies by Özeren Keşkek and Aytuğar (8), Sancar and Duman (20), Karatay and Avcı (4), Murthy and Santosh (29), and Abdulhadi et al. (31), the mean OF depth was 5.67 mm, 3.54 mm, 4.89 mm, 5.21 mm, and

3.58 mm, respectively. Patil et al. (26) reported that the mean OF depth on the right and left sides was 5.3 mm and 5.42 mm, respectively. In the study by Murthy and Santosh (29), a mean OF depth of 5.21 mm was reported, while Naidu et al. (30) reported median depths of 5.6 and 6 mm on the right and left sides, respectively; Shrestha et al. (10) reported that OF on the right side was deeper. In the study by Lakhani et al. (12), the highest depth of OF was reported as 6.543 and 6.2 mm on the right and left sides, respectively, in the 51–60 years age group. In this study, the mean OF depth was 5.9 mm and 6.1 mm on the right and left sides, respectively. Thus, a slightly higher OF depth was recorded in this study compared to the evaluated studies mentioned above.

MERP and CP Height

In this study, the mean MERP height was 27.9 mm on both the right and left sides. The mean CP height was 22.0 mm and 21.8 mm in the right and left sides, respectively. Özeren Keşkek and Aytuğar (8) reported mean MERP and CP heights of 26.35 mm and 20.66 mm, respectively. Belgin et al. (33) reported that the average of the right and left MERP and CP height were 25.55 mm and 20.55 mm,as well as 25.24 mm and 20.82 mm, respectively. Erdogan et al. (34) reported the right and left CP heights as 25.01 mm and 25.38 mm, respectively. However, in the study by Munoz-Leija et al. (35), the mean right CP height was 8.94 mm and 10.21 mm in males and females, respectively, while the mean left CP height was 8.99 mm and 10.20 mm in males and females, respectively. The low values in Munoz-Leija et al.'s study (35) were attributed to the difference in the method of measurement characterized by measuring the anteroposterior length of the CP. However, the results of the other two studies (33, 34) were close to those in this study.

OF and CP Width

This study reported that the mean OF width was 4.1 mm and 3.4 mm on the right and left sides, respectively. The mean CP width was 2.8 mm and 2.4 mm on the right and left sides, respectively. In the study of Özeren Keşkek and Aytuğar (8), the OF and CP widths were reported as 3.51 mm and 2.72 mm, respectively. Skorek et al. (36) reported mean OF width to the lateral lamella and CP values of 3.4 mm and 3.2 mm, respectively. In a cadaveric study by Coelho et al. (37), the average CP width (including the crista galli) was reported as 4.53 mm.The higher CP width found by Coelho et al. (37) may be related to the fact that they studied cadavers and included crista galli in the measurements. Angle of the Lateral Lamella-Cribriform Plate Özeren Keşkek and Aytuğar (8) reported right and left ALLCP of 72.23° and 76.09°, respectively. Elwany et al. (18) reported mean ALLCP of 29.13° and 29.28° on the right and left sidesin males, respectively, and 24.15° and 24.2° on the right and left sides of females, respectively. Abdullah et al. (38) reported a mean ALLCP of 70.1°. In the current study, the mean right and left ALLCP were 77.6° and 79.1°, respectively. The mean ALLCP angle inthis study was close to those found in the studies by Abdullah et al. (38) and Özeren Keşkek and Aytuğar (8), but higher than the study by Elwany et al. (18).

Relationship between Sinusitis and Olfactory Fossa Anatomy

Periyasamy et al. (28) investigated OF anatomy and rhinosinusitis and reported the OF depth in rhinosinusitis and control patients. Similar to the results in our study, they concluded that type 2 was more prevalent in both the case and control groups. Apart from that study, to the best of our knowledge, no other in-depth studies about the effect of rhinosinusitis on the anatomy of the OF exist in the literature.

Although the absence of other in-depth studies evaluating the relationship between the anatomy of the OF and the presence of rhinosinusitis suggests our study is a significant contribution to the literature, this could be considered a study limitation, as there are no comparable study results to discuss. Nevertheless, this study will be a guide for future studies on this subject. And future studies with larger sample sizes will contribute to the literature. Evaluation of OF anatomy only in the sinusitis group could be considered another study limitation. In future studies, the anatomy of the OF in other paranasal sinus diseases, such as nasal polyposis or allergic fungal sinusitis, could be evaluated.

The olfactory fossa, an anatomical structure of the anterior skull base, is susceptible to injury during FESS as a result of its proximity to the nasal cavity and paranasal sinuses. It is bordered medially by the crista galli, laterally by the LLCP, and inferiorly by the fragile CP. The LLCP is the thinnest bone in the entire anterior skull base, so it is the most injury-prone area of the OF, and lesions are common (25, 39).

Type 3 has the longest lateral lamellae, resulting in a maximum risk of perforation in the anterior cranial fossa. Anatomical variations result in challenges for the endoscopic surgeon, such as a lower skull base, which greatly reduces the height of the ethmoid complex. The surgeon may incorrectly assume that the superior ethmoidal air cells are located here and accidentally enter the anterior cranial fossa, causing iatrogenic sequelae (23, 40, 41).

In conclusion, preoperative evaluation of OF anatomy is very important in minimizin complications that may occur during FESS. Indeed, these pre-surgery measurements give confidence to surgeons, and CT is an important imaging modality in evaluating the anatomy of this region.

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