ETHMOIDAL ANATOMIC VARIATIONS. CLINICORADIOLOGICAL STUDY.

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ABSTRACT

Although the ethmoid is the most addressed bone in nasal endoscopic procedures, few studies have been conducted documenting its anatomic variations. Most of the time, surgeons perform a large anterior ethmoidectomy, a procedure so extensive that does not allow a detailed view of its anatomy. Using minimally invasive surgical techniques and image-guided surgery, we have found anatomic variations of the ethmoid sinus that, if proven to have a functional implication in nasal physiology, may change the actual rationale for functional endoscopic sinus surgery of the ethmoid.
INTRODUCTION

By the sixth week of gestation, the nasal groove became deeper, creating the nasal cavity, which lateral walls are plain (primitive lateral nasal wall). When development continues from the lateral nasal wall became two prominence, one called “maxilloturbinal” from which rises the inferior turbinate, and a second called “ethmoidoturbinal” that divides in ethmoidal cells, unciform process and middle, superior and supreme turbinates (structures that composes the middle meatus and part of the superior).

At birth, the ethmoid cells that are well developed are the anterior ones. Until the age of 12 all cells became pneumatized and the bone has expanded totally.

The ethmoid cells varies in their shape and organization, that can be frontal, maxillar (Haller), sphenoidal (Onodi) and also turbinal (concha bullosa). This variations make the ethmoid to be considered as a labyrinth, without anatomic constants for many authors.

The most posterior insertion of the middle turbinate to the lateral nasal wall is called basal lamella, this anatomic reference divides the anterior and posterior ethmoid cells. In a traditional way is considered that the anterior ethmoid cells (Agger nasi, ethmoid bulla) drains it’s contents into the infundibulum in the middle meatus, while the posteior ethmoid cells drain trough the superior meatus, near the sphenoid sinus. Usually there is a space between the ethmoid bulla and the basal lamella, named retrobullar recess, that drains it’s contents trough the hiatus semilunaris superioris, that’s the name that receives the space between the ethmoid bulla and the middle turbinate.

Some author confirm that the “bulla” is not a correct anatomical name, because this cell does not have a posterior wall of it’s own, but is limited in this plane by the basal lamella.

All paranasal sinuses are covered with an epithelium pseudostratified ciliated and caliciform cells. The no ciliated cells have a surface like a brush that increases the total surface of the epithelium and this ciliated cells increases it’s number as they approach to drainage sites of the sinuses. Because the ciliated cells move at the same time, there is a mucous pattern flow at rates near 9mm per minute against gravity. This flow pattern is because of the development of the sinuses is inferior and lateral, always leaving a medial and superior ostium,
where the secretions are transported to drain through the nasal cavity.

Traditionally ethmoid surgery has been extensive, with wide resections of their cells that never let a real documentation of their anatomic variations. But now, the more conservative endonasal surgery and the more frequent guided image assisted surgery has lead us to find some anatomic variations that has not been described previously with some functional implications, that could change the traditional concepts of the functional ethmoid surgery.

These findings took us to a study for the documentation of that ethmoidal variations.
MATERIAL AND METHODS.

From March of 2000 through June of 2001, to all patients going through a functional endoscopic sinus surgery of minimum invasion in our center, we perform a presurgical nasal tomography with axial slides of 1 mm thickness and separated by 3 mm. Every study was evaluated for 3 expert surgeons in a separated manner, documenting the ethmoid variations and its integrity. The same study was used for image guided surgery system (Landmarx, Jacksonville Fl).

The first 100 patients to have the inclusion criteria were admitted in the study. The inclusion criteria were more than 14 years of age, and ethmoid bone clearly seen in the tomographic study, no history of nasal trauma and no previous nasal surgical procedures.

During surgery, previous infiltration of the region, the lateral wall of the middle turbinate was remodeled, exposing the middle meatus and the unciform process was medialized and resected totally. Exteriorizing the infundibulum and exposing the whole ethmoid bulla, and the first register of the findings was made.

Lately the lateral wall of the ethmoid bulla was resected from the most inferior aspect and the findings were connoted. Finally the posterior ethmoid was explored, making a resection of the basal lamella whenever was necessary.

The dissection was made very carefully, using an endoscope of 30° and 4 mm, a microdebrider with an angled shaver (40°) (XPS, blade Rad 40, Xomed, Jacksonville, Fl). The surgeries were observed by three surgeons at the same time, and each one made its connotations. All surgery was image guided and the anatomy was corroborated. The findings were registered and compared at the end of the study.
RESULTS

From the 100 patients included in the study, 200 ethmoid bones were analyzed. There were 49 female and 51 male, with ages between 15 and 64 years. The correlation between findings were more than 98% of all observers.

In the dissection, at the moment of the uncinectomy and exposing totally the anterior ethmoid, medial and inferior surface of the ethmoid bulla, it was found an anterior orifice that communicates the bullar space through the infundibulum in 32 ethmoid bones (16% cases) (Figure 1).

Once exteriorized the bullar space, orifices were searched that communicated this one with the retrobullar space and hiatus semilunaris superioris, distinguishing 2 variations. The most frequent, an orifice in the posterior and medial plane 81.5% of the cases (n=163), and the other posterior and superior in 2.5% of patients (n=5) (Figure 2, 3). In some cases there were more than one anatomical variation. (Figure 4).

The analysis of the posterior ethmoid reveal very interesting data. The most of the patients have an orifice that communicates the most posterior and medial wall of the ethmoid trough the superior meatus 71.5% (n=143), while the 28.5% (n=57) could be explored by the simple dissection of the ethmoid bulla trough a natural fenestration of the basal lamella. (Figure 5, 6) Near the 13% of patients show combinations of this variations. (Figure 7).
DISCUSSION

This findings change the actual anatomical concept of the ethmoid bulla and posterior, and suggest that the traditional concepts of the anatomy of the ethmoid are wrong. If there is a demonstration that this anatomical variation have functional implications, the concepts of ethmoid surgery change totally. We need additional studies to: 1) Show the frequency of this variations in other populations, 2) to determine if this anatomical variations have functional implications, and 3) show if this variation affect the normal nasal physiology and mucociliar transport.

Setliff has been the pioneer and principal promoter of a conservative dissection of the nasal cavities. He has documented, with a great casuistic, the benefits of a conservative approach in a long follow up and has shown that the simple ventilation of the natural ostium of each sinus (using maxillary for example) is enough to improve the state of the cavity and return to the normal mucociliar function. We believe that this approach would be the surgical standard for the treatment of recurrent sinonasal disease in the future, because it has demostrated to be the most beneficial technique for patients.

This findings were shown initially in the Wesr course of Rhinology in USA, march 2001. Also Setliff, just documented a paper recently published in which he shows his findings in ethmoid surgery, with variation very close to the ones exposed in this article, giving more credibility to our affirmations.
CONCLUSION

We have bases to believe that in the cases in which the posterior ethmoid drains anterioposteriorly trough the basal lamella, the secretions passes into the middle meatus. Since the initial descriptions of Hilding we know that the mucociliar movement pattern depend on the pneumatization of each paranasal sinus, been from anterior to posterior in the ethmoid; this findings make us think, that when there is a fenestration in the basal lamella that comunicates both ethmoids, the secretions gone through the ethmoid infundibulum instead of the superior meatus as always said. We are supporting this findings by another study of the mucociliar drainage pattern in the ethmoids, that will be published in other paper.

The clinical applications of this study is to understand that the drainage of the ethmoid has variabilities, that the posterior ethmoid in 70% of the cases drains through the superior meatus as we known since the first studies, but in 30% of the cases it drains through the anterior ethmoid, so when a diseased anterior ethmoid exists, it will affect in 30% of the cases the posterior ethmoidm not any more been the posterior ethmoid visualized as an independent diseased, because that’s true in 70% of the cases.
Figure 1. Anterior drainage of the bulla ethmoidalis.
Figure 2. Posterio-medial drainage of anterior ethmoid.
Figure 3. Superoposterior drainage of the anterior ethmoid.
Figure 4. Compound drainage of anterior ethmoid.
Figure 5. Posterior ethmoid. Medial orifice of drainage.
Figure 6. Posterior ethmoid. Anterior orifice of drainage.
Figure 7. Posterior ethmoid. Combined drainage.
BIBLIOGRAPHY


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Table 1. Different Drainage sites of the Bulla Ethmoidalis

<table>
<thead>
<tr>
<th>Type of Drainage</th>
<th>Number of Nostrils</th>
<th>%</th>
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<tbody>
<tr>
<td>Anterior</td>
<td>32</td>
<td>16</td>
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<tr>
<td>Posterior-medial</td>
<td>163</td>
<td>81.5</td>
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<tr>
<td>Posterior-Superior</td>
<td>5</td>
<td>2.5</td>
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<td>Total (n= 100 patients)</td>
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<td>100</td>
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Table 2. Different types of Drainage of the Posterior Ethmoid

<table>
<thead>
<tr>
<th>Type of Drainage</th>
<th>Number of Nostrils</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>57</td>
<td>28.5</td>
</tr>
<tr>
<td>Medial</td>
<td>143</td>
<td>71.5</td>
</tr>
<tr>
<td>Total (n=100 patients)</td>
<td>200</td>
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</tr>
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</table>
Figure 1. Anterior drainage of the Bulla ethmoidalis. Arrow indicates site of drainage.

A. Endoscopic view.
B. CT image of the drainage.

Figure 2.- Posterior-medial drainage of Anterior ethmoid.

A. Arrows indicates orifice of drainage.
B. Seeeker through the orifice of drainage showing the passage.

Figure 3.- Supero-posterior drainage of the anterior ethmoid.

Axial CT scan at ethmoid level, arrow shows the orifice of drainage.

Figure 4.- Compound drainage of Anterior ethmoid.

A. Endoscopic view during surgery showing both orifices of drainage by the arrows.
B. Axial CT scan at ethmoid level. Arrows shows both orifices of drainage.

Figure 5.- Posterior ethmoid. Medial orifice of drainage. Axial CT scan at ethmoid cells level.

The arrow shows the orifice of drainage.

Figure 6.- Posterior ethmoid. Anterior orifice of drainage.

Endoscopic view during surgery, arrow shows the pattern of drainage through the orifice.

Figure 7.- Posterior Ethmoid. Combined drainage.

Endoscopic view after anterior ethmoidectomy. Arrows shows the sites of drainage.

Table 1.- Different drainage sites of the Bulla Ethmoidalis.

Table 2.- Different types of drainage of the Posterior Ethmoid.