

# Evaluation of Anatomical Variations in Ostiomeatal Unit by Computed Tomography

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## Abstract

**Introduction:** The ostiomeatal unit has a lot of anatomical variations. Evaluation of these variations is important in patients who undergo computed tomography (CT) scan for their Rhinological complaints. These anatomical variants are responsible for chronic ailments like rhinosinusitis, and their knowledge is essential to not only reduce complications during procedures like functional endoscopic sinus surgery but also to explain the disease recurrence and allow surgeons to decide their operative approach.

**Purpose:** The purpose of the study was to evaluate and determine the incidence of anatomical variations of ostiomeatal unit on CT and to assess the relation of these variations with sinonasal mucosal diseases.

**Materials and Methods:** This is a prospective cross-sectional study done at the Department of Radiodiagnosis in a tertiary care center over a period of 24 months with 100 subjects having sinonasal complaints which were referred from various departments for CT scan.

**Results:** The attachment of the uncinate process had many variations with attachment to the lamina papyracea being 84%, attachment to the skull in 8%, attachment to the middle turbinate in 6%, and free lying in 2%. The uncinate process pneumatization was seen in 6% cases. Giant ethmoid bullae were noted in 11% cases while hypoplastic ethmoid bullae were seen in 4%. In terms of association with sinusitis, only uncinate process pneumatization was found to have a significant statistical association.

**Conclusion:** The most common ostiomeatal unit anatomical variant was varied attachment of the uncinate process. The least common variant noted was the uncinate process pneumatization; however, only this variant was found to have a positive correlation with sinusitis in comparison to other ostiomeatal unit variants.

**Key words:** Computed tomography, Ethmoid bulla, Functional endoscopic sinus surgery, Ostiomeatal unit, Pneumatization, Uncinate process

## INTRODUCTION

Ostiomeatal unit is a complex anatomic region that houses the drainage areas of frontal, maxillary and the anterior ethmoid sinuses. Ostiomeatal unit anatomy is highly variable from one person to another. The diverse variations in the anatomy of the ostiomeatal unit have been studied worldwide since long. Different studies have quoted different percentages for these anatomic variations.<sup>[1]</sup>

## Embryology

The ostiomeatal unit develops during late fetal life and in infancy<sup>[2]</sup> from two of the five parallel lamellae. Initially, these lamellae appear as slits, but then quickly grow into a tubular form and then into a round or globular shape at term. The first lamella corresponds to the uncinate process while the second to the bulla ethmoidalis.

## Anatomy<sup>[3]</sup>

Ostiomeatal unit comprises the bulla ethmoidalis, uncinate process, hiatus semilunaris, infundibulum, and maxillary sinus ostium. Bulla ethmoidalis, the largest and anterior most ethmoidal cell, is a rounded elevation produced by the underlying middle ethmoidal sinus. It is the largest and anteriormost ethmoidal cell. The uncinate process is sickle-shaped with a horizontal and a vertical limb. It has a free margin posteriorly and has a variable attachment superiorly.

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Hiatus semilunaris is a deep semicircular sulcus below the bulla, best seen on parasagittal sections. Infundibulum is a short passage at the anterior end of the hiatus. Maxillary sinus ostium is the opening of the maxillary sinus into the nasal cavity.

### **Anatomical Variants<sup>[3]</sup>**

The anatomical variants of the ostiomeatal unit can be categorized as follows.

#### ***Uncinate process attachment variations***

The superior end has a varied attachment. It can attach to the lamina papyracea, the skull base, the middle turbinate, or even lie free in the middle meatus.

#### ***Uncinate process pneumatization***

It is also called as an uncinata bulla. It occurs due to the growth of agger nasi cells into the most anterosuperior region of the uncinata process. Pneumatization can result in narrowing of infundibulum and sinus drainage occlusion.

#### ***Ethmoidal bulla variations***

It can be absent, hypoplastic, or enlarged.

Computed tomography (CT) scan is the choice of investigation for ostiomeatal unit. Coronal scans are best used to visualize the ostiomeatal unit.

### **Purpose of the Study**

The purpose of the study was to evaluate and determine the incidence of anatomical variations of ostiomeatal unit on CT and to assess the relation of these variations with sinonasal mucosal diseases.

## **MATERIALS AND METHODS**

This is a prospective cross-sectional study conducted at the Department of Radiodiagnosis in a tertiary care center over a period of 24 months from November 2015 to October 2017. The proportion of the population with an anatomic variation of paranasal sinuses was estimated by calculating the sample size which came out to 100. A clearance certificate was obtained from the Ethical Committee of the Institute. Subjects having sinonasal complaints which were referred from various outpatient departments (OPDs), and wards for CT examination were, thus, taken after applying the inclusion and exclusion criteria as follows.

### **Inclusion Criteria**

The following criteria were included in this study:

- Patients with sinonasal symptoms, who were referred from various clinical OPDs and wards to the Department of Radiodiagnosis.
- Both males and females.

- Patients age more than 12 years.
- Patients who are willing to participate in the study.

### **Exclusion Criteria**

The following criteria were excluded from this study:

- Trauma to face.
- Previous surgery to the sinonasal region.
- Diseases invading and eroding the bones of sinuses
- Invasive, polypoidal, expansile, and neoplasms of PNS.

After obtaining a written informed consent, patients were subjected to undergo CT scan of the ostiomeatal unit in GE Bright Speed Edge Select 8 slice CT scanner. Axial images were acquired with 2.5 mm collimation, and from this raw data sagittal and coronal reformation were obtained with 0.625 mm collimation.

Data from the CT examination were collected in a compact disc and entered in a pro forma and stored in both hard and soft copies. Variables from the data so collected were analyzed using Epi Info 6.

Since the participants were already referred to the Department of Radiodiagnosis for CT evaluation of the ostiomeatal unit, no extra budget was incurred in this study.

## **OBSERVATIONS AND RESULTS**

In the 100 cases evaluated, a variety of ostiomeatal unit anatomical variants were found. The following were assessed:

1. Ostiomeatal unit
  - a. Uncinate process attachment
  - b. Uncinate process pneumatization
  - c. Ethmoid bulla size.
2. Sinusitis wise association of anatomical variants of the ostiomeatal unit.

The most common ostiomeatal unit anatomical variant was noted to be varied attachment of the uncinata process. The least common variant noted was the uncinata process pneumatization.

### **Uncinate Process Attachment**

The superior attachment of the uncinata process to the lamina papyracea (84%) was the most common attachment noted followed by attachment to the skull base (8%) and then to the middle turbinate (6%). Free lying type of uncinata process was noted only in 2% of cases and was the least common variant of uncinata process attachment noted.

### **Uncinate Process Pneumatization**

The uncinata process was found to be pneumatized in 6% cases. Out of these, the left-sided pneumatizations

(4%) were the most common ones while bilateral pneumatizations (2%) were the least common.

### Ethmoid Bulla Size

Bilateral giant ethmoid bulla (6%) was the most commonly noted variant while unilateral hypoplastic bulla (1% each) was the least common variant.

### Association of Ostiomeatal Unit Anatomical Variants with Sinusitis

The anatomical variation that had a significant correlation with the presence of sinusitis was the pneumatized uncinata process ( $P = 0.001$ ). Rest of the variations of the ostiomeatal unit did not have a statistically significant association with sinusitis.

## DISCUSSION

CT is an important modality in the evaluation of the ostiomeatal unit. With the advent of newer procedures like functional endoscopic sinus surgery (FESS) for the treatment of sinonasal ailments, the use of CT for pre-operative workup of these cases has even more increased. This not only has an improved treatment outcome but also due to the adequate delineation of anatomy and the variations of the ostiomeatal unit, there are lesser chances of complications such as bony injury, cerebrospinal fluid (CSF) leak, vascular injury, or neural injury.<sup>[4]</sup>

The basic principle of FESS is removal of disease in the ostiomeatal complex region, which is best appreciated on CT scan as documented by Dua *et al.*<sup>[5]</sup>

Mamatha *et al.* emphasized the concept that ostiomeatal complex is the key factor in the causation of chronic sinusitis and that the coronal plane is preferred since it best displays the ostiomeatal complex.<sup>[6]</sup>

### Uncinate Process Attachment

Four different attachments of the uncinata process have been described, namely, attachment to the lamina papyracea, attachment to the skull base, attachment to the middle turbinate, and freely lying.

In the present study, the uncinata process attachment to the lamina papyracea was seen in 84% cases, to the skull base in 8% cases, to the middle turbinate in 6% cases, and freely lying in 2% cases. This was consistent with the study conducted by Arun *et al.*<sup>[7]</sup> with attachment to the lamina papyracea seen in 67.5% cases, to the skull base in 18.5% cases, to the middle turbinate in 9.5% cases, and free lying in 4.5% cases. It was also consistent with the study conducted by Landsberg and Friedman<sup>[8]</sup> with lamina papyracea attachment seen in 60.5%, skull

base attachment in 3.6% cases, and middle turbinate attachment in 1.4% cases.

### Uncinate Process Pneumatization

Uncinate process pneumatization also called the uncinata bulla, can cause ostiomeatal unit obstruction and can impede drainage of the sinuses.

In the present study, uncinata process pneumatization was found in 6% of the patients. Similar proportions were noted in studies conducted by Adeel *et al.*<sup>[9]</sup> which showed 5.2% cases, Kumar *et al.*<sup>[10]</sup> showed 5% cases, and Leunig *et al.*<sup>[11]</sup> showed 8.8% of cases.

### Ethmoid Bulla Size

Giant ethmoid bulla can be a cause of sinus infection due to the potential airspace within it just like any other sinus.

In the present study, giant ethmoid bulla was present in 11% of the patients. Similar proportions were found in studies conducted by Amita *et al.*<sup>[12]</sup> with 10% cases, Dua *et al.*<sup>[5]</sup> with 14%, and Ahmed and Kanmadi<sup>[13]</sup> with 16.2% cases.

Hypoplastic ethmoid bullae were noted in 4% cases in the present study which was consistent with the study conducted by Earwaker,<sup>[14]</sup> in which they were found to be in 8.2% cases.

However, we did not get any case of an unpneumatized or atrophic ethmoid bulla, while Earwaker<sup>[14]</sup> had noted about 11% cases with unpneumatized ethmoid bulla. This could be because of a large sample size of his study (800 cases).

### Sinusitis Wise Association of Anatomical Variants of the Ostiomeatal Unit

In the present study, the anatomical variation that had a significant correlation with the presence of sinusitis was the uncinata process pneumatization.

Fadda *et al.*, in their study of 200 CT scans, found that medial deviation of uncinata process, hypertrophic ethmoidal bulla, and the presence of sinus mucosal disease had a statistically significant association ( $P < 0.05$ ).<sup>[15]</sup>

Likewise, Dasar and Gokce studied CT scan in 400 patients with an age range of 20–83 years to see the frequency of anatomical variations of the paranasal sinuses and their association in sinonasal mucosal diseases. They found that the uncinata bulla with sinonasal mucosal diseases ( $P = 0.004$ ) and that of giant ethmoid bulla with sinonasal mucosal diseases ( $P = 0.002$ ) was significant.<sup>[16]</sup>

As is evident from the discussion above, most of the anatomical variants and its proportions noted in the present study were consistent with other similar studies in literature.

However, few of the variants show different proportions of their prevalence and their association with sinusitis. This could be because of different sample sizes, different age ranges, different study techniques, demographic, and ethnic differences in different study population and different statistical methodology for data analysis.

### Implications

#### FESS

The knowledge of the anatomy of the ostiomeatal unit and its variations plays an immense role in guiding the surgeons appropriately during FESS. This not only allows them to decide a proper course of action according to the type of pathology and the exact site involved but also provides them a roadmap so that inadvertent complications during surgery, like a CSF leak, vascular injury or neural injury can be avoided.

#### Association with sinusitis

Although a majority of the normal anatomic variants of the ostiomeatal unit have not been found to be significantly associated with causation of sinusitis, it is a well-known fact that other factors that lead to the narrowing or blocking of the ostiomeatal unit lead to pathologies such as sinusitis and polyps.

### Strengths of the Study

#### Budget

Since the data will be collected from the participants who are already referred to the Department of Radiodiagnosis for CT evaluation of the paranasal sinuses, no extra budget was incurred in this study.

#### No extra radiation

Since the CT examination findings were evaluated after performing a routine imaging in the same protocol, if the patients were not included in the study, the study subjects were not exposed to any additional radiation.

### Limitations of the Study

#### Less sample size

The sample size of a 100 patients seems inadequate while compared to many other studies done in the past, according to the available literature.

#### Less sliced CT machine

The CT machine used in the study was of 8 slices only. However, if a higher resolution machine was available, better images would have been procured, and the detailed anatomy of the ostiomeatal unit could have been better delineated.

## CONCLUSIONS

Anatomical variations of the ostiomeatal unit are best evaluated by CT. These variations may sometimes lead to

recurrent sinusitis, mainly due to impaired sinus drainage and ventilation. Understanding the different variations and location, hence, is important not only in evaluating the disease extent but also to pave a roadmap for FESS surgeons.

The superior attachment of the uncinat process to the lamina papyracea was the most common type of anatomical variant noted, while the uncinat process pneumatization was the least common anatomical variant noted.

Although many anatomical variants were noted, the variant that had a significant correlation with the presence of sinusitis was only the pneumatized uncinat process.

This study, hence, concludes that, though there were many anatomical variants noted, only one of them had an association with sinusitis, which very well depicts that the anatomical variants are as such not a causal factor in sinus inflammation. However, the knowledge of them is imperative for the surgeons so that they have an ease to differentiate the normal anatomy variants during FESS and avoid surgery-related complications.

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