A CADAVERIC STUDY ON ANATOMICAL VARIATIONS OF THE OSTIOMEATAL COMPLEX
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ABSTRACT

BACKGROUND
Ostiomeatal complex is the final common pathway for the drainage of secretions from maxillary, frontal, anterior and middle ethmoidal air sinuses. Any obstruction at the ostiomeatal complex region can result in impedance to the free flow of secretions or even blockage of secretions in these anteriorly draining sinuses. Obstructions can be due to distortion of normal anatomy or some pathological processes. In case of a distorted anatomy, there is a high chance for the chronicity of sinus infections. Ostiomeatal complex is formed within the ethmoid bone. Ethmoid sinuses and air cells, due to their bizarre embryological development are notorious for anatomical variations at the level of ostiomeatal complex. Some of these variations are thought to be very significant in the persistence of sinus infections, especially when the size and degree of variation is more. A thorough knowledge of the anatomy of the lateral nasal wall and its variations would be of immense help for the endoscopic sinus surgeons to tackle the confusing situations that arise at the level of variation during surgery.

MATERIALS AND METHODS
The present study was done to evaluate the different anatomical variations of the ostiomeatal complex by cadaveric dissection. Fifty cadaveric specimens of the lateral nasal wall were taken and meticulous dissection was done to find out the anatomical variations of the ostiomeatal complex. The study was done over a period of two years from January 2015 to December 2016 in the Department of Anatomy, Government Medical College, Kottayam.

RESULTS
The result of the study was very much rewarding as majority of the specimens had variations of the ostiomeatal complex. It was also noted that an increase in the number of anatomical variations was associated with chronic sinusitis (as indirectly depicted by the presence of accessory maxillary ostia that arise following persistent blockage of the normal maxillary ostium).

CONCLUSION
The study showed a very close correlation between the number and size of the variations of the ostiomeatal complex and chronic sinusitis (as indicated by the presence of accessory maxillary ostia in the cadavers). Thus, an early surgical correction of these variations would help to prevent progression and complications of chronic sinusitis.

KEYWORDS
Ostiomeatal Complex, Sinusitis, Anatomical Variations.

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BACKGROUND
Ostiomeatal Complex (Ostiomeatal Unit, OMC) refers to the maxillary sinus ostium, ethmoid infundibulum, hiatus semilunaris and frontal recess (Figure 1 and 2). It is the final common pathway for the drainage of secretions from the maxillary, frontal, anterior and middle ethmoidal sinuses within the maxillary sinus ostium, ethmoid infundibulum, hiatus semilunaris and frontal recess (Figure 1 and 2). It is the final common pathway for the drainage of secretions from the maxillary, frontal, anterior and middle ethmoidal sinuses into the middle meatus and its obstruction plays a pivotal role in the development and persistence of sinusitis.¹

¹The mucociliary transport patterns of secretions within the paranasal sinuses and their drainage routes were studied, which showed that they followed very definite pathways. While these pathways could be impeded or even blocked by various pathologic conditions, their directions were not significantly altered.² These two major observations regarding the ostiomeatal complex and the mucociliary transport patterns of the paranasal sinuses led to the focus on precise understanding of the microanatomy and anatomical variations of the ostiomeatal complex. Further studies revealed that the ethmoid sinuses had a lot of anatomical variants, which could significantly alter or block the normal drainage of secretions from the paranasal sinuses.

Aims and Objectives
1. To evaluate the different anatomical variations of the ostiomeatal complex by cadaveric dissection.
2. To assess the percentage of each anatomical variant.
3. To assess the size of each pneumatised variant (as far as possible).

**Dissected Specimen of Lateral Nasal Wall with Middle Turbinate Reflected**

**Figure 1. Showing a Dissected Specimen of the Lateral Nasal Wall with the Middle Turbinate Reflected**

**Dissected Specimen showing the Ostiomeatal Complex**

**Figure 2. Shows a Progressive Dissection of the same Specimen in Figure 1 revealing the Ostiomeatal Complex**

**Figure 3. Shows a Specimen of the Lateral Wall of Nose with a Concha Bullosa (Pneumatised Middle Nasal Concha/Turbinate)**

**MATERIALS AND METHODS**

The contents of the nasal cavity were exposed by a mid-sagittal section through the head. The soft tissues and bony fragments along with the nasal septal cartilage removed after the hemisection. The superior, middle and inferior nasal conchae, which are located within the nasal cavity proper are identified. Superior meatus, the space between the superior and middle conchae is identified. Middle concha is checked for any paradoxical curvature (convexity of nasal concha towards the lateral nasal wall instead of the normal concavity). Middle concha is sagitally sectioned to look for any pneumatisation (Concha Bullosa, seen in Figure 3). Inferior to this lies the middle meatus, the space between the middle and inferior conchae. Finally, the inferior conchae and the inferior meatus is also identified.

With the help of a forceps, the middle concha is lifted upwards and the ethmoidal bulla is identified; the opening of the ethmoidal infundibulum into the semilunar hiatus is noted. The middle concha is cut away from its junction with the lateral wall of the nasal cavity and the middle meatus is completely exposed. Uncinate process, ethmoid bulla and the region of agger nasi are checked for any variation like prominent agger nasi cell (Figure 4). The ethmoidal bulla is formed by the bulging of ethmoidal air cells into the middle meatus. The ethmoidal bulla is notorious for variations in its dimensions. The ethmoidal bulla can be oversized from the hypertrophy of the ethmoidal air cells (for all practical purposes, an oversized ethmoid bulla is one that obstructs the hiatus semilunaris). The natural ostium of the maxillary sinus is noted (it is oval in shape and a bit inclined). The area of the middle meatus is inspected if there are accessory openings for the maxillary sinus (accessory maxillary ostia are seen either anterior to or posterior to the natural ostium depending on nasal membrane which was breached), as in Figure 5 and 6. Then the medial wall of the maxillary sinus is widened upwards to look for any bulge in the roof of the maxillary sinus near the ostium (Haller cell).
Inclusion Criteria

Twenty five cadavers (fifty specimens of the lateral nasal wall) were used for the study. Variations of the middle turbinate, uncinated process, ethmoid sinus, maxillary ostium and the frontal recess were studied. These structures were carefully dissected and photographs of the variations were taken and the results were tabulated. The pneumatised areas of bones were dissected and measured with a standard scale to know their dimensions.

Exclusion Criteria

Specimens of lateral nasal wall with facial trauma were excluded. Cadavers showing evidences of previous nasal surgeries were also excluded.

RESULTS

Out of the total 50 specimens studied 16 specimens had no variations of the OMC, 25 specimens had one anatomical variant (50%) and 9 specimens had two anatomical variants (18%).
The accessory maxillary ostium was seen in 15 specimens, out of which 9 were seen in specimens having one variation of the ostiomeatal complex (36%) and 6 were seen in specimens having two variations of the ostiomeatal complex (66.67%).

Accessory maxillary ostium were seen in 15 specimens in total, out of which 4 were in the anterior fontanelle and 11 were in the posterior fontanelle.

As the dimension of the Concha Bullosa increases, the chance for obstruction at OMC increases and subsequent presence of accessory ostia increases. When the size of Concha Bullosa was around 1 cm or more, there invariably was an accessory ostium.

**Table 1. Showing Anatomical Variants of OMC with Number of Specimens and Percentage**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Anatomical Variants of OMC found During the Study</th>
<th>Number of Specimens in which Each Variant was Seen</th>
<th>Percentage of Specimens with Each Variant (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concha Bullosa</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>Paradoxical Middle Turbinate</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Prominent Agger Nasi Cell</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Large Ethmoid Bulla</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Medially Bent Uncinate Process</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Pneumatised Uncinate Process</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Haller Cell</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Table 2. Showing Specimens with Accessory Maxillary Ostium and the Percentage**

<table>
<thead>
<tr>
<th>Specimens with Accessory Maxillary Ostium</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimens with one variant of the ostiomeatal complex</td>
<td>36</td>
</tr>
<tr>
<td>Specimens with two variants of the ostiomeatal complex</td>
<td>66.67</td>
</tr>
</tbody>
</table>

**Table 3. Showing Association of Specimens having Two Variants of the Osteimal Complex with Accessory Maxillary Ostia**

**Table 4. Number of Specimens and its Percentage showing Accessory Maxillary Ostium in Anterior and Posterior Fontanelle**

**Table 5. Showing the Association between the Size of Concha Bullosa and Presence of Accessory Ostium**

**Observation**

Out of the 50 specimens of the lateral nasal wall studied, the following findings were seen:

- 25 specimens had at least one variation of the ostiomeatal complex.
disorders and also associated with accessory osteal ostia.

The presence of accessory maxillary ostia were studied in detail, which yielded the following results:

- Accessory ostia were seen in 15 specimens (out of 50).
- Among the 9 specimens with two OMC variations, 6 specimens (66.67%) had accessory ostia.
- Posterior nasal membrane/fontanelle was breached more than the anterior one.

These findings indirectly indicate that as the number of anatomical variations at the level of the ostiomeatal complex increases, the chance for obstruction at the OMC region increases resulting in the chronicity of sinus diseases and formation of accessory sinus ostia.

- Accessory ostia were seen mainly in the posterior nasal fontanelle (73.33%).
- Whenever Haller cell and pneumatised uncinate process were present, accessory ostia were also seen. 75% of Concha Bullosa were also associated with accessory ostium.
- As the size of Concha Bullosa increases, the chance for accessory ostium also increases. In other words, as the size of concha bullosa increased, the level of obstruction at the level of ostiomeatal complex also increased.

DISCUSSION

In 1950s and the early 1960s, Messerklinger described the normal and abnormal mucociliary transport patterns of secretions in the paranasal sinuses. His landmark study is considered as a revolution in the field of paranasal sinus surgery. He used nasal endoscope and sinuscope and his observation was that the secretions of the various paranasal sinuses did not reach their respective ostia by random routes, but followed very definite pathways which seemed to be genetically determined. While these pathways may be blocked or even blocked by various pathologic conditions, their direction is not significantly altered.

In 1965, Naumann coined the term “Ostiomeatal Complex” for the final common pathway for the drainage of secretions from the maxillary, frontal and anterior ethmoid sinuses.

In 1971, Hamilton and Mossman H. W described embryology of the lateral nasal wall and the paranasal sinuses.

In 1988, a study on the different anatomical variations of the ostiomeatal complex on CT scans came out with the percentage prevalence of each variant. Concha Bullosa was the highest recorded variant with (24%), bent uncinate process (21%), paradoxical middle turbinate (15%), over-pneumatised bulla (18%), agger nasi cells (15%) and Haller cells (13%).

In 1991, Bolger et al suggested that the different anatomical variations of the ostiomeatal complex may be the underlying causes for recurrent sinus disease.

Another study in 1991 commended that the incidence with which the anatomical variations were seen in a ‘normal’ population might appear to be less frequent than in those individuals with chronic sinusitis, but on closer inspection it was clear that it was the narrowing of the ostiomeatal complex rather than the existence of the variant which was the important factor. This study gave an insight about the importance of the size of the different anatomical variations and their propensity to cause narrowing of the ostiomeatal complex.

Depending on the patterns of embryological migration of ethmoid air cells into different areas, different types of pneumatisation occurs. The main types of pneumatisations are the following-

- a) Lacrimal Bone - Agger Nasi Cell; b) Inferior to orbit-Haller's Cell; c) Middle Nasal Concha - Concha Bullosa; d) Frontal Bone - Frontal cells, e) Above sphenoid - Onodi Cell.

Concha Bullosa

A pneumatised and ballooned up middle nasal concha is called concha bullosa. It may be bilateral (usually) and may have septations within it. Zuckermandl coined the term ‘Concha Bullosa’ in 1893 to refer to the “distension of the vertical concha by an air cell.”

Paradoxically Curved Middle Turbinate

In 1978, Messerklinger et al suggested that paradoxical middle turbinate is a rare occurrence.

Another study reported a prevalence of 7.9%. In this series, middle turbinates had a paradoxical curvature (concavity of the middle nasal concha points towards the septum and convexity towards the lateral nasal wall) in 203 cases (25%) and large paradoxical middle turbinates were present in 109 cases (15%).

Uncinate Process

A “doubled middle turbinate” which was in fact a medially bent uncinate process protruding out of the middle meatus was described. The superior aspect of the uncinate tip may deviate laterally, medially or anteriorly out of the middle meatus, appearing as a second middle turbinate bone.

Ethmoid Bulla

In 1893, E. Zuckermandl coined the term “torus lateralis” (meaning lateral bulge) for the solid non-pneumatized hillock of the anterior ethmoid. H. Stammberger and G. Wolf (1988) reported that an enlarged ethmoidal bulla may
contribute to sinus disease by obstructing the infundibulum or middle meatus.11

Haller Cells
As described by Albert Von Haller in 1765, these cells grow into the bony orbital floor that constitutes the roof of the maxillary sinus, are differentiable from the bulla and have a potential pathophysiologic relationship to a narrowed ethmoid infundibulum or maxillary sinus ostium.2 Kennedy and Zinreich (1988) described Haller cells as ethmoidal air cells that project inferiorly to the ethmoidal bulla into the floor of the orbit in the region of the maxillary sinus ostium. They reported its prevalence as 10% of the population.12

Agger Nasi Cells
In 1973, Ritter described agger nasi cells as those cells that lie below the frontal sinus, inferolateral to the lacrimal sac and represent pneumatisation of the lacrimal bone by extension of the anterior ethmoidal cells.13 In 1988, Stammberger and Wolf endorsed that these cells are located anterior and superior to the insertion of middle turbinate bone along the lateral nasal wall.11 In anatomic dissection, the prevalence of the agger nasi cell varies from 10% (Schaefer, Manning, Close in 1989).14

Nasal Fontanelles and Accessory Maxillary Ostia
In the bony skeleton, there are always defects between the uncinate process and the inferior turbinate that are covered with a dense connective tissue, which is a continuation of the peristium and the mucous membranes. In the bony skeleton, these defects lead into the maxillary sinus. These are the structures that Zuckerkandl called the anterior and posterior fontanelles. Since these fontanelles do not have a bony base, this part of the lateral nasal wall is known as its membranous area. In cases of chronic obstruction at the level of the ostiomeatal complex, these membranous areas rupture resulting in anterior or posterior maxillary ostia.15

In 1993, Anatomic Terminology Group met at the International Conference in USA and recommended in its report, the preferred modern nomenclature for the structures in the lateral nasal wall and its variants.16

CONCLUSION
Anatomical variations of the ostiomeatal complex are very common. As the number of variants increase, the chance for persistence or worsening of the obstruction rises and subsequent chronicity of sinus infections increases. More the size of the variant, greater is the chance for the OMC block. As the OMC block worsens, there is increased chance for the formation of the accessory maxillary ostia and that too mainly in the posterior fontanelle. Hence, a timely surgical intervention at the level of the ostiomeatal complex would significantly improve the otherwise complicated course of chronic sinusitis.

REFERENCES