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Radiological anatomy of frontal sinus

By drtbalu

Anatomy of frontal sinus is highly variable. Precise understanding of these variables will help a surgeon to avoid unnecessary complications during frontal sinus surgery. This e-book tries in a nutshell to discuss the possible variations associated with this area.

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Radiological anatomy of frontal sinus

By

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Introduction: Frontal sinus is a complex and highly variable structure. These anatomic variations have a tremendous impact on the direction of drainage, efficiency of mucociliary clearance mechanism and frontal recess morphology. CT scans of frontal sinus have conventionally been performed with continuous 3mm coronal and axial slices. High resolution multiplanar scanners have made sagittal reformatted images a possibility. These scanners enable imaging in three planes.

Embryology: Sinonasal embryology plays an important role in the anatomical variations seen in various patients. Paranasal sinuses begin their development during the first trimester from the six ethmoturbinals. These turbinals enlarge and progressively coalesce to form the lateral nasal wall. The agger nasi cell develops from the most superior remnant of the first ethmoturbinal. The remnant from the descending portion of first ethmoturbinal forms the uncinat process. Basal lamella of the second ethmoturbinal pneumatizes to form Bulla ethmoidalis. The basal lamella of third ethmoturbinal forms the basal lamella of the middle turbinate. Nasal mucosa invaginates at specific points into the lateral nasal wall forming sinus pits. These sinus pits enlarge to form the maxillary, frontal and ethmoidal sinuses. The mesenchyme around these sinus pits resorbs allowing for enlargement of sinus cavities. The point of mucosal invagination gives rise to the sinus ostium. Frontal sinus drainage pathway is complex because of the variable anatomy of agger nasi, anterior ethmoidal cells, and pattern of insertion of uncinat process.

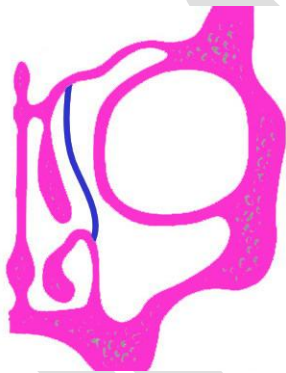
Frontal sinus drainage pathway: The frontal sinus grows and expands into the diploic space of frontal bone from the frontal sinus ostium. Each frontal sinus grows independently of the other. Their growth or lack of it is dependent on the ventilation, drainage and growth of surrounding sinuses and skull base.

The frontal sinus narrows inferomedially into a funnel shaped area known as frontal sinus ostium. Anterior wall of this area is bounded by a bony ridge known as “nasal beak”. The frontal sinus ostium is oriented perpendicular to the posterior wall of the sinus at the level of anterior skull base.

Some authors divide frontal sinus drainage pathway into superior and inferior compartments. The superior compartment is formed by the union of adjacent air spaces at the antero inferior portion of the ethmoid bone. Its size and shape varies with the variable anatomy of fronto ethmoidal air cells. The superior compartment

communicates directly with the inferior compartment. The inferior compartment is a narrow passage way formed by the ethmoidal infundibulum or the middle meatus. If the uncinat process gets attached to the skull base the inferior portion is formed by the ethmoidal infundibulum. On the contrary if the uncinat process gets attached to the lamina papyracea the inferior compartment is formed by the middle meatus.

Frontal recess area: Is anatomically defined as the most anterior and superior part of anterior ethmoidal complex. This is precisely where from the frontal bone gets pneumatized. In the sagittal plane the frontal recess appears like an inverted funnel. It opens superiorly into the frontal sinus ostium. The lateral wall of frontal recess area is formed by lamina papyracea. Its medial wall is formed by the vertical attachment of middle turbinate. Its posterior wall is highly variable, and is formed by the bulla ethmoidalis if it reaches up to the level of skull base. A large bulla could cause narrowing of this critical area obstructing frontal sinus drainage channel. Any imaging modality should critically examine this area where pathology could lurk. The agger nasi cells and the uncinat process play a role in the formation of the floor of this area.



If the uncinat process is attached to skull base as shown in the figure above the frontal recess drains into the superior end of ethmoidal infundibulum.



If the uncinete process gets attached to the superior-anterior portion of the middle turbinate as shown in the figure above the frontal recess drains into the superior end of ethmoidal infundibulum.

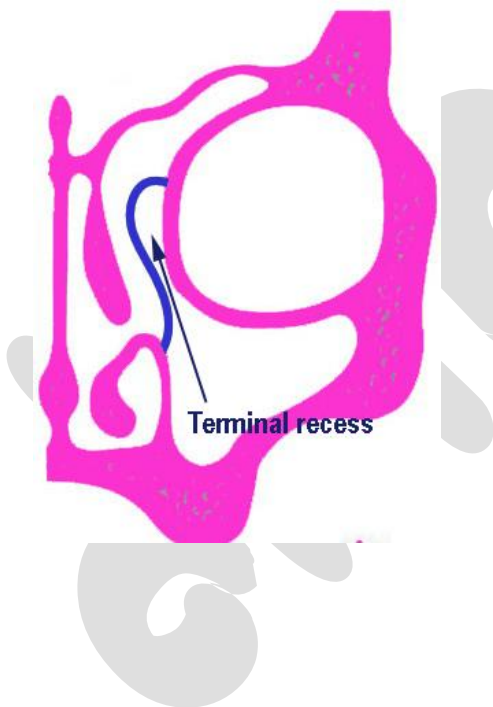


Figure showing terminal recess

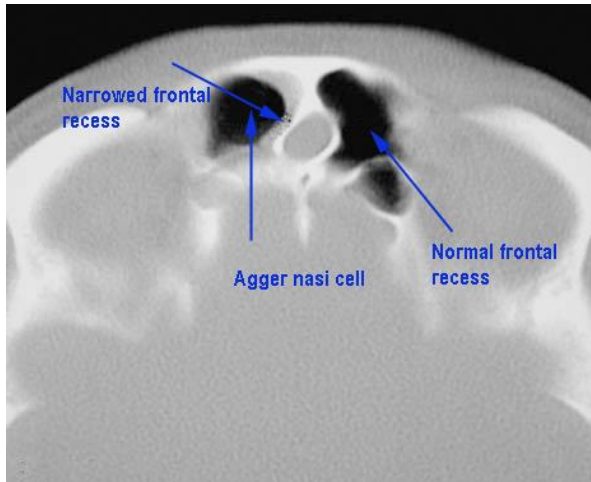
If the uncinete process gets attached to lamina papyracea the frontal recess opens directly into the superior aspect of middle meatus. The ethmoidal infundibulum ends directly into a terminal recess.

Ethmoidal infundibulum: This is a three dimensional space bounded by:

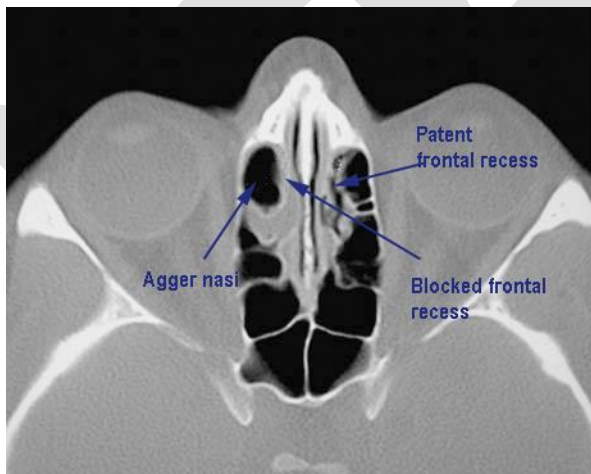
- 1. Laterally – By lamina papyracea**

2. Anteromedially – By uncinate process
3. Posteriorly – By Bulla ethmoidalis

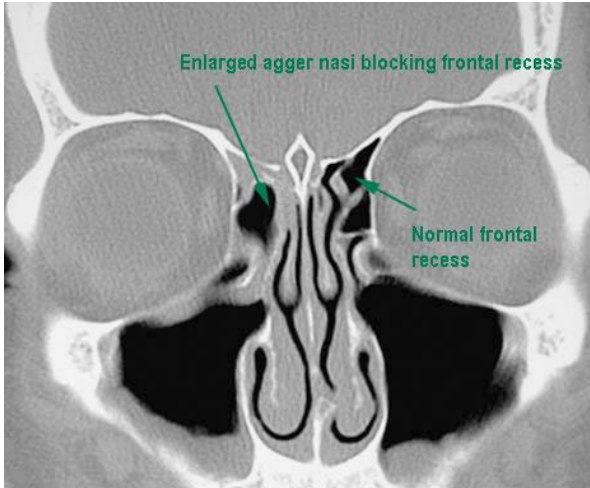
Frontal sinus drainage can occur via ethmoidal infundibulum if the uncinate process doesn't get attached to the lamina papyracea.



Axial CT showing large agger nasi cell narrowing the frontal recess area obstructing frontal drainage tract



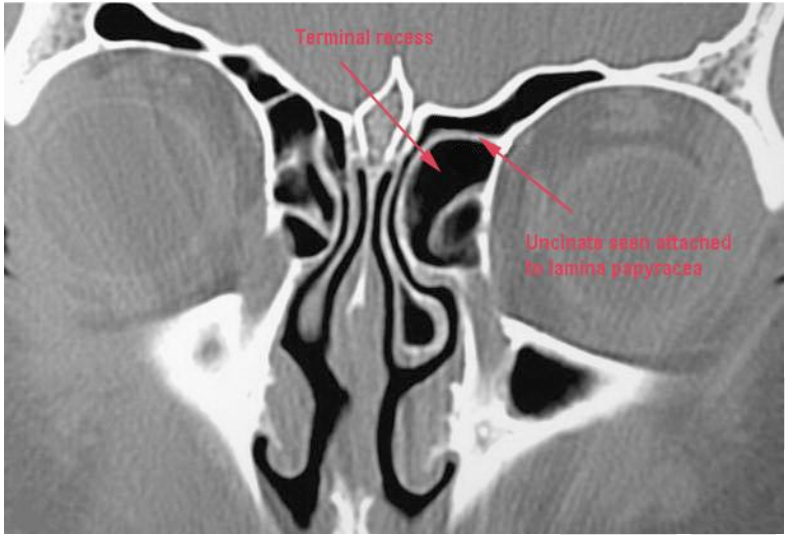
Next axial cut showing enlarged agger nasi cell obstructing the frontal recess area



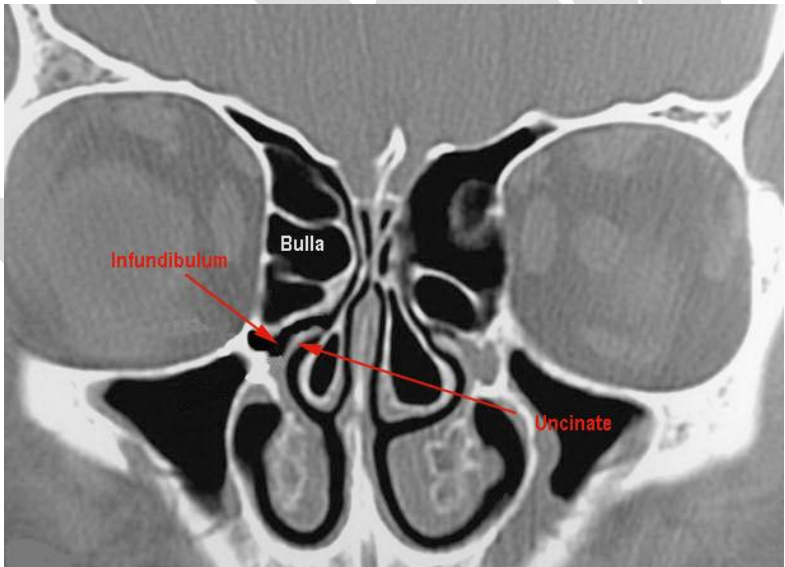
Coronal CT showing enlarged agger nasi blocking frontal outflow tract



Coronal CT showing uncinete process attached to skull base. The frontal recess is seen between the agger nasi and uncinete process



Coronal CT scan showing uncinete process being attached to lamina papyracea. This causes terminal recess to form. Frontal sinus drains directly into middle meatus as shown in this figure



This coronal CT scan shows the uncinete process being attached to the middle turbinate. Note the presence of infundibulum between the bulla and the uncinete process. Frontal sinus is seen opening into the infundibulum. Note also the fairly deep olfactory fossa.

Anatomic variants of frontal sinuses:

Detailed understanding of variations seen in the anatomy of frontal sinus will help the surgeon to avoid unnecessary complications during surgical procedures involving the frontal sinus and skull base.

Frontal cells: These are rare anatomic variants that involve ethmoidal pneumatization that impinge on the frontal recess area. These cells may also extend to involve the lumen of frontal ostium. According to Bent there are four types of frontal cells.

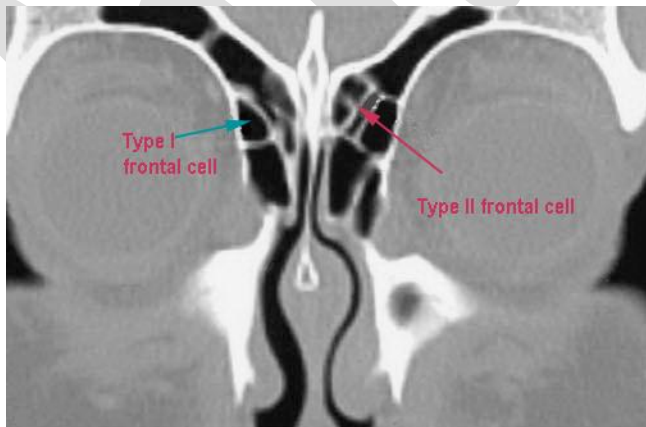
Bent's classification of frontal cells:

Type I frontal cells: This is a single frontal recess cell above the agger nasi.

Type II frontal cells: This is a tier of cells above agger nasi, projecting within the frontal recess

Type III frontal cell: This is a single and massive cell arising above the agger nasi. The pneumatization occurs in a cephalad direction in to the frontal sinus.

Type IV frontal cell: This is a single isolated cell within the frontal sinus. This cell is sometimes difficult to visualize due to its very thin walls.



Coronal CT scan showing type I and type II frontal cells



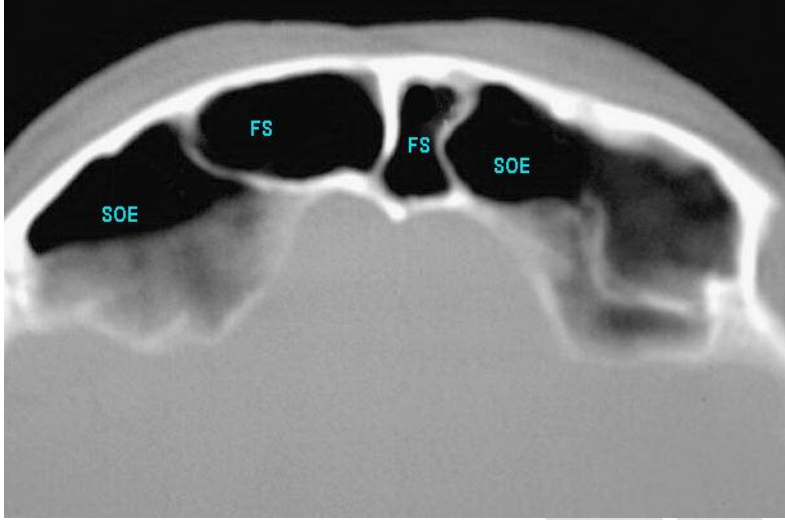
Coronal CT showing Type III frontal cell



Coronal CT showing type IV frontal cell

Supraorbital ethmoidal air cell:

These cells are caused by pneumatization of orbital plate of frontal bone posterior to the frontal recess and lateral to the frontal sinus. Sometimes these supraorbital air cells can reach up to the anterior margin of the orbital plate mimicking a frontal sinus.



Axial CT showing supraorbital cell