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Effects of the position of uncinate process on olfactory fossa depth and lateral lamella length

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Abstract

Objectives: To investigate the variations of olfactory fossa and lateral lamella by reference to the attachment site of uncinate process.

Methods: To perform the comparison of the olfactory fossa depth, 250 patients were categorized into three groups. Patients with bilateral type A uncinate process were included in the group A, patients with a unilateral type A uncinate process were included in the group B, and the patients with a type B or C uncinate process on both sides were included in the group C. To compare the lateral lamella length, we used the categorization of 500 uncinate processes from 250 patients, based on the attachment site of uncinate: lamina papyracea, skull base and middle turbinate.

Results: The mean olfactory fossa depth did not significantly differ between the group A and B (p=0.503), however, it was significantly greater in the group C, compared to both to the group A (p<0.001) and B (p=0.003). The mean lateral lamella length did not significantly differ between the lamina papyracea group and middle turbinate group (p=0.387) however, it was significantly greater in the skull base group, compared both to lamina papyracea (p<0.001) and middle turbinate groups (p<0.001).

Conclusion: Patients with uncinate processes attached to skull base and/or middle turbinate on both sides had a lower olfactory fossa, and the uncinate process attached to the skull base is associated with longer lateral lamella.

Keywords: lateral lamella; middle turbinate; olfactory fossa; skull base; uncinate process

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Introduction

The anatomical variations of lateral nasal wall and paranasal sinuses may affect the position of the skull base. During endoscopic sinus surgery, surgeons should pay attention on the depth of olfactory fossae and length of lateral lamella of the cribriform plate (LLCP) to avoid the well-known complication of this surgical procedure; skull base injury. The olfactory fossae are the grooves of the cribriform plate and contains the olfactory bulb and LLCP serves to separate this anterior cranial fossa from ethmoid air cells. The depth of the olfactory fossa is determined by the length of the LLCP and may be asymmetric.[1–5] Thus, pre-operative evaluation of the skull base and adjacent structures upon paranasal computed tomography (CT) is crucial.

A categorization based on the olfactory fossa depth was performed by Keros[1] previously. Individuals with a deeper olfactory fossa usually have a longer LLCP. LLCP is a thin and weak bone plate constituting the lateral boundary of cribriform plate as a bridge between cribriform plate and fovea ethmoidalis, which is an extension of the orbital plate of the frontal bone forming the lateral part of the ethmoid roof. Considering that the uncinate process of ethmoid bone has three different attachment sites,[2] the position of the skull base may have an association with the status of uncinate process. Several studies investigated the association of olfactory fossa depth and/or LLCP length with adjacent anatomic structures,[3,4] however; to the best of our knowledge, only a limited number of studies thus far has focused on the association between the skull base and uncinate process. Therefore, in this study we aimed to investigate the variations of olfactory fossa and LLCP by reference to the attachment site of uncinate process.

Materials and Methods

After a detailed search of paranasal CT archives of our tertiary institution, we included paranasal CT sections of 250 patients. We compiled the data using a Toshiba Alexion CT unit (Canon Medical Systems Corp., Otawara, Tochigi, Japan) with a radiologic archiving and imaging system (Probel, İzmir, Turkey). The parameters of the CT scanner were 130 kVp, 1.2 mm slice thickness, 0.8-s rotation time, and 1 mm pitch. Patients with any history of sinus surgery, facial trauma, paranasal sinus tumors including inverted papilloma, cystic fibrosis, and generalized nasal polyposis that might alter the anatomy of uncinate process and ethmoid roof were excluded from the study. To compare the olfactory fossa depth and LLCP length based on the attachment site of the uncinate process, two different categorizations were performed. To perform these categorizations, we utilized the classical previous description of the attachment of uncinate process by Wormald[2] as; uncinate process with a superior attachment to lamina papyracea (Type A-considered as normal position), skull base (Type B), and middle turbinate (Type C).

To perform the comparison of the olfactory fossa depth, 250 patients were categorized into three groups. The patients with bilateral type A uncinate process were included in the group A, the patients with a unilateral type A uncinate process were included in the group B, and the patients with a type B or C uncinate process on both sides were included in the group C. We measured the olfactory fossa depth of the patients on the coronal CT sections in which crista galli was most prominent, in accordance with the previous description by Keros,[1] based on the position of cribriform plate relative to ethmoid roof. In accordance with the Keros[1] classification, olfactory fossa depth between 1–3 mm was determined as type 1, 4–7 mm as type 2 and 8–16 mm as type 3. Then, the mean olfactory fossa depth values of the groups were compared statistically.

To compare the LLCP length, we used the categorization of 500 uncinate processes from 250 patients, based on the attachment site of uncinate. We measured LLCP length as the lateral boundary of cribriform plate, between horizontal cribriform plate and fovea ethmoidalis. Then, the mean LLCP lengths of three groups (lamina papyracea, skull base and middle turbinate) were compared statistically.

Results of the analysis were presented as mean±standard deviation. The normal distribution of the data was confirmed using Kolmogorov-Smirnov normality test ($p>0.2$). The olfactory fossa depth and LLCP length of three groups were compared using one-way analysis of variance (ANOVA) test. The homogeneity of the data was investigated using Levene's test. Post-hoc analyzes were performed using Tukey's test. All statistical analysis was performed using SPSS 23.0 software on MacOS 12.2.1 (IBM Corp, Armonk, NY. USA). A p-value under 0.05 was considered statistically significant.

Results

In total, paranasal CT sections from 250 patients were included. For the comparison of olfactory fossa depth, the patients were categorized as three group. Group A consisted of 85 patients [43 males and 42 females, median age: 29 (18–76) years], group B consisted of 66 patients [34 males and 32 females, median age: 29 (18–70) years], and group C consisted of 99 patients [40 males and 59 females, median age: 28 (18–66) years]. The groups were age and gender-matched ($p=0.889$ and $p=0.258$, respectively). The distribution of the groups based on Keros[1] classification was presented in **Table 1** and comparison of the mean olfactory fossa depth values of the groups was presented in **Table 2**. One way ANOVA revealed that olfactory fossa depth did significantly differ between three groups ($p<0.001$). According to the post-hoc tests, the mean olfactory fossa depth did not significantly differ between the group A and B ($p=0.503$), however, the mean olfactory fossa depth was significantly greater in the group C, compared to both to the group A ($p<0.001$) and B ($p=0.003$) (**Figure 1**). Thus, we found that patients with uncinate processes with a superior attachment to skull base and/or middle turbinate (abnormal position) on both sides had a lower olfactory fossa.

Table 1
Keros distribution of the groups.

Groups	Type 1	Type 2	Type 3
A (n=85)	19 (22.4%)	64 (75.3%)	2 (2.3%)
B (n=66)	9 (13.63%)	55 (83.33%)	2 (3.04%)
C (n=99)	9 (9.09%)	71 (71.71%)	19 (19.2%)

Table 2
Comparison of olfactory fossa depth.

Groups	Olfactory fossa depth (mm)
A (patients with bilateral type A uncinate process) (n=85)	5.05±1.41
B (patients with unilateral type A uncinate process) (n=66)	5.32±1.37
C (patients with type B or C uncinate process on both sides) (n=99)	6.11±1.6
p-value*	<0.001

*of one-way ANOVA.

For the comparison of LLCP lengths, 500 uncinate processes from 250 patients were categorized based on attachment site; lamina papyracea group (n=265), skull base group (n=135) and middle turbinate group (n=100). One way ANOVA revealed that the mean LLCP length did significantly differ among three groups (p<0.001) (**Table 3**). According to the post-hoc tests, the mean LLCP length did not significantly differ between the lamina papyracea group and middle turbinate group (p=0.387), however, it was significantly greater in the skull base group, compared both to lamina papyracea (p<0.001) and middle turbinate groups (p<0.001) (**Figure 2**). Thus, we found that attachment of the uncinate process into skull base might be associated with a longer LLCP.

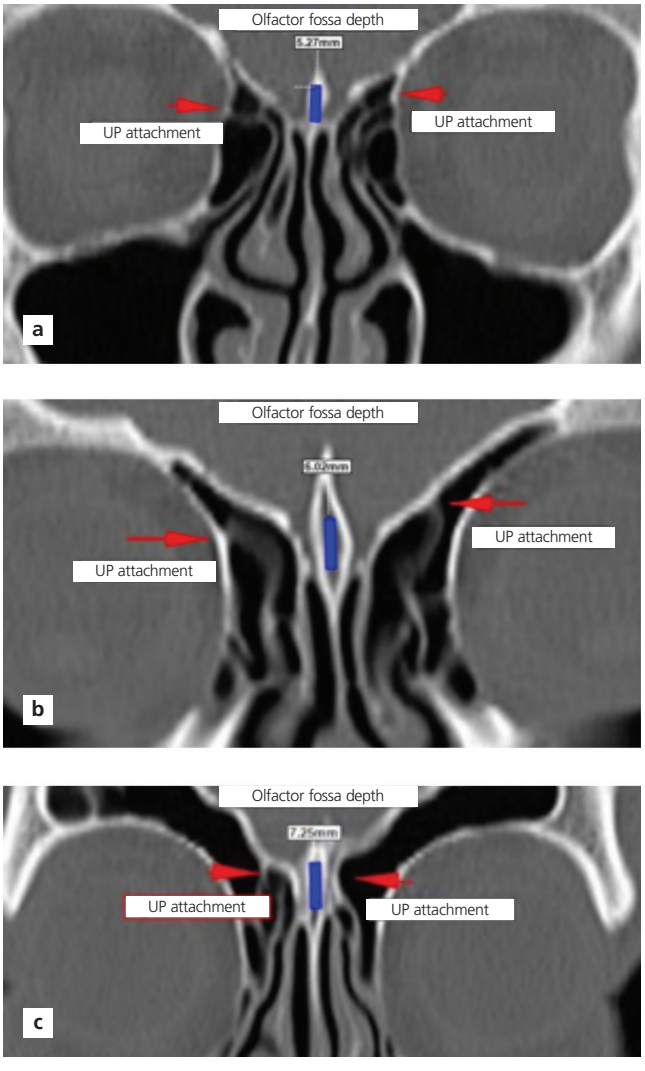

Figure 1. (**a**) Measurement of olfactory fossa depth on a patient from group A (with bilateral type A uncinate process); (**b**) measurement of olfactory fossa depth on a patient from group B (with a type A uncinate process on right); (**c**) measurement of olfactory fossa depth on a patient from group C (with a type B/C uncinate process on both sides).

Discussion

In this radiological and anatomical investigation, we focused on the association between the attachment site of the uncinate process and the position of skull base. We found that patients with uncinate processes with a superior attachment to skull base and/or middle turbinate on both sides had a lower olfactory fossa. Additionally, the patients with an uncinate process attached to the skull base had a longer LLCP.

The position of skull base has a surgical implication for patients undergoing endoscopic sinus surgery: the lower the olfactory fossa, the longer the LLCP.[1,4] It is known that the LLCP is the weakest area of the skull base, and the patients with a lower olfactory fossa has a greater risk of skull base injury with a longer LLCP. Thus, we can speculate that patients with an uncinate process attached to the skull base carries an increased risk of skull base injury because of their longer lateral lamellas compared to the patients with an uncinate process attached to the lamina papyracea and middle turbinate.

When the previous literature is reviewed, there exist several studies investigating the relationships of the skull base and adjacent anatomical structures.[3,4,6] Additionally, authors focused on the angle between LLCP and the cribriform plate in recent publications.[7,8] Moreover, the LLCP was reported as being an anatomical risk factor for iatrogenic cerebrospinal fluid leak.[9,10] Barroso et al.[11]

Table 3
Comparison of lateral lamella length.

Groups*	Lateral lamella length (mm)
Lamina papyracea (n=265)	5.08±1.31
Middle turbinate (n=100)	6.01±1.42
Skull base (n=135)	6.99±1.51
p-value†	<0.001

*Based on the superior attachment point of uncinate process; †of one- way ANOVA.

reported that the variations of attachment of the uncinate process did not affect the development of frontal sinus mucoceles. However, to the best of our knowledge, only a limited number of studies study thus far have investigated the effects of the different attachment types of uncinate process on the development of the skull base, olfactory fossa depth and LLCP length.

The embryologic associations of the anatomical structures around paranasal sinuses are well-known. Ozcan et al.[12] reported the effects of paranasal sinus development on the position of orbital medial wall. Additionally, a coexistence between the hypoplasia of maxillary and frontal sinuses are known.[13] As reported by Kayabasi et al.,[4] maxillary sinus hypoplasia might be associated with a lower olfactory fossa and longer LLCP, bringing about an increased risk of skull base injury. Thus, superior attachment of uncinate process might affect the olfactory fossa depth and LLCP length. This study revealed the significant effect of uncinate process with a superior attachment to skull base on the LLCP length, however, as being a radiologic study, it has a disadvantage against cadaveric studies, considering as the major limitation of the study. In addition, according to the Keros[1] classification, olfactory fossa depth was determined as measurement only on crista galli, thus we added LLCP data on both sides to rule out this limitation. Nevertheless, surgeons should keep in mind that patients with uncinate processes attached to skull base or middle turbinate may have a deeper olfactory fossa, associated with an increased risk of iatrogenic skull base injury.

Conclusion

In conclusion, patients with uncinate processes with a superior attachment to skull base and/or middle turbinate on both sides had a lower olfactory fossa, and the uncinate process attached to the skull base is associated with longer LLCP and increased risk of iatrogenic skull base injury during endoscopic sinus surgery.

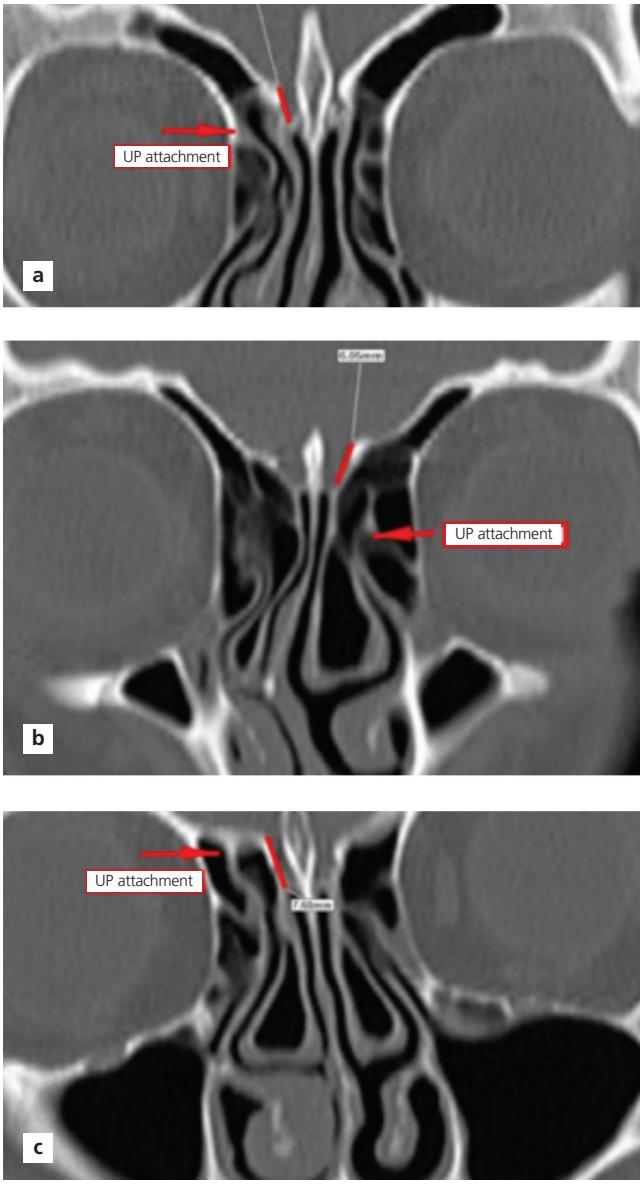

Figure 2. (**a**) Measurement of lateral lamella length on a type A uncinate process (attached to lamina papyracea); (**b**) measurement of lateral lamella length on a type B uncinate process (attached to middle turbinate); (**c**) measurement of lateral lamella length on a type C uncinate process (attached to skull base).

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

ÖH: designing the study, data collection and analysis, writing the manuscript, SK: data analysis, revising the manuscript, supervision of the study, DÖ: data collection and analysis, revising the manuscript.

Ethics Approval

This retrospective investigation was conducted in line with the dictates of Helsinki Declaration and approved by the local ethics committee of Aksaray University (IRB No: 2021/04-08).

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