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# Study of anatomical variations of ostiomeatal complex in chronic rhinosinusitis patients

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## ABSTRACT

**Background:** Anatomical variations like nasal septal deviations, concha bullosa, paradoxical middle turbinate, pneumatized or medially bent uncinate etc. can encroach upon the ostiomeatal unit and narrow ostiomeatal channels. The aim of the study was to study the anatomical variations of ostiomeatal complex commonly associated with paranasal sinus disease among patients with chronic sinusitis using computed tomography.
**Methods:** A prospective longitudinal study was conducted in the ENT department of our hospital for a period of one year. All the adult patients with complaints suggestive of chronic rhinosinusitis for a period of more than 12 weeks, patients with acute exacerbation of chronic rhinosinusitis and with persistent chronic rhinosinusitis requiring surgical intervention are included in our study. Based on our inclusion and exclusion criteria a total of 138 patients were involved in the study.
**Results:** In our study we saw the association between various sinusitis and the anatomic variations of the ostiomeatal complex and we found that concho bullosa found to have a strong significant association with maxillary sinusitis (43.6%) and anterior ethmoid sinusitis (42.1%). Most of the patients with posterior ethmoid sinusitis (53.8%) had a statistical significant association in developing deviated nasal septum type of anatomical variant and majority of the patients with sphenoidal sinusitis had a onodi cell type of anatomical variant and their association was found to be statistical significant ($p<0.05$).
**Conclusions:** The importance of CT scan and nasal endoscopy is emphasized in patients with persistent symptoms to identify the anatomical variations that may contribute to the development of chronic sinus mucosal disease.

**Keywords:** Chronic rhinosinusitis, Ostiomeatal unit, Computed tomography, Anatomic variation

## INTRODUCTION

Chronic rhino sinusitis (CRS) is a very common condition in ENT practice affecting approximately 1/6thof the Indian population. The National Institute of Allergy and Infectious Diseases (NIAID) estimated that 1 in 8 Indians suffer from CRS and this disease is more widespread than diabetes, asthma or coronary heart disease.[1] The chronic nature and the debilitating symptoms of the disease are a cause of significant morbidity in CRS patients and greatly impair their quality of life. American Academy of Otorhinolaryngology and Head and Neck Surgery - Rhinosinusitis task force (RSTF) in 1997, defined Rhinosinusitis as the condition manifested by an inflammatory response of the mucous membrane of the nasal cavity and paranasal sinuses, fluids within these cavities and / or underlying bone. Etiology of CRS includes structural anatomical

obstruction, recurrent upper respiratory infections, allergies, biofilm formation and less commonly ciliary dyskinesias, mucopolysaccharoidosis and cystic fibrosis.[2,3]

Stammberger and Kennedy define osteomeatal complex as a functional unit of the anterior ethmoid complex representing the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid sinuses.[4] OMC is a narrow anatomical region consisting of middle turbinate, uncinate process, bulla ethmoidalis, frontal recess, ethmoidal infundibulum, middle meatus, and anterior ethmoidal, maxillary and frontal sinus ostia.[5] Haller's cell, pneumatization of agger nasi cell, a pneumatised and or medialized uncinate process, paradoxical middle turbinate and enlarged ethmoidal bulla.[6] However, their roles in pathogenesis of rhinosinusitis are still unclear.

CT scan and nasal endoscopy are preferred diagnostic modalities to determine the mucosal abnormalities and bony anatomic variations of paranasal sinus and assess the possible pathogenicity of these findings in patients undergoing evaluation for sinusitis.[7] The normal OMC is visualized on 2 or 3 mm thick coronal CT section.[8] Messerklinger reported that infundibulum and middle meatus were the most common sites influenced by anatomic variation of OMC and Stammberger found that more than 90% of this disease is caused by anatomic variation of OMC.[9-11]

Anatomical variations like nasal septal deviations, concha bullosa, paradoxical middle turbinate, pneumatized or medially bent uncinate etc. can encroach upon the Ostiomeatal unit and narrow ostiomeatal channels.[12] This leads to impaired drainage and dysventilation of the paranasal sinuses which are primary predispositions for development of sinusitis. Some less common variations like presence of haller cell, onodi cell can also hinder sinus drainage and contribute to the development of sinusitis. Surgical clearance of these chronically infected sinuses while maintaining their ventilation and drainage is the treatment of choice.[13] To achieve this goal, there should be some diagnostic modalities which guide us towards exact diagnosis and safe intervention. CT scan and nasal endoscopy provides the ability to accurately access this area for evidence of localized disease or any anatomic defect that compromises ventilation and mucociliary clearance.

### *Aim*

To study the anatomical variations of ostiomeatal complex commonly associated with paranasal sinus disease among patients with chronic sinusitis using computed tomography.

## METHODS

A prospective longitudinal study was conducted in the ENT department of Vinayaka Missions Kirupananda Variyar Medical College Hospital for a period of one year between January 2017 and December 2017. The study was formally started after getting the clearance from the institutional ethical committee. All the adult patients of more than 17 yrs and less than 50 yrs with complaints suggestive of chronic rhinosinusitis for a period of more than 12 weeks, patients with acute exacerbation of chronic rhinosinusitis and with persistent chronic rhinosinusitis requiring surgical intervention are included in our study. Patients with acute or fungal sinusitis, patients with mass or polyps obstructing the nasal cavity, with history of previous sinonasal surgeries or trauma with altered anatomy, patients with facial anomalies and with known ciliary motility disorder like Kartagener's syndrome or Down's syndrome were excluded from the study. Based on our inclusion and exclusion criteria a total of 138 patients were involved in the study. An informed written consent was obtained from all the study subjects.

A thorough clinical examination was done and the diagnosis of CRS was established. All the patients in the acute phase of the disease were treated conservatively with a course of antibiotics, topical and oral decongestants. The patients with persistent symptoms and signs were counseled regarding endoscopic evaluation and imaging of nose and PNS by CT scan and further about the need for surgery.

CT scan was performed with GE CT scanner of our Hospital, Salem. After obtaining the scout projections,the area of scanning was designed to include the region from roof of frontal sinus upto the hard palate. Coronal sections were performed with the patients in prone position with extended neck and the plane perpendicular to axial plane. Limited axial sections were performed with the patient in supine position and the plane of data acquisition parallel to hard palate. All films are taken without contrast.

The assessment of CT images was done by two methods the first one is Gliklich and Metson staging method. It includes 4 stages which are as follows

Stage 0: <2 mm thickness of mucosa on any sinus wall.

Stage 1: All unilateral disease or anatomical abnormality,

Stage 2: Bilateral disease limited to Ethmoidal or Maxillary sinuses

Stage 3: Bilateral disease with involvement of at least one Sphenoidal or Frontal sinus

Stage 4: Pansinusitis and the second one is Lund-Mackay scoring system, which includes scores ranging from 0–2. For all Sinus systems: 0–no abnormalities, 1–partial opacification, 2–total opacification. For the Ostiomeatal complex: 0–not occluded, 2- occluded. Each sinus cavity is scored according to the amount of disease present.

Total score ranges from 0 to 24, with a maximum of 12 for each side.

All data were entered and analysed using SPSS version 21. Mean and standard deviation was derived for all the parametric variables and the chi-square test was used to derive the statistical inference related to the association between the study variables.

## RESULTS

Table 1 shows the age and gender wise distribution of the study population. The minimum age of the study subjects was 17 years and the maximum age was 50 years and the mean age was 32.2 years. In males and females majority of the study subjects were between 21 and 30 years and the distribution of the different age group between males and females are almost similar wnd no statistically significant difference was observed between them. Among the various types of sinusitis reported among the study subjects maxillary sinusitis (63%) was found to be more common followed by anterior ethmoid sinusitis (55%) and frontal sinusitis (52.1%) and sphenoidal sinusitis (21.7%) was the least common type. Among the site of involvement of the sinusitis we found the involvement of right side was slightly more common than the left side and also few patients had bilateral involvement of sinusitis (Table 2). In our study subjects 66.6% of the patients with sinusitis had ostiomeatal unit block among which right sided block was found to be more common followed by left sided block and 19.5% of the subjects had bilateral ostiomeatal unit block (table 3). Our results had shown a strong statistical significant association of all types of sinusitis except sphenoidal sinusitis with ostiomeatal block. More than 84% of patients with any type of sinusitis had ostiomeatal block, so it infers that all patients with sinusitis had to be examined for the ostiomet al unit (Table 4). Table 5 shows the various type of anatomical variations of the ostiomeatal complex among the patients with sinusitis. All the anatomical variations was found using CT pictures. In our study subjects we found deviated nasal septum (71%) was the most common anatomical variation, followed by aggernasi cell (62.3%) and conchobullosa (57.2%), prominent bulla ethmoidalis (47%) and paradoximal middle turbinate (45.6%) were also seen in almost equal numbers. Some rare variations like Onodi cell (8.6%), pneumatised uncinate process (5.7%), Haller cell (4.3%) and pneumatisation of septum (3.6%) were also seen among the patients with chronic sinusitis. In our study we saw the association between various sinusitis and the anatomic variations of the ostiomeatal complex and we found that concho bullosa found to have a strong significant association with maxillary sinusitis (43.6%) and anterior ethmoid sinusitis (42.1%), majority of the patients with maxillary sinusitis and anterior ethmoid sinusitis had concho bullosa type of anatomical variant in their ostiomeatal complex. Majority of the patients with frontal sinusitis (45.8%) had aggernasi cell type of anatomical variant in the ostiomeatal complex and it showed a statistical significant association ($p<0.05$). Most of the patients with posterior ethmoid sinusitis (53.8%) had a statistical significant association in developing deviated nasal septum type of anatomical variant and majority of the patients with sphenoidal sinusitis had a onodi cell type of anatomical variant and their association was found to be statistical significant ($p<0.05$).

**Table 1: Age and gender wise distribution of the study subjects.**

| Age group | Gender | | Total (%) |
|---|---|---|---|
| | Male (%) | Female (%) | |
| **10–20** | 4 (5.5) | 2 (3) | 6 (4.3) |
| **21–30** | 24 (33.3) | 25 (37.8) | 49 (35.5) |
| **31–40** | 22 (30.5) | 19 (28.7) | 41 (29.7) |
| **41–50** | 22 (30.5) | 20 (30.3) | 42 (30.4) |
| **Total** | 72 (100) | 66 (100) | 138 (100) |
| **Mean±SD** | 32.6±6.2 | 31.8±7.3 | 32.2±6.4 |

**Table 2: Distribution of the study subjects based on their presence of sinusitis.**

| Sinusitis | Side of involvement | Frequency (n=138) | Percentage (%) |
|---|---|---|---|
| **Maxillary sinusitis (n=87)** | Right | 40 | 28.9 |
| | Left | 32 | 23.1 |
| | Bilateral | 17 | 12.3 |
| **Frontal sinusitis (n=72)** | Right | 35 | 25.3 |
| | Left | 27 | 19.5 |
| | Bilateral | 6 | 4.3 |
| **Anterior ethmoid sinusitis (n=76)** | Right | 34 | 24.6 |
| | Left | 29 | 21 |
| | Bilateral | 13 | 9.4 |
| **Posterior ethmoid sinusitis (n=65)** | Right | 31 | 22.4 |
| | Left | 26 | 18.8 |
| | Bilateral | 8 | 5.7 |
| **Sphenoid sinusitis (n=30)** | Right | 9 | 6.5 |
| | Left | 9 | 6.5 |
| | Bilateral | 12 | 8.6 |

**Table 3: Distribution of the study subjects based on the presence of ostiomeatal unit block.**

| Ostiomeatal unit | Frequency (n=138) | Percentage (%) |
|---|---|---|
| **Right ostiomeatal unit block** | 36 | 26 |
| **Left ostiomeatal unit block** | 29 | 21 |
| **Bilateral ostiomeatal unit block** | 27 | 19.5 |

**Table 4: Association between sinusitis and ostiomeatal unit block among the study subjects.**

| Sinusitis | Ostiomeatal unit block | | P value |
|---|---|---|---|
| | Present (n=92) (%) | Absent (n=46) (%) | |
| **Maxillary sinusitis (n=87)** | 80 (91.9) | 7 (8.1) | <0.0001 |
| **Frontal sinusitis (n=72)** | 61 (84.7) | 11 (15.3) | <0.0001 |
| **Anterior ethmoid sinusitis (n=76)** | 64 (84.2) | 15 (15.8) | <0.0001 |
| **Posterior ethmoid sinusitis (n=65)** | 56 (86.1) | 9 (13.9) | 0.010 |
| **Sphenoid sinusitis (n=30)** | 20 (66.6) | 10 (33.3) | 0.051 |

**Table 5: Distribution of the various anatomical variations of the ostiomeatal complex among the study subjects (n=138).**

| Anatomical variations of the ostiomeatal complex | Frequency | Percentage (%) |
|---|---|---|
| **Deviated nasal septum** | 98 | 71 |
| **Aggernasi cell** | 86 | 62.3 |
| **Concha bullosa** | 79 | 57.2 |
| **Prominent bulla ethmoidalis** | 65 | 47.1 |
| **Paradoxical middle turbinate** | 63 | 45.6 |
| **Medialised uncinate process** | 36 | 26 |
| **Frontal cell** | 25 | 18.1 |
| **Onodi cell** | 12 | 8.6 |
| **Pneumatised uncinate process** | 8 | 5.7 |
| **Haller cell** | 6 | 4.3 |
| **Pneumatisation of septum** | 5 | 3.6 |

**Table 6: Association between sinusitis and the various anatomical variations of the ostiomeatal complex among the study subjects.**

| Anatomical variations of the ostiomeatal complex | Maxillary sinusitis (n=87) | Frontal sinusitis (n=72) | Anterior ethmoid sinusitis (n=76) | Posterior ethmoid sinusitis (n=65) | Sphenoidal sinusitis (n=30) |
|---|---|---|---|---|---|
| | N (%) | N (%) | N (%) | N (%) | N (%) |
| **Deviated nasal septum (n=98)** | 16 (18.3) | 20 (27.7) | 26 (34.2) | 35 (53.8) | 1 (3.3) |
| **Aggernasi cell (n=86)** | 19 (21.8) | 33 (45.8) | 24 (31.5) | 10 (15.3) | 0 |
| **Concha bullosa (n=79)** | 38 (43.6) | 3 (4.1) | 32 (42.1) | 5 (7.6) | 1(3.3) |
| **Prominent bulla ethmoidalis (n=65)** | 20 (22.9) | 16 (22.2) | 18 (23.6) | 12 (18.4) | 7 (23.3) |
| **Paradoxical middle turbinate (n=63)** | 10 (11.4) | 16 (22.2) | 19 (25) | 12 (18.4) | 6 (20) |
| **Medialised uncinate process (n=36)** | 8 (9.1) | 7 (9.7) | 10 (13.1) | 7 (10.7) | 4 (13.3) |
| **Frontal cell (n=25)** | 4 (4.5) | 6 (8.3) | 5 (6.5) | 6 (9.2) | 4 (13.3) |
| **Onodi cell (n=12)** | 0 | 1 (1.3) | 0 | 1 (1.5) | 10 (33.3) |
| **Pneumatised uncinate process (n=8)** | 1 (1.1) | 3 (4.1) | 1 (1.3) | 2 (3) | 1 (3.3) |
| **Haller cell (n=6)** | 0 | 2 (2.7) | 1 (1.3) | 3 (4.5) | 0 |
| **Pneumatisation of septum (n=5)** | 0 | 1 (1.3) | 1 (1.3) | 2 (3) | 1 (3.3) |
| **P value** | <0.001 | <0.001 | <0.001 | <0.01 | <0.05 |

## DISCUSSION

Although chronic sinusitis is a clinically diagnosable condition, imaging studies are essential for assessing the extent of the disease and planning for surgical treatment.[14] At present CT scan study especially using coronal plane due to its similarity with the surgical orientation, is the most preferred imaging investigation for this purpose.[15-17] CT provides a good perspective of sinonasal anatomy and pathology of both the bone and the soft tissue components, and thus is considered superior to plane radiography and nasal endoscopy.[18] Anatomic variations of paranasal sinus structures may predispose patients to recurrent rhinosinusitis and in selected cases, to headache. However, the relative importance of anatomic variations is still a matter of discussion and variable results have been reported. Hence, in this study CT coronal sections were chosen to study the anatomical variations. According to Mackay and Lund the ostiomeatal complex acts as a drainage

pathway for maxillary, anterior ethmoids and frontal sinuses.[19] Posterior ostiomeatal unit was considered as part of the sphenoid sinus. In several areas of the ostiomeatal complex overcrowding due to anatomical variation, two mucosal layers contact each other, thus increasing the likelihood of local impairment of mucociliary clearance. Secretions may then be retained at the site, creating the potential for infection even without ostial closure. Anatomically, the most likely areas of mucosal contact are in the narrow mucosa lined channels of the middle meatus and the ethmoidal infundibulum. The present study includes 138 patients diagnosed as chronic rhinosinusitis as per the criteria given by recent RSTF 2007, between the period January 2016 and September 2017. In the present study there were almost equal number of males (52%) and females (48%). Various studies have shown a female preponderance of sinusitis. Female preponderance was also reported by US National Center for health statistics.[20,21] It was reported that female dominance was due to hormonal changes that occurs during puberty, pregnancy, menstruation and sexual excitement due to vasomotor imbalance leading to frequent sinusitis in females, whereas studies conducted by Wani et al, Sheet et al and Gupta et al had shown male predominance in developing chronic rhinosinusitis.[22-24] The mean age of our study subjects was 32 years and this was in consensus with the study done by Gulgun et al, Baradaranfar et al and Parul Sachdeva1.[25-27] In our study maxillary sinuses (63%) are the commonest sinuses to be involved in our study, followed by Anterior ethmoid sinuses (55%), Frontal sinuses (52%), Posterior ethmoids (47%) and Sphenoid sinuses (22%) and the results of our study was almost in par with the study conducted by Fadda et al.[28] A study conducted by Maru et al had shown anterior ethmoid sinusitis was more common than the maxillary sinusitis and the incidence rate of sphenoidal sinusitis (41.8%) was found to be very high and similar studies conducted by Zinreich et al and Bolger et al had shown anterior ethmoidal sinusitis to be more common than maxillary sinusitis.[29-31]

In the present study we found the incidence of ostiomeatal unit block was 66% whereas the study reported by Earwaker it was only 51%.33 and the study done by Fadda et al it was 75% incidence of ostiomeatal unit block.[32,28] In our study the commonest anatomical variation found was deviated nasal septum (71%) and it was 55% in the study done by Maru et al (2011) and 60% was quoted by Fadda et al and studies had shown the incidence of DNS between 18–80%. and our study had further proven that Septal deviation (48%) was the commonest anatomical variant noted in patients with posterior ethmoid sinusitis and the association was found to be statistically significant ($p<0.001$), which has not been found reported in the literature.[28,29] In the present study the incidence of concha bullosa was 57%. Concha bullosa can obstruct the OMU and lead to sinusitis. In this study 66% of concha bullosa were found prevalent in cases with Maxillary sinusitis and 64% in Anterior ethmoidal sinusitis and the association was found to be statistically significant ($p<0.001$). Fadda et al, Ozcan et al and Lom et al also found significant relationship between concha bullosa and sinusitis.[28,33,34] Aggernasi is the another commonest anatomic variation noted in the present study and aggernasi cells were found common in cases of frontal sinusitis and may be the cause of frontal sinusitis due to obstruction of the frontal sinus drainage pathway. This is in consensus with the study done by Baradarnfar et al which show higher CT scores in sinus CT staging in patients with presence of AggerNasi.[26] In our study we found the incidence of onodi cell (8.7%) is one among the least common anatomic variation as the most commonest anatomic variation among the patients with sphenoidal sinusitis and the various studies done previously report incidence in the range of 2.5 - 24% but in our study we found a statistical significant association of onodi cell among sphenoidal sinusitis patients, but it is not possible to state that the Onodi cell is the single causative factor for the disease.[35,36]

## CONCLUSION

Anatomical variations were observed to be one of the predominant etiologies for OMU block as well as sinusitis. This study emphasizes on identification of specific anatomical variations of ostiomeatal complex and its importance when considering as an etiological factor for CRS. Hence, the importance of CT scan and nasal endoscopy is emphasized in patients with persistent symptoms to identify the anatomical variations that may contribute to the development of chronic sinus mucosal disease.

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