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Observational Study

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Importance of Keros Classification in Surgery

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ABSTRACT

Objective: The relationship between the cribriform plate and the uncinate process may be elaborated with the help of the Keros classification. The observations were analysed using high-resolution computed tomography (HRCT). Additionally, the relationship between the superior attachment of the uncinate process, the existence of concha bullosa, and the different types of ethmoid roofs were examined.
Methods: Five-hundred and sixteen subjects complaining of sinonasal disorders between 2015 and 2016 were enrolled retrospectively at the Okmeydani Training and Research Hospital, Department of Otolaryngology. HRCT scans of 1-mm sections were obtained. Keros classification was used for the measurement of the depth of the olfactory fossa as follows: Keros I: 1-3 mm, Keros II: 3-7 mm, and Keros III: 7-16 mm.
Results: Fifty-one point nine percentage of cases were of Keros type II, 27.7% of type III, and 20.3% of type I. In 82.4% of the reported cases, the uncinate process was attached to the lamina papyraceae, in 11% of the cases it was attached to the middle nasal turbinate, and in 6.4% cases to the skull base. A concha bullosa was observed in the right nasal cavity in 13.8% of the cases, in the left nasal cavity in 11% of the cases, and bilaterally in 16.3% of the cases. Variances observed in the Keros types were not statistically significant with respect to sex ($p>0.05$). Concha bullosa was significantly more frequently seen in females (53.1%) relative to males ($p=0.001$).
Conclusion: Endoscopic sinus surgery (ESS) is the primary mode of treatment for chronic sinus diseases. In this procedure, a proper assessment of the vital structures is very important to avoid further complications. In the present study, it has been suggested that determining the depth of the ethmoid roof is necessary to avoid injuring the bony lamella, which can lead to cerebrospinal fluid rhinorrhea.

KEY WORDS: Keros classification; Ethmoid roof; Paranasal Sinus; Cribriform plate.

ABBREVIATIONS: HRCT: High-resolution computed tomography; ESS: Endoscopic Sinus Surgery.

INTRODUCTION

Chronic sinonasal diseases are among the most common diseases demanding surgical attention in the field of otolaryngology.[1] Although, some diseases can be treated with medicines; surgical intervention is more often needed. Endoscopic sinus surgery (ESS) is the most commonly implemented approach for treatment at present.[2,3] Thorough anatomical knowledge is considered mandatory, especially with respect to the skull base, to prevent serious surgical complications. Therefore, variations in anatomy should be diagnosed before surgery and examined carefully for every patient. Keros classification is a widely used procedure for the evaluation of the depth

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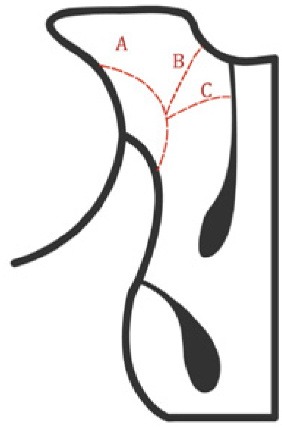
of the nasal roof and should be assessed preoperatively; which may otherwise lead to many life-threatening complications.

The uncinate process and the attachment of the middle turbinate can be associated with several anatomical regions. Rarely, those structures may attach directly to the nasal roof. Interfering with this anatomical location can cause serious clinical complications including cerebrospinal rhinorrhea, meningitis, etc. High-resolution computed tomography (HRCT) is the gold standard for diagnosis in the paranasal sinuses and neighboring structures and is a vital tool for pre-operative assessment to prevent related medical complications.[4]

In this study, the relationship between the cribriform plate and the uncinate process was investigated using the Keros classification. The relationship between the superior attachment of the uncinate process, the existence of concha bullosa, and the different types of ethmoid roofs were also examined carefully.

Figure 1: A Schematic Representation of Keros Types.



MATERIALS AND METHODS

Institutional review board approval was obtained from the Okmeydani Training and Research Hospital Ethical Committee. HRCT of the paranasal sinuses of 516 subjects who had sinonasal disorders in 2015-2016 were included in the study. Exclusion criteria were a previous history of nasal surgery, maxillofacial trauma, benign or malignant tumors of the sinonasal tract, and cases with asymmetrical morphology of the olfactory fossa. The pediatric population was not included in the study.

HRCT (Philipps 128 slice, Holland) scans of 1-mm sections were obtained. The Keros classification is used for measuring the depth of the olfactory fossa and defined as follows: Keros I: 1-3 mm, Keros II: 3-7 mm, and Keros III: 7-16 mm (Figures 1 and 2).[5] In all the scans, the attachment of the uncinate process was also observed and grouped as: type 1 attached to the lamina papyracea, type 2 to the skull base, and type 3 to the middle turbinate. Concha bullosa cases were also identified. Concordance between the Keros types and the other groups was observed.

Statistical analysis was performed using SPSS software version 22 (IBM, USA). Continuous data has been reported as mean±standard deviation. Statistical significance was accepted when $p<0.05$. The chi-squared test was used to determine the statistically significant variances.

RESULTS

The average age of the participants in the study was 34.37±12.03 years (Table 1). Fifty-one point nine percentage of cases were associated with Keros type II, 27.7% with type III, and 20.3% with type I. In 82.4% of cases, the uncinate process was attached to the lamina papyraceae, in 11% cases to the middle nasal turbinate, and in 6.4% cases to the skull base. Concha bullosa was in the right nasal cavity in 13.8% of cases, in the left nasal cavity in 11% of the cases, and bilateral in 16.3% of cases (Table 2, Figure 3). On the basis of the Chi-square test, differences in Keros types were not statistically significant as was observed with respect to sex ($p>0.05$) and Concha bullosa (53.1%) was significantly higher in females relative to males ($p=0.001$).

Figure 2: Computerized Tomography Images of KEROS Types.

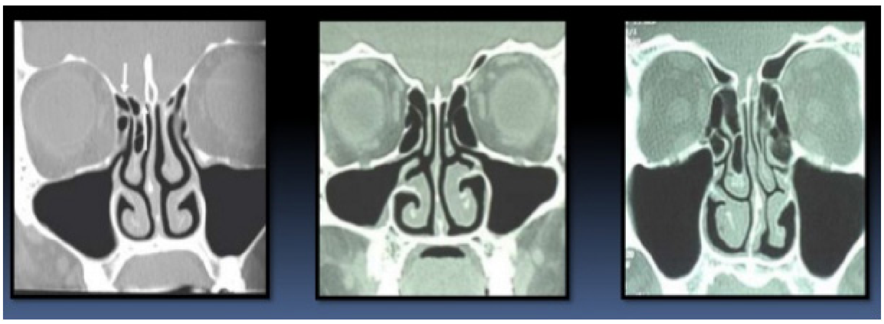


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Table 1: Patient Demographics.

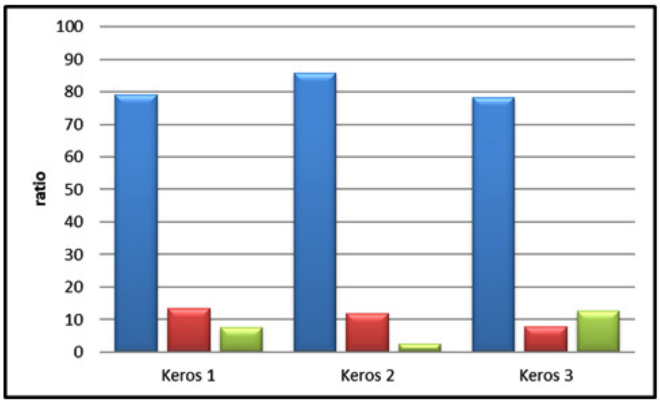
		n	%
Age	14-29	213	41.3
	30-39	130	25.2
	40 and above	173	33.5
Sex	Male	356	69
	Female	160	31
Keros type	Keros 1	105	20.3
	Keros 2	268	51.9
	Keros 3	143	27.7
Unsinat process attachment	L.Papyracea	425	82.4
	Middle Turbinate	57	11
	Skull Base	33	6.4
Concha Bullosa	None	304	58.9
	Right	71	13.8
	Left	57	11.0
	Bilateral	84	16.3

Table 2: Keros Types and Concha Bullosa According to Sex.

		Sex		*p*
		Male	Female	
		n (%)	n (%)	
Keros type	Keros 1	74 (%20.8)	31 (%19.4)	0.759
	Keros 2	181 (%50.8)	87 (%54.4)	
	Keros 3	101 (%28.4)	42 (%26.3)	
Concha Bullosa	None	229 (%64.3)	75 (%46.9)	0.001*
	Right	39 (%11.0)	32 (%20.0)	
	Left	32 (%9.0)	25 (%15.6)	
	Bilateral	56 (%15.7)	28 (%17.5)	

*Chi-Square test *p<0.05*

Figure 3: Attachment Points of Uncinate Process.



Blue: Lamina paprycea, Red: Middle chonca, Green: Skull base

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Tablo 3: Keros Types, Uncinate Process Attachments and Concha Bullosa.

		Keros Type			p
		Keros 1	Keros 2	Keros 3	
		n (%)	n (%)	n (%)	
Unsinate process attachment	L. Papyraceae (Type 1)	83 (%79)	230 (%85.8)	112 (%78.3)	0.100
	Middle Turb. (Type 2)	14 (%13.3)	32 (%11.9)	11 (%7.7)	0.299
	Skull base (Type 3)	8 (%7.6)	7 (%2.6)	18 (%12.6)	0.001*
Concha bullosa	None	57 (%54.3)	150 (%56)	97 (%67.8)	0.297
	Right	17 (%16.2)	39 (%14.6)	15 (%10.5)	
	Left	14 (%13.3)	32 (%11.9)	11 (%7.7)	
	Bilateral	17 (%16.2)	47 (%17.5)	20 (%14)	

Among the Keros types, having performed chi-square analysis, there was no significant relationship between the attachment of the uncinate process to the concha bullosa (p>0.05). However, among the Keros types with the uncinate process attached to the skull base, statistical significance was observed (p=0.001). There were significant differences in the ratio of the skull base attachment between Keros types 1 and 2 (p=0.038), and between types 2 and 3 (p=0.001) (Table 3) The ratio of the skull base attachment in Keros type 2 (2.6%) was significantly lower than that of types 1 (7.6%) and 3 (12.6%). There was no significant difference between the Keros types and the prevalence of concha bullosa (p>0.05). The analysis of the recorded data was performed using Chi-square test.

DISCUSSION

Our data revealed that Keros type 2 was the most commonly observed type in medical conditions and lamina paprycea was the most common site of insertion of uncinate process but the variations were not rare. Especially, Keros type 3 with skull base attachment was a potential dangerous clinical variation. The sinonasal tract can be visualized with the naked eye or by using nasal endoscopy. If clinically suspected, diseases or variations can be examined using the HRCT evaluation, which showed the anatomical structures and their relationships to each other, anatomical variations, and pathologies.[6-8]

Although, anatomical knowledge and experience reduces the chances of arising complications, ESS has been associated with some problematic symptoms; minor complications including bleeding, infection, crusting, synechiae, ostial stenosis, and recurrence of the disease;[9] and major complications including extraocular muscle damage, cerebrospinal fluid rhinorrhea, intracranial damage, and orbital emphysema.[10]

Pre-operative assessment may help to prevent cerebrospinal fluid rhinorrhea. If the olfactory fossa is deep, as in Keros III, the surgeon must take care not to approach medially during the surgery, as a thin bony lamella constitutes most of the roof and the frontal support is missing. These patients are prone to complications associated with the ethmoid roof. However, in Keros I, surgery may be safer to perform.[5-11]

Uncinectomy is the primary step of ESS. The attachment of the uncinate process can vary and should be analyzed before surgery. Stamberger et al[12] reported three different types of attachments. The uncinate process was attached to the middle turbinate in the first type, to the frontal roof in the second, and to the lamina papyraceae in the third. These variations of the uncinate process alter surgery in terms of finding the frontal recess. If not examined properly, damage to the skull base and cerebrospinal fluid rhinorrhea may possibly result.[13]

Pneumatized middle concha is another frequently observed variation in the sinonasal region, with a rate of incidence of 13-73%,[14-15] subsequently exerting pressure on the middle concha and ethmoid labyrinth.[16,17] An uncinate process may also come in contact with a pneumatized middle concha, which may require surgical intervention.

Our data revealed that Keros type 2 was the most common type, followed by type 1, which was consistent with the results of Guldner et al.[18] However, Elwany et al[19] reported that Keros type 3 was the most common one to be observed. Our study indicated that gender was not a significant factor for influencing variations, which was consistent with the conclusions of Elwany et al.[19]

Studies examining the point of attachment of the uncinate process were consistent with the recorded results.[20-22] The only exception was that Keros type 3 were observed to be more common than type 2, which may have been so, on account of the limited number of participants in the study.

ESS is a delicate surgery that is associated with major complications. The only approach to avoid those complications is to conduct a meticulous assessment of each patient before surgery. This evaluation is only possible with HRCT, and there are some key points to differentiate the danger areas of the sinonasal tract prior to ESS.

CONCLUSION

Our study suggested the determination of the depth of the ethmoid roof to avoid injuring the bony lamella and thus reduced

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the risks of developing cerebrospinal fluid rhinorrhea.

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The authors report nothing to declare.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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