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Original Article

Anterior skull base variations and its implications using CT scan imaging for safer Endoscopic surgeries

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ABSTRACT

Introduction: Computerized tomographic imaging of the nasal and paranasal regions has become an indispensable tool for the endoscopic sinonasal surgery. The uncinate process is an important bony structure located in the lateral wall of the nose.The olfactory fossa is a space, situated superior to the cribriform plate and has a variable depth.
Methods: A descriptive, case-control study was carried out on 120 patients with a clinical diagnosis of chronic rhino sinusitis who were referred for a sinus CT scan by ENT specialists.
Results: Right side type I uncinate process of 90% was more prevalent in the males of the cases group and 86% is in the females of the control group. Prevalence of left side type II keros classification was seen in 66.7% and 63.3% of cases group and 73.3% and 83.3% of the control group for both the genders.
Discussion: Knowledge about the superior insertion of uncinate process and height of the olfactory fossa provides understanding about the upper limit of surgical dissection and aids in road mapping the confident direction for the functional endoscopic surgeons.
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1. Introduction

Computerized tomographic imaging of the nasal and paranasal regions has become an indispensable tool for the endoscopic sinonasal surgery. It offers the gold standard in imaging the degree of the sinus diseases. Functional endoscopic sinus surgery (FESS) is a minimally invasive technique used to restore sinus ventilation and normal function. The purpose of FESS is to restore physiologic mucociliary flow and maintains the normal sinus drainage pattern.

The uncinate process of the ethmoid bone is an important bony structure situated along the lateral wall of the nose.It is a superior extension of the lateral nasal wall. Along with the ethmoidal bulla, it forms the boundaries of the hiatus semilunaris and ethmoid infundibulum, the structures through which the frontal sinus and maxillary sinuses drain. It is a pertinent structure in relation to paranasal sinus drainage pathway as they cause substantial functional blockage of the osteomeatal complex. Majority of the uncinate process variations are represented by insertion into an unusual topography Insertions of uncinate process variations can be clearly appreciated on coronal CT scan.Frequently,uncinate process insertion into bony structures results in blind-end obstructions (Fig. 1).[1]

The olfactory fossa is a space, situated superior to the cribriform plate and has a variable depth. The ethmoid roof denotes the olfactory fossa depth. Level difference between cribriform plate and ethmoid roof is an important surgical area, since the lateral lamella can vary in thickness from 0.2 to 0.5 mm and provides minute resistance to penetration (Fig. 2).[2]

Knowledge of height and width of the olfactory fossa provides understanding about the upper limit of surgical dissection and aids in road mapping the confident direction for the functional endoscopic surgeons. Significance of the paranasal variations is documented to evaluate its prevalence and contribution for endonasal surgeries (Fig. 3).

This study aims at classifying the superior insertion of uncinate process tip and the depth of the olfactory fossa.

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Fig. 1. Type I uncinate process insertion towards the lateral insertion on both the sides (white arrows).

2. Materials and methods

2.1. Design

A descriptive, case-control study was carried out on 60 patients with a clinical diagnosis of chronic rhino sinusitis who were referred for a para nasal sinus CT scan by the ENT specialists. The control group comprising of 60 were selected from the non ENT and neurology clinic patients with diagnosis other than chronic sinusitis. The patient's age group ranged from 18 to 65 years. The patients were segregated into males and females and assessed on both the sides (Fig. 4).

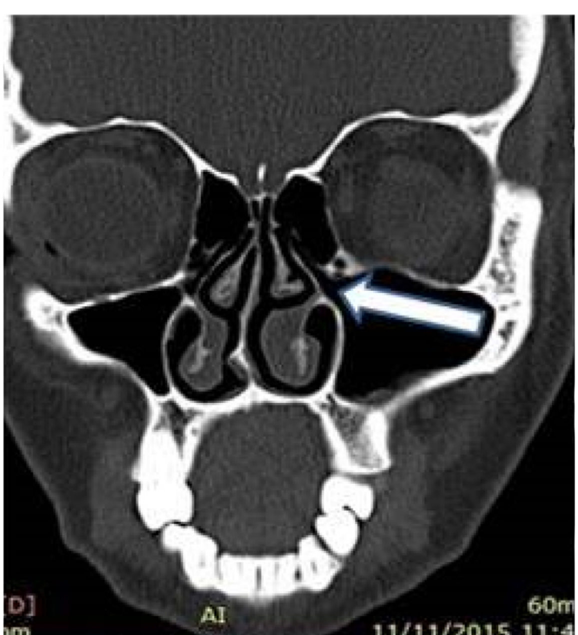

Fig. 2. Type II uncinate process insertion running towards the anteriro skull base on both the sides (white arrow).

Fig. 3. Type III uncinate process insertion towards the medial sideon both the sides (white arrow).

2.2. Method

For the computerized tomographic study, Siemens AG, Somatom Spirit spiral scanner has been used as imaging modality. It provides precise high-resolution reconstruction of the anatomical and neurovascular structures. In all cases, systematic imaging of the nasal sinus region were performed in coronal and axial slices using bone algorithm with 3-mm inter scan interval.

The study parameters were variations of the uncinate process insertions and depth of the olfactory fossa. Each CT scan was analyzed separately in half-heads. Anatomical findings of each patient was carefully scrutinized and recorded on the patient's data sheet (Fig. 5).

The anatomic variations of superior attachment of uncinate process can be

Type I—upper tip of uncinate process bends laterally and inserted into the lamina papyracea,

Type II—uncinate process extends superiorly to the roof of the ethmoid, upto the skull base,

Type III—the superior end of the uncinate process turn medially and is attached to the middle turbinate.

The three types of olfactory fossa are as follows;

Type 1- the cribriform plate is 1–3 mm more caudal than the ethmoid roof. Therefore the ethmoid roof is almost in the same plane as the cribriform plate.

Type 2- the cribriform plate is 4–7 mm lower. So the lateral lamella is higher and fovea ethmoidalis has a steeper course.

Type 3 -cribriform plate is 8–16 mm. This is the most dangerous for the surgeon due to a perforation through the lateral lamella of the cribriform plate

2.3. Statistical analysis

The patients data was entered into MS excel sheet.SPSS version 16 software was used for data analysis. Data was analyzed in terms

Fig. 4. Type I measurement of depth of the olfactory fossa on both the sides in millimetres.

of the number and percentage of the uncinate process insertion type and olfactory fossa type (Fig. 6).

2.4. Ethical approval

This study was approved by institutional review board. (Ethical Approval No: kmc/cert./10-2015/36). Written informed consent

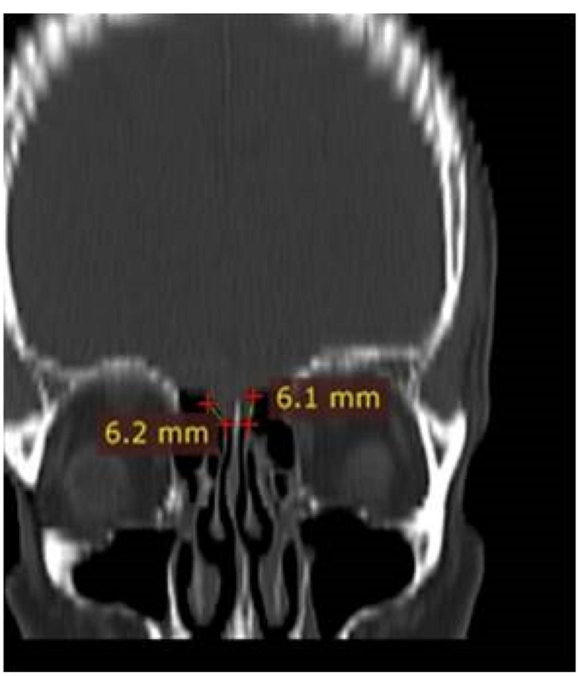

Fig. 5. Type II measurement of depth of the olfactory fossa on both the sides in millimetres.

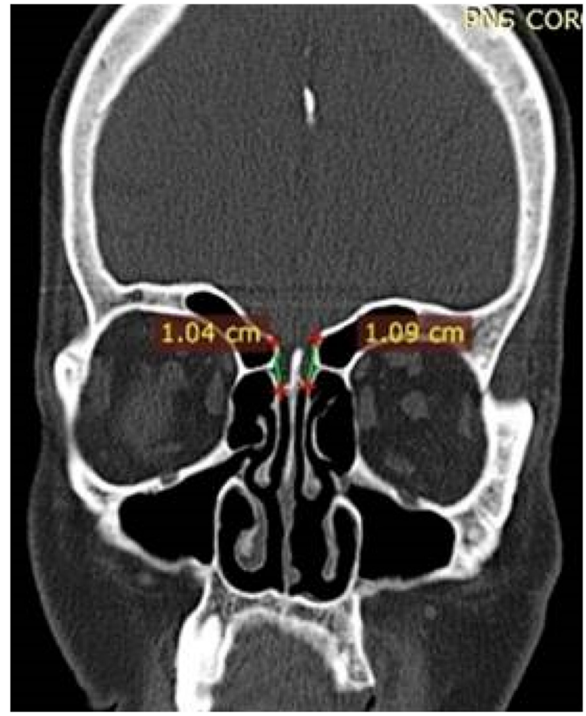

Fig. 6. Type III measurement of depth of the olfactory fossa on both the sides in millimetres.

was obtained from the patients for participation and publication of this research project.

3. Results

The results of the anatomical variations of uncinate process insertions for males and females between the cases and control groups are shown in Tables 1 and 2.

The results of the anatomical variations according to keros classification for males and females between the cases and control groups are shown in Tables 3 and 4.

4. Discussion

The aim of this study was to define the anatomical variations of uncinate process and keros classification of the olfactory fossa.The characteristic uncinate process has been described as a thin, bony hook like leaflet with a sagittal orientation, running from anterosuperior to posteroinferior direction. It is physiologically relevant for draining the frontal recess. Its concave posterosuperior free margin is parallel to the anterior surface of the ethmoid bulla. The uncinate process attaches to the perpendicular process of the palatine bone and the ethmoid process of the inferior turbinate with bony spicules. The convex anterior margin is in contact with

Table 1
Distribution of uncinate process insertions types between the males of cases &control group.

Males						
	Cases n (%)			Controls n (%)		
Types	I	II	III	I	II	III
Right side	27 (90)	1 (3.3)	1(3.3)	26(86.7)	1(3.3)	3 (10)
Left side	22(73.3)	0	6(20)	23 (76.7)	1(3.3)	6 (20)

Right side type I uncinate process of 90% is more prevalent in the males of the cases group.

Table 2
Distribution of uncinate process insertions types between females of cases group & control group.

Females						
	Cases n (%)			Controls n (%)		
Types	I	II	III	I	II	III
Right side	21 (70)	1 (3.3)	6(20)	26(86.7)	0	4 (13.3)
Left side	23 (76.7)	1 (3.3)	5(16.7)	21 (70)	2(6.7)	6 (20)

Right side type I uncinate process of 86% is more prevalent in the females of the control group.

Table 4
Classification of the olfactory fossa depth between the females of the cases and control group.

Females						
	Cases n (%)			Controls n (%)		
Types	I	II	III	I	II	III
Right side	2 (6.7)	20 (66.7)	8(26.7)	0	24(80)	6 (20)
Left side	2 (6.7)	22 (73.3)	6(20)	0	25(83.3)	5 (16.7)

Left side type II keros classification 73.3% and 83.3% is more prevalent in the males and females of the control group.

the bony lateral nasal wall and may extend up to the lacrimal bone.[3,4]

Traditionally, the uncinate process is identified from its lower segment through the architecture of the osteomeatal unit. They project from the ethmoid bone to the ethmoid process of inferior nasal concha. As a result, anatomical variations of the uncinate process is considered as one of the predisposing factor for the development of chronic rhino sinusitis in the anterior ethmoid and frontal cell region.[1]

The hypertrophied and laterally curved uncinate process causes narrowing of hiatus semilunaris and the ethmoid infundibulum. The medially curved posterior margins of uncinate process may approximate to middle turbinate and may narrow the ethmoid infundibulum [5–8]

There are anatomical variation of the uncinate process is represented by insertion into unusual topographic locations. The uncinate process is a superior extension from the lateral wall of the nasal cavity and generally is inserted into the posteromedial portion of the aggernasi.Uncinate process insertion into other structures may result in a blind-end obstructions. The superior aspect of the uncinate tip may deviate laterally, medially, or anteriorly out of the meatus, appearing as a second middle turbinate bone.[1–3]

Stammberger et al classified the insertions of uncinate process as

Lateral insertion-In cases where the uncinate process inserts into the lamina papyracea, wherein the maxillary sinus drainage may be impaired.

Insertions of the uncinate process ti into the anterior skull base

Medial insertion- If the uncinate process attaches to the middle turbinate or cribriform plate, the frontal and unilateral maxillary sinuses drainage may be impaired, resulting in a mechanism of sinus mucus recirculation.[9–11]

Variations such as hypertrophy, deviation and pneumatization may affect the drainage system generating abnormalities in the osteomeatal complex and predisposes to obstruction. Anatomical variations of the uncinate process intend to cause deprived sinus ventilation and considerable functional blockage of the anterior ethmoid, osteomeatal complex and frontal recess region.It may be due to the extension of the agger nasi cell within the anterosuperior portion of the uncinate process. It has also been suggested as a predisposing factor for impaired ventilation of the anterior group of sinuses and frontal sinus.[4]

Nevertheless, the severity of the degree of medial insertion of the uncinate process causes the mucosal contact with middle turbinate or covering up the ostium of maxillary sinus. This acts as a contributing factor that increases the pathogenicity of chronic rhinosinusitis.[12,19]

In our present study, right side type I uncinate process of 90% is more prevalent in the males of the cases group. Right side type I uncinate process of 86% is more prevalent in the females of the control group. Majority of the patients included in our study fall under right side type I insertions.

Anita et al., Thimmappa et al., Tuli et al., Biswas et al., Mamatha et al., Dua et al. showed prevalence of uncinate process variations about 5.6%,47%,4%,6%,45% and 6%.Our present study has categorized the superior tip insertions into lateral insertion, insertions into the skull base and lateral insertions.The prevalence has been shown in table number 1 for both the groups in males and Table 2 for both the groups in females.Previous studies also has classified in the same pattern and meta analysis is shown in Table number 5 .

Presence of anatomical variations of the uncinate process alone in patients of chronic sinusitis cannot be justified as an indication for uncinectomy.Injudicious removal of the uncinate process especially in cases with allergic rhinosinusitis can expose the sinus mucosa to contaminated air causing persistent or even worsening of the mucosal disease in the ethmoid cavity and its dependent major sinuses.[13,14]

The roof of the ethmoidal air cells also called fovea ethmoidalis, is higher than the medial roof of the nasal cavity formed by the cribriform plate.The cribriform plate is usually lower than the ethmoid roof, which gives off lateral lamellae, creating the floor, walls and upper limit of the olfactory fossa. The cribriform plate forms the partition between the nasal chamber and the anterior cranial fossa and is more caudal than the ethmoid roof.[2,15]

The cribriform plate may be located at variable levels and so they are classified according to the criteria developed by Keros. It is based on the height of the olfactory fossa in relation to the roof of the ethmoid sinus as compared with the length of the lateral lamella of cribriform plate of ethmoid plate. In majority of patients, the plane of the fovea ethmoidalis passes above the upper one-third of the vertical diameter of the corresponding orbit. A foveal

Table 3
Classification of the olfactory fossa depth between the males of the cases and control group.

Males						
	Cases n (%)			Controls n (%)		
Types	I	II	III	I	II	III
Right side	0	18 (60)	12(40)	0	18(60)	12 (40)
Left side	0	20(66.7)	10(33.3)	0	19(63.3)	11(36.7)

Left side type II keros classification 66.7% and 63.3% is more prevalent in the males and females of the cases group.

Table 5
Distribution of uncinate process insertions types in various population.

S NO	AUTHORS	YEAR	MEDIAL	LATERAL	SKULL BASE
1	Al-Abri R et al	2014	27.87	22.13	
2	Nouraei et al	2009	9.3		
3	Beale et al	2009	3	67	14
4	Ali A et al	2005	20	60	8
5	Nitinavakarn et al	2005	22.8	21.4	
6	Tuli et al	2012	67	14	3

Distribution of uncinate process insertions types in various population is shown in Table 5.

Table 6
Keros classification of olfactory depth in various population.

S NO	Study	YEAR	I % (1-3 mm)	II % (4-7 mm)	III % (8-16 mm)
1	Nouraei et al	2009	92	7	1
2	Rashid Al Abri et al	2014	30	34	36
3	Benjaporn et al	2005	11.9	68.8	19.3
4	Ali Arif et al	2005	20	78.7	1.3
5	G rosado et al	2006	29	60	11
6	Josefino et al	2008	81.5	18	0.5
7	Arslan et al	1999	20	16	64
8	Kero et al	1962	12	70	18

Distribution of keros classification for olfactory depth in various population is shown in Table 6.

plane passing through the mid-orbital plane or below predisposes the patient to accidental penetrations.[17,18]

The higher the keros grade, the greater the chance of injury to the cribriform plate and olfactory fossa.It fatally leads to consequential risk of iatrogenic CSF fistula and olfactory impairment. In 1962, Keros studied 450 skulls and described 3 types of olfactory fossa which are formed by cribriform plate and the fovea ethmoidalis.[2,16–18]

In our study, prevalence of the anatomical variation has been shown in Tables number Table 3 and 4. Previous studies also has classified in the same pattern and meta analysis is shown in Table number 6 .

It perpetuate into lethal CSF rhinorrhea and intracranial injuries.The lateral lamella is longest in Type III and so this configuration presents the maximum risk of perforation into the anterior cranial fossa.Anatomical variations do propagate the endoscopic surgeon to tragedies like a low skull base. A lower skull base drastically reduces the height of the ethmoidal complex. The surgeon may wrongly presume that there are more superior ethmoidal air cells situated. So he inadvertently enters the anterior cranial fossa and cause iatrogenic sequeale.[16–18]

Deeper olfactory fossa shows a greater differential in height between the fovea and cribriform plate leading to higher risk of surgical trauma.Asymmetry in height of the ethmoid roof also predisposes to inadvertent dangerous tragedies.[6,19]

Understanding the complex anatomy of anterior skull base and its relationship including fovea ethmoidalis, olfactory fossa, lateral lamella and course of anterior ethmoid ethmoid artery are crucial in avoiding complications during sinus surgeries.Inadvertent violation of fovea ethmoidalis or cribriform plate leads to CSF leak, direct penetration to the duramater consequently leading to intracranial and intracerebral complications.[20]

5. Conclusion

Variations such as hypertrophy,deviation and pneumatization of anatomical structures may affect the drainage system generating abnormalities in the osteomeatal complex and predisposes to obstruction. The configuration of the cribriform plate in relation to the roof of the ethmoid sinus is of particular significance with respect to the risk of skull base injury and cerebrospinal fluid leak.

Conflict of interest

None declared

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Conflict of interest

None declared

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