Rhinology: Sinus Anatomy and Embryology

Jeffrey Suh, M.D
UCLA Head and Neck Surgery
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References

- Stammberger, Functional Endsocopic Sinus Surgery, 1991.
- Valvassori's Imaging of the Head and Neck. 2nd edition.
- Kennedy, "Anatomy of the paranasal sinuses," Diseases of the Sinuses, 2001

"The anterior cranial fossa is amazing in its complexity, design… almost dream-like in its perfection. It is the most fascinating part of the skull base and probably the entire body by far."

Sarah Mowry, MD

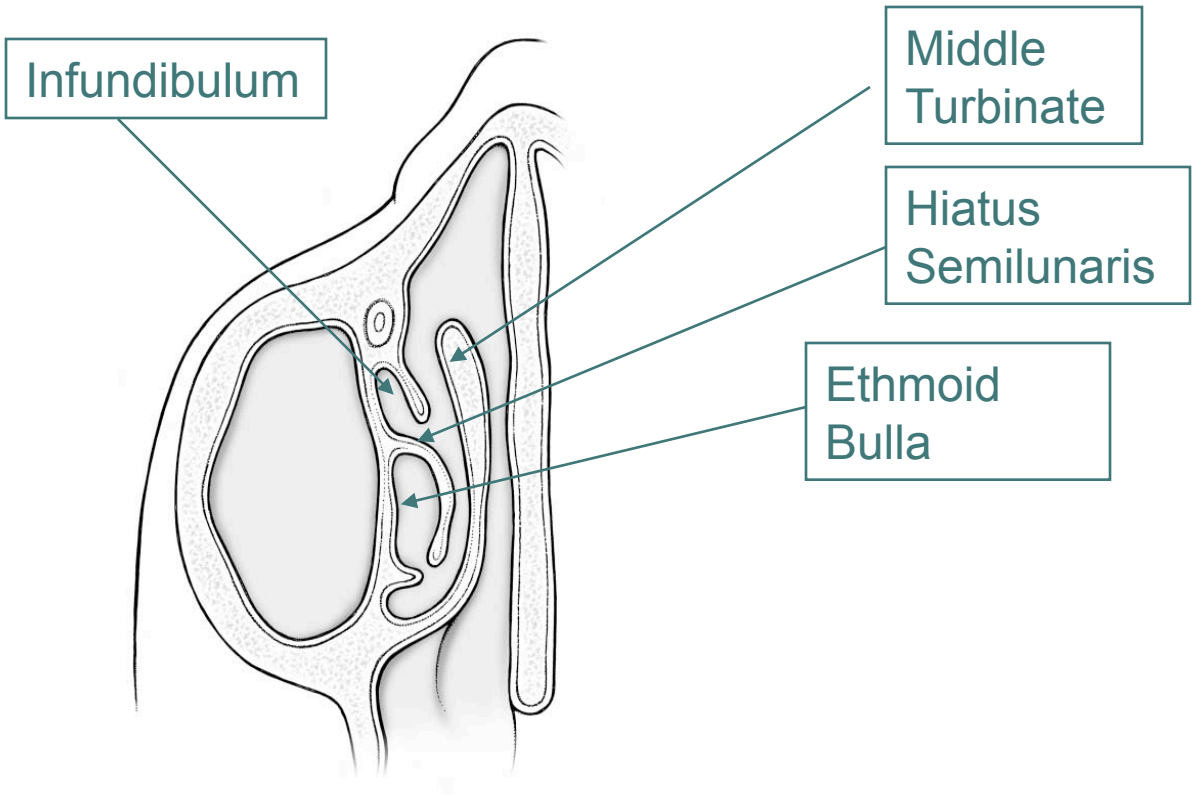
Goals

- Review sinonasal anatomy
- Emphasize relevant principles to help you with the inservice exam
- Discuss Embryology (briefly)

Part 1:
Anatomy Review

Sinus Anatomy

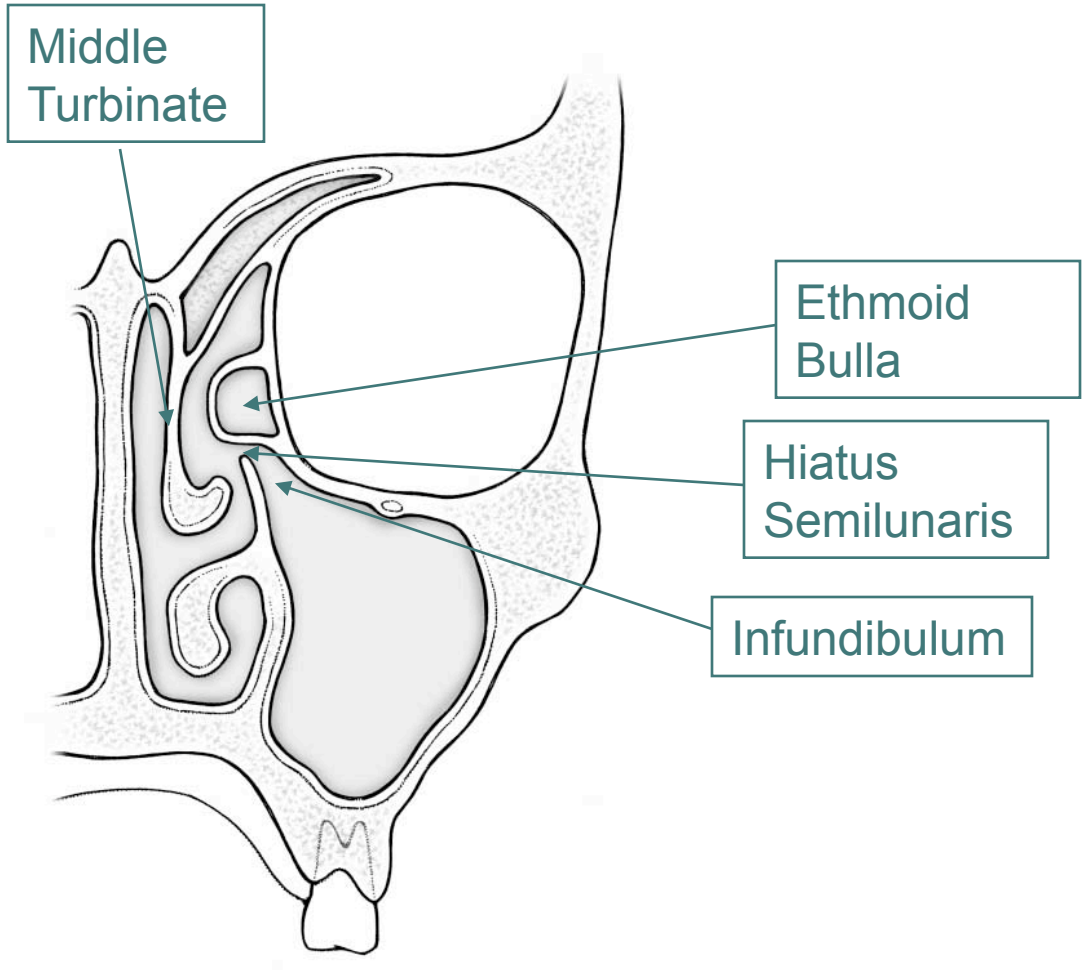
- Infundibulum
- Hiatus Semilunaris
- Ethmoid Bulla
- Nasolacrimal Duct



Axial View:

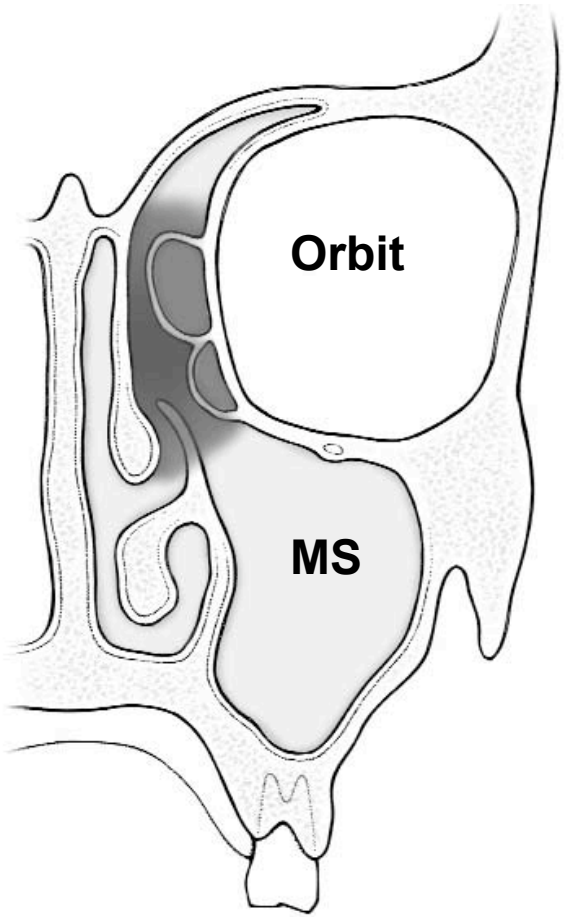
Sinus Anatomy

Coronal View:



Ostiomeatal Complex

- Functional concept, not anatomic structure
- No rigid boundaries
- Middle meatus drainage area for the maxillary sinus, anterior ethmoid, and frontal sinus



Part 2:
Ethmoid Development

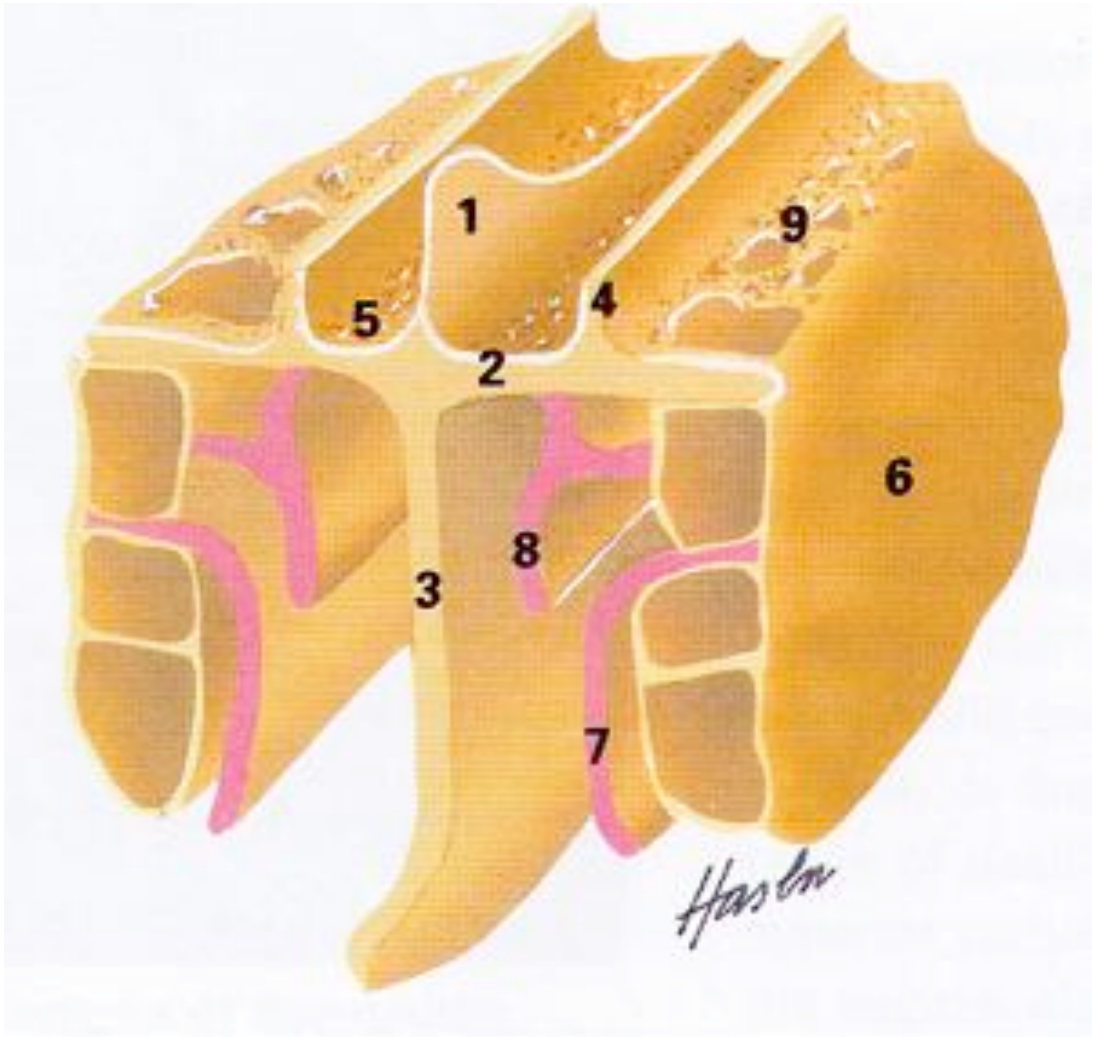
Ethmoid Bone

- “The labyrinth”
- In reference to Ethmoidectomy:

> “Theoretically, the operation is easy. In practice, however, it has proven to be one of the easiest operations in which to kill a patient.”

Mosher HP. The surgical anatomy of the ethmoid labyrinth, Ann Otol, 38:869-901, 1929

1) Crista Galli
2) Cribiform (lamina cribosa)
3) Nasal Septum
4) Cribiform (lateral lamella)
5) Olfactory Fossa
6) Lamina Papyracea
9) Fovea Ethmoidalis



Ethmoid Concepts

- Ethmoturbinals
  - Embryology
- Ethmoid Lamellae
  - Bony partitions with attachments to the lateral sinus wall
  - Surgical landmarks

Ethmoturbinals

- Classic anatomic studies attribute paranasal sinus development to lateral wall ridges called ethmoturbinals in the 9th to 10th week
- These are medial extensions from the lateral wall of the nasal capsule
- 5-6 ridges appear during the eight week of development, and through regression and fusion only 3-4 persist

Kennedy DW et al. Anatomy of the Paranasal Sinuses. In Diseases of the Sinuses. 1st Edition, 2001

Ethmoturbinals

- First ethmoturbinal regresses during development
  - Ascending portion forms the agger nasi
  - Descending portion forms the lateral extension of the uncinate process

Kennedy DW et al. Anatomy of the Paranasal Sinuses. In Diseases of the Sinuses. 1st Edition, 2001

Ethmoturbinals

- Second ethmoturbinal
  - Middle turbinate
- Third ethmoturbinal:
  - Superior turbinate
- Fourth and Fifth ethmoturbinals:
  - Supreme turbinate (when present)

Kennedy DW et al. Anatomy of the Paranasal Sinuses. In Diseases of the Sinuses. 1st Edition, 2001

Embryology

- The ethmoturbinals are all considered to be ethmoid in origin
- An additional ridge, the maxilloturbinal, arises inferior to these structures and ultimately forms the inferior turbinate

Kennedy DW et al. Anatomy of the Paranasal Sinuses. In Diseases of the Sinuses. 1st Edition, 2001

The Ethmoid Roof
Skull Base Configuration

- Keros described 3 forms (Keros, 1965)
  - Type 1: the lateral lamella (of the cribiform plate) is in the same plane as the roof of the ethmoid sinus and has a shallow 1-3mm olfactory fossa
  - Type 2: olfactory fossa is 4-7mm deep due to a longer lateral lamella
  - Type 3: 8-16mm, the lateral lamella is most vulnerable to penetration

Keros Classification

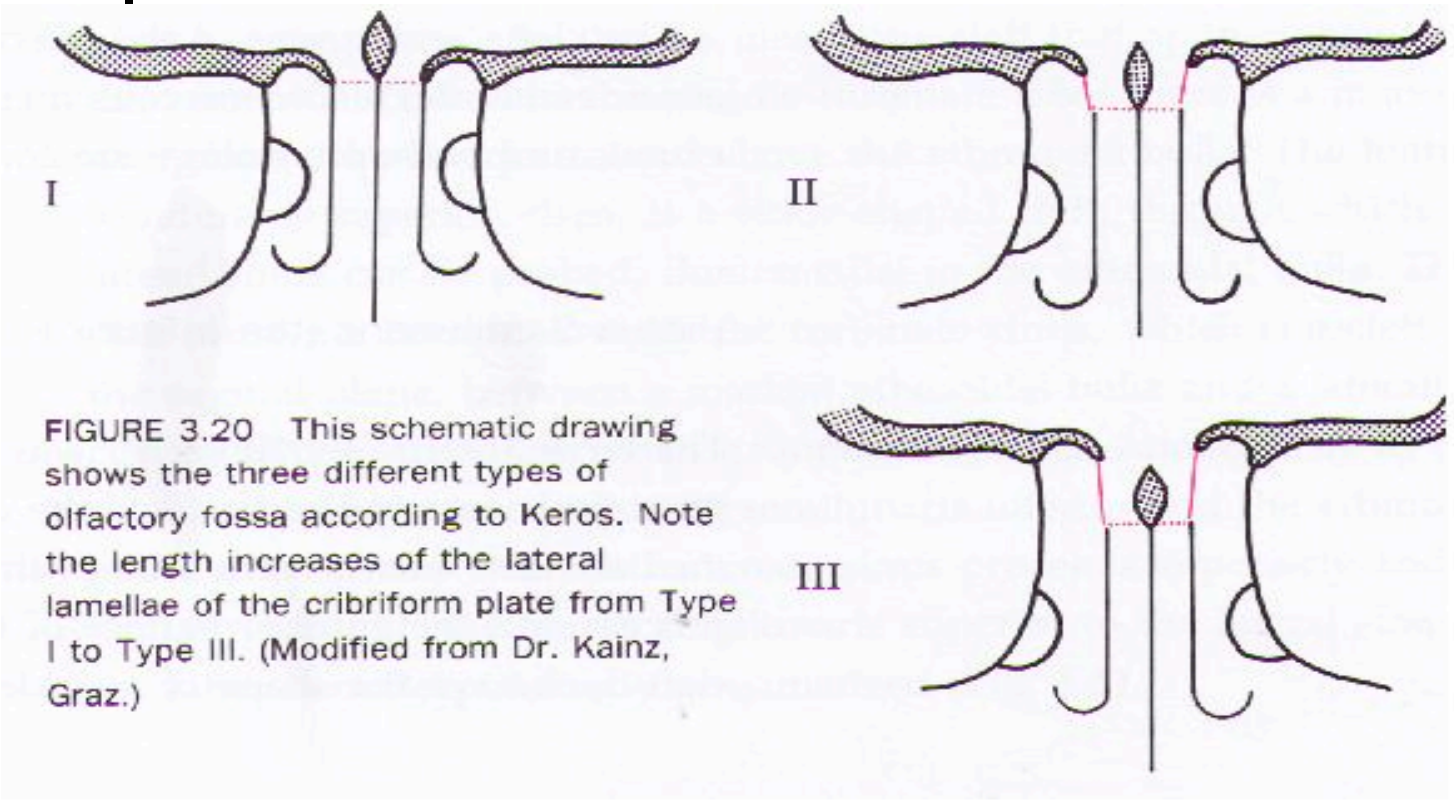
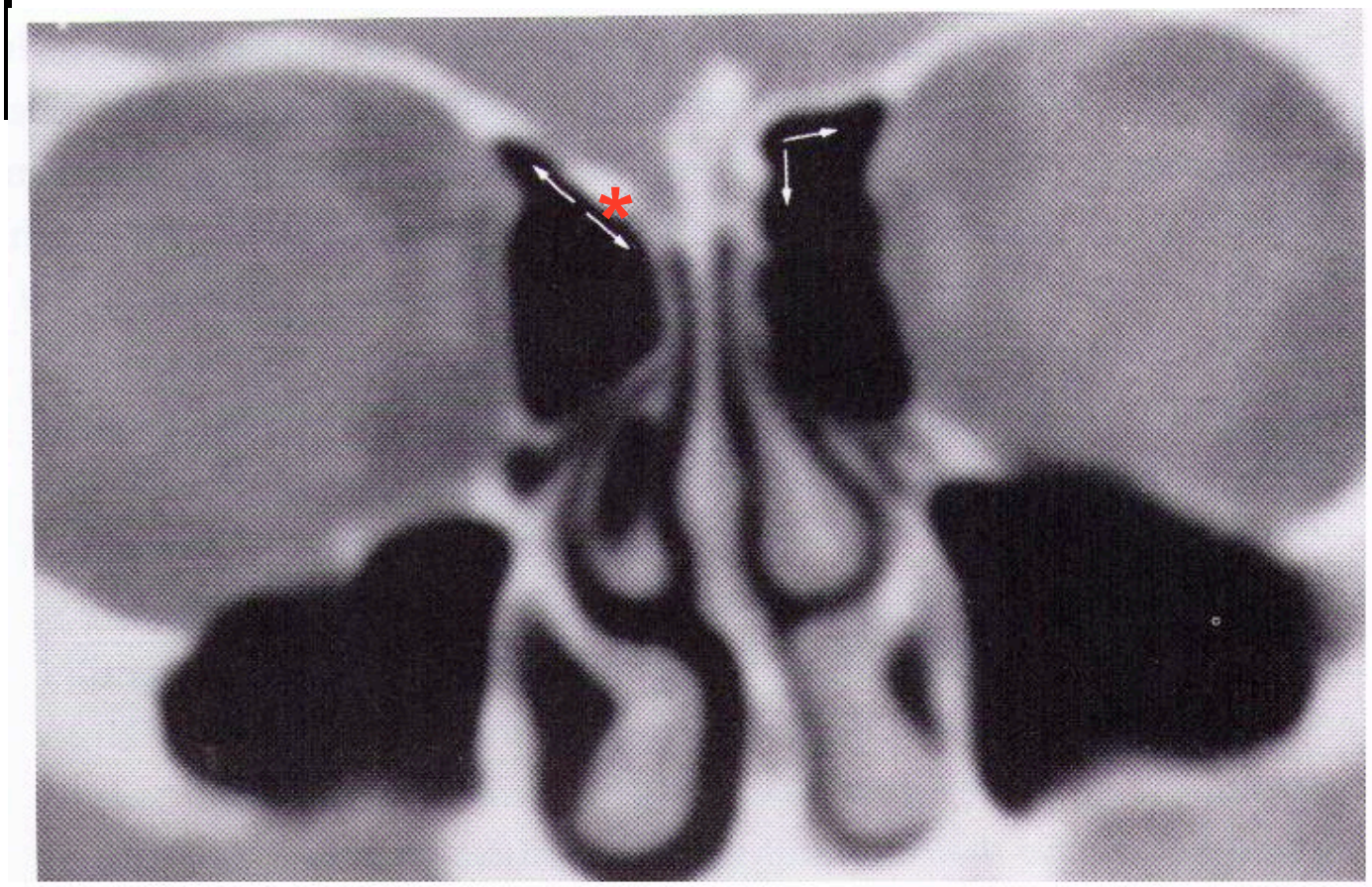


FIGURE 3.20 This schematic drawing shows the three different types of olfactory fossa according to Keros. Note the length increases of the lateral lamellae of the cribriform plate from Type I to Type III. (Modified from Dr. Kainz, Graz.)

- Type 1: 1-3mm
- Type 2: 4- 7mm
- Type 3: 8-16mm

Skull Base Asymmetry



- Type 1: 1-3mm
- Type 2: 4- 7mm
- Type 3: 8-16mm

*Lateral Lamella of Cribiform is the thinnest bone of the skull base

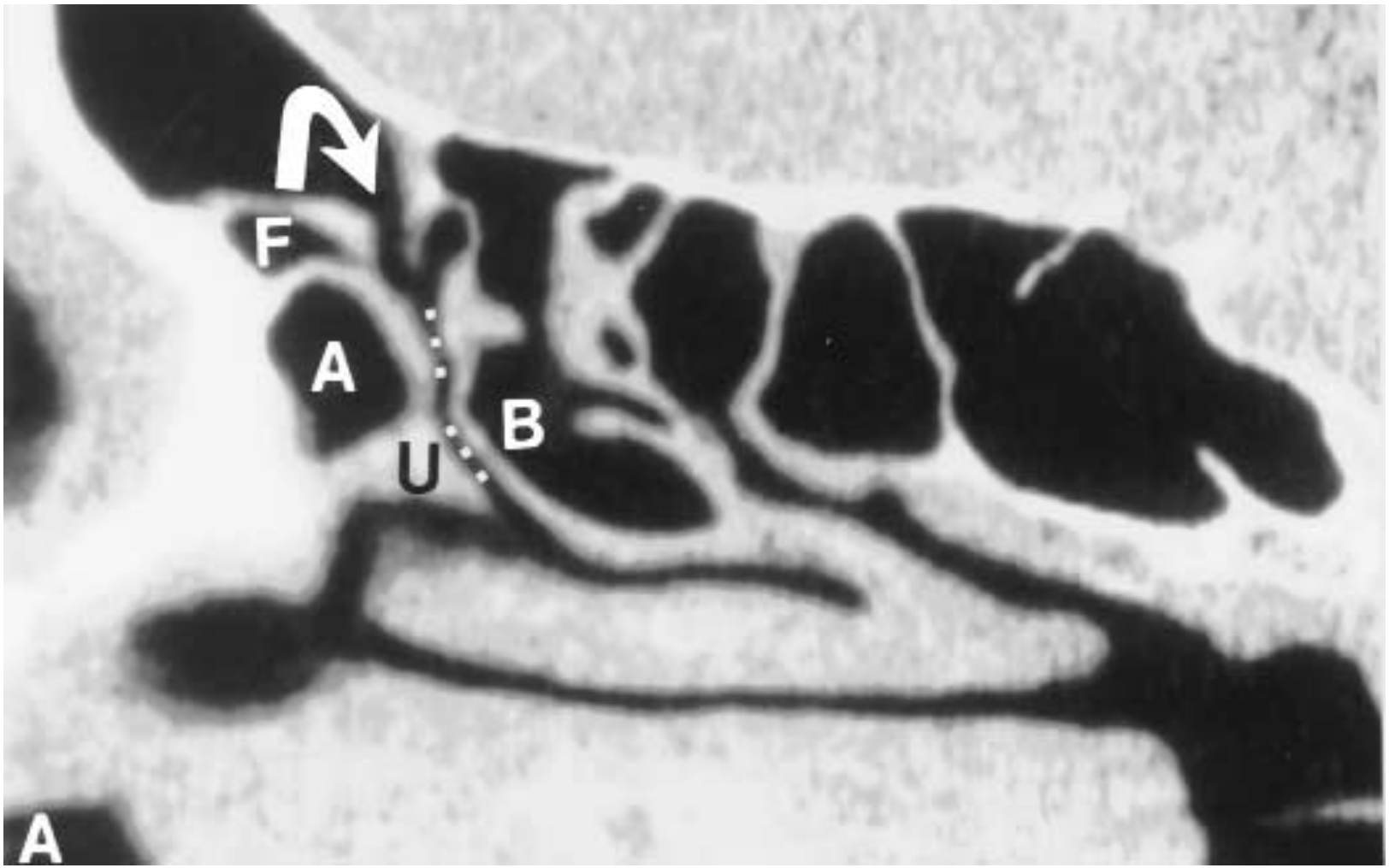
Agger Nasi

- ‘Little Mound’
- Most anterior ethmoid air cell
- Part of 1st ethmoturbinal
- Defines ant. boarder of frontal recess

Agger Nasi Cell

- Prevalence
  - Early 20th anatomists: 40-60%
  - Van Alyea (1939): 89%
  - Bolger (1991): 98%

Relationship of Agger nasi to frontal recess



Ethmoid Lamella

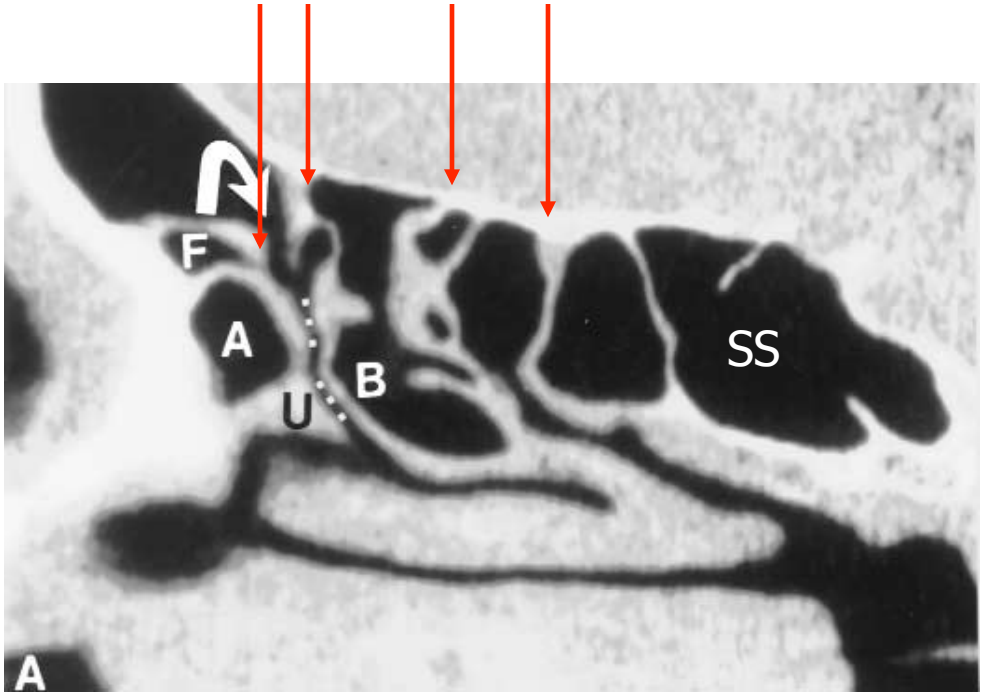
Lamella = bony attachments to lateral wall

Uncinate process

Ethmoid bulla

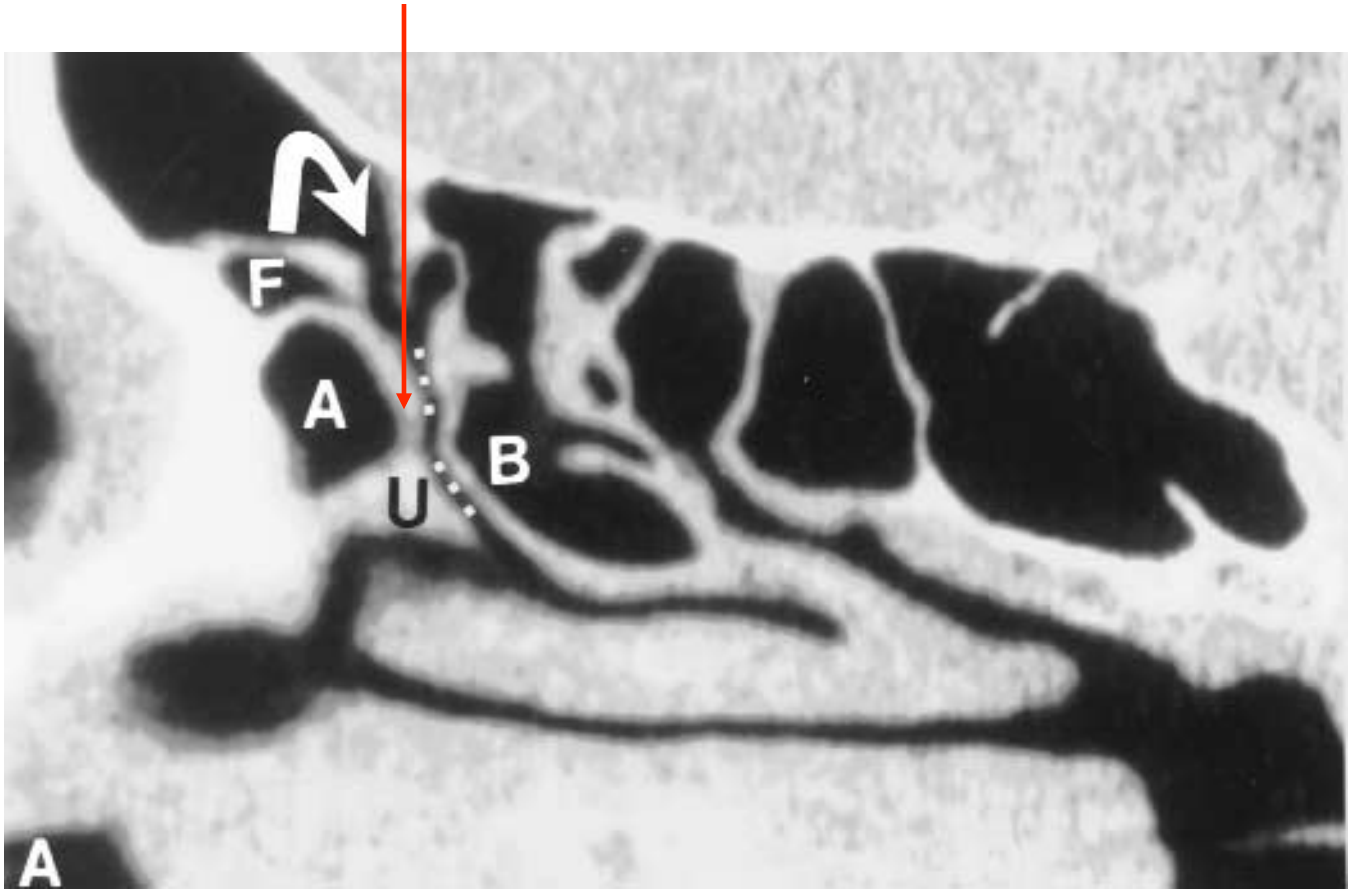
Middle turbinate

Superior turbinate



These structures are sequentially encountered and partially removed during FESS

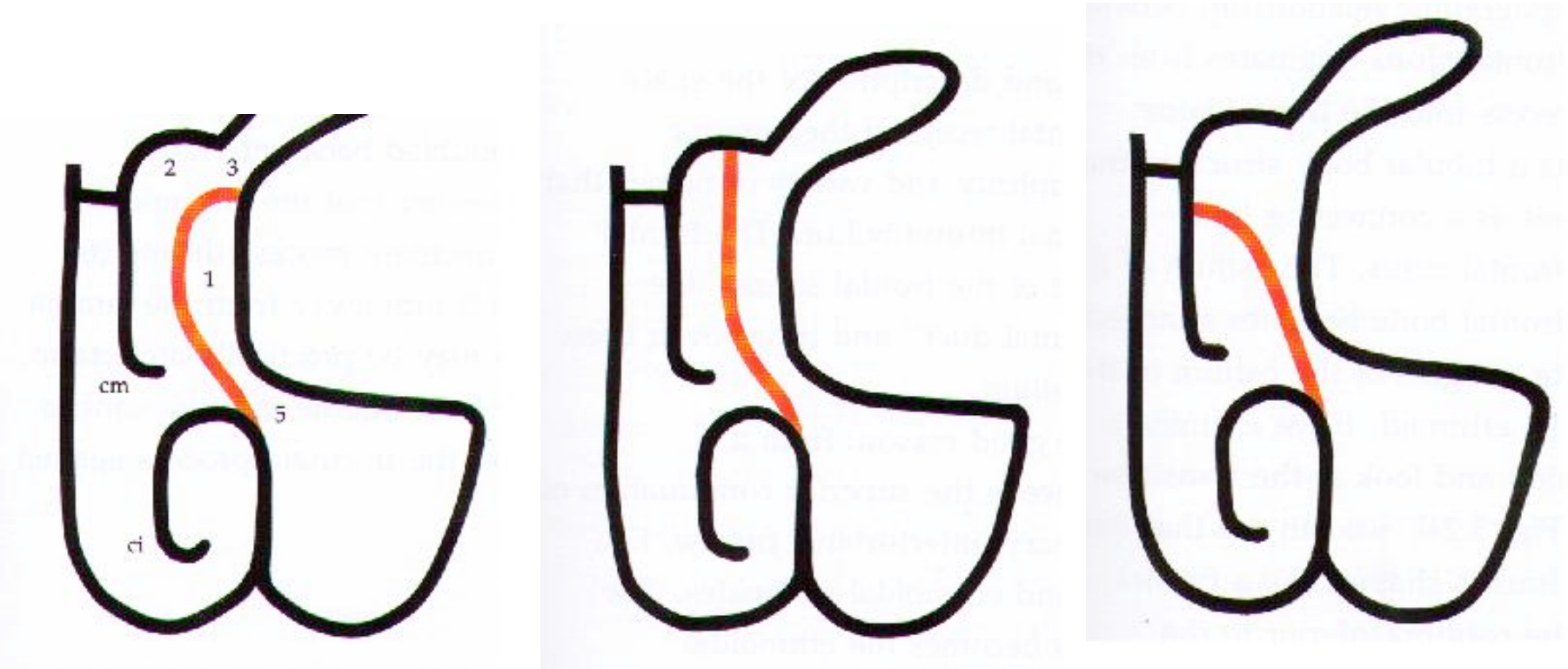
Part 3: Uncinate process (Lamella #1)



Uncinate process

- Sickle shaped bone in sagittal plane
- Part of the ethmoid
- From 1st ethmoturbinal (like agger nasi)
- Can have 3 superior different attachments that determine frontal sinus outflow

Uncinate process



88%

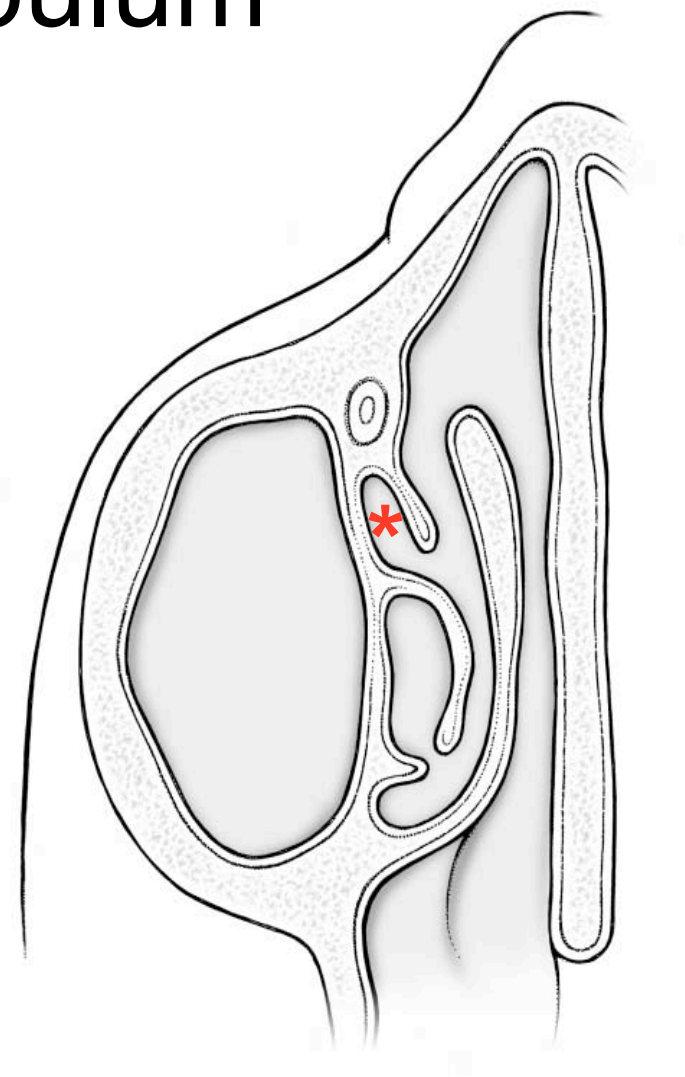
12%

Infundibulum

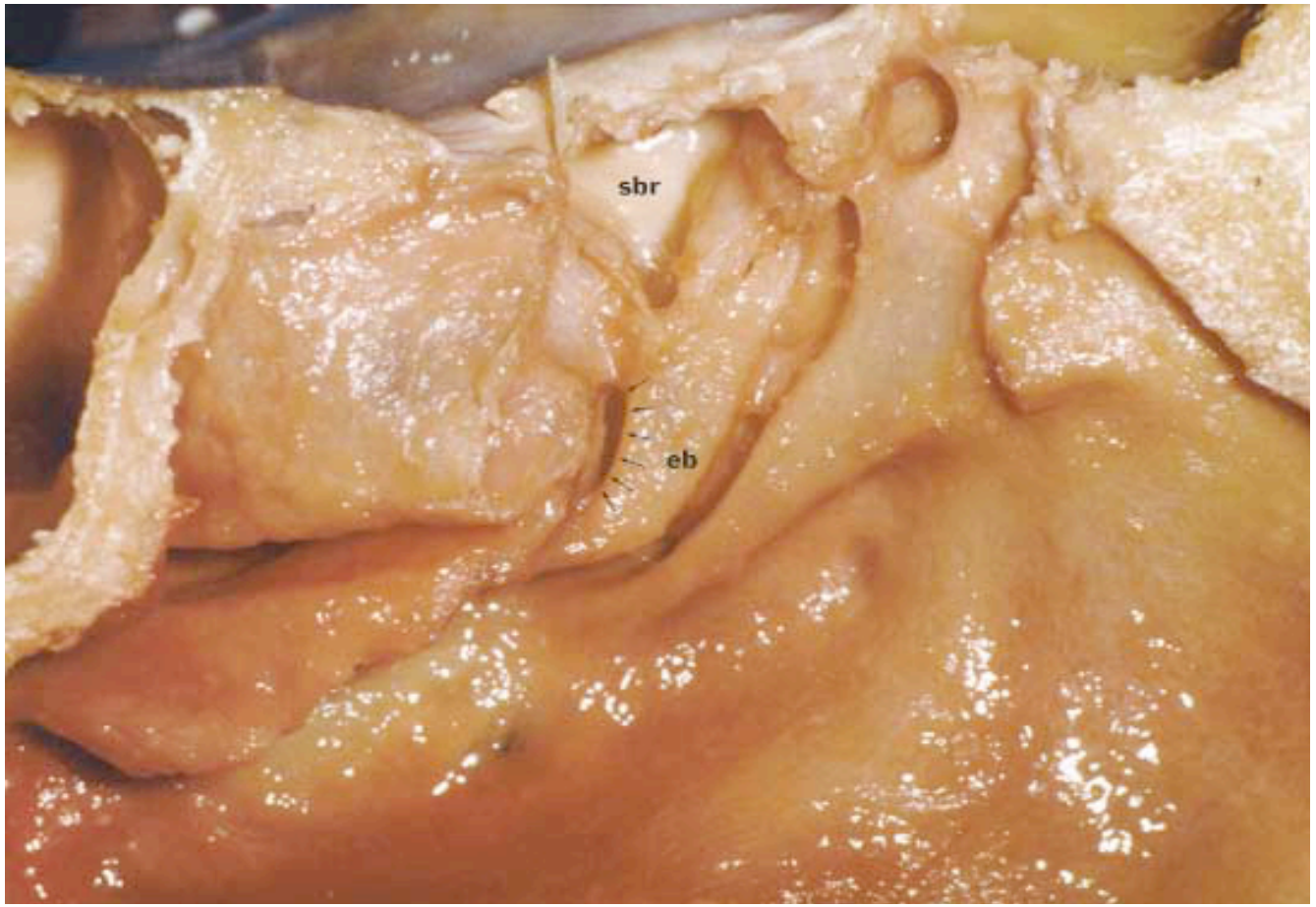
- Any funnel-shaped space
  - Ethmoid
  - Frontal (recess)

Ethmoidal infundibulum

- 3-dimensional space
- Accessed from the nasal cavity via the hiatus semilunaris
- Drainage for
  - Anterior ethmoid cells
  - Maxillary sinus
  - Frontal sinus (sometimes)

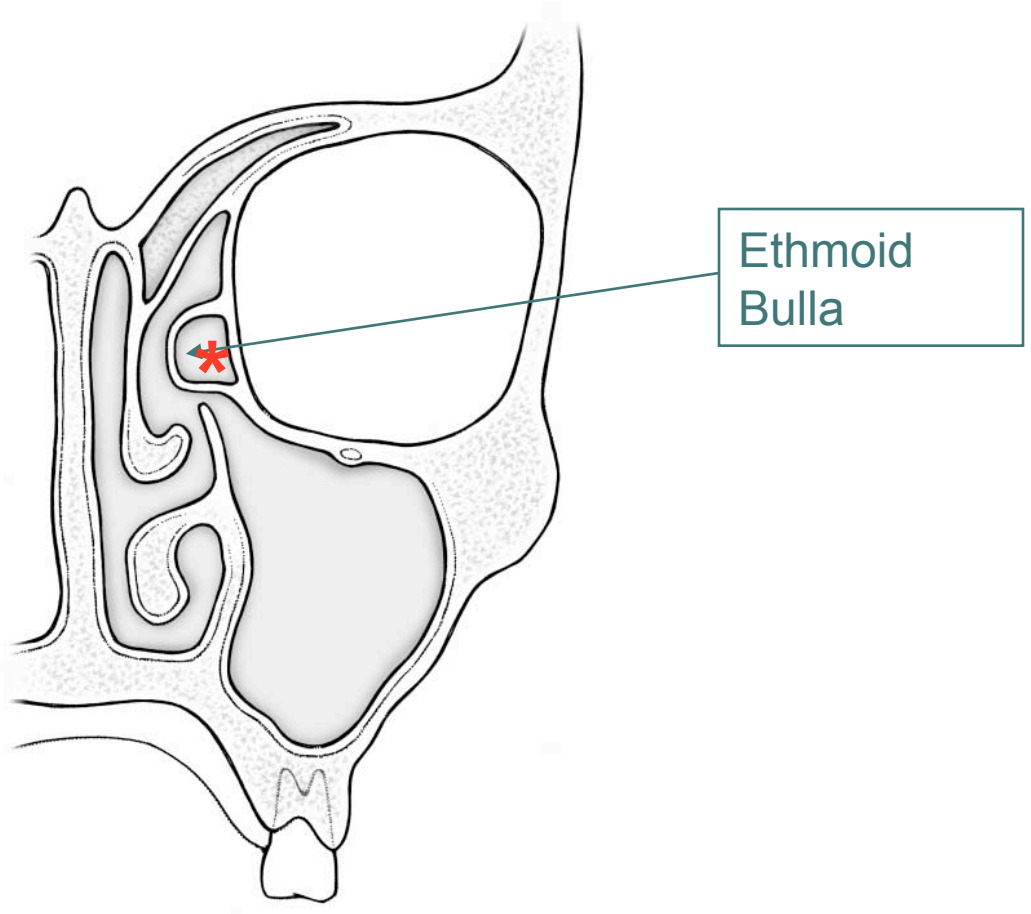


Part 4:
Ethmoid Bulla
Lamella #2



Ethmoid Bulla

- Bulla = hollow, thin-walled bony prominence
- Most consistent and well pneumatized anterior ethmoid air cell
- Makes up posterior boarder of frontal recess



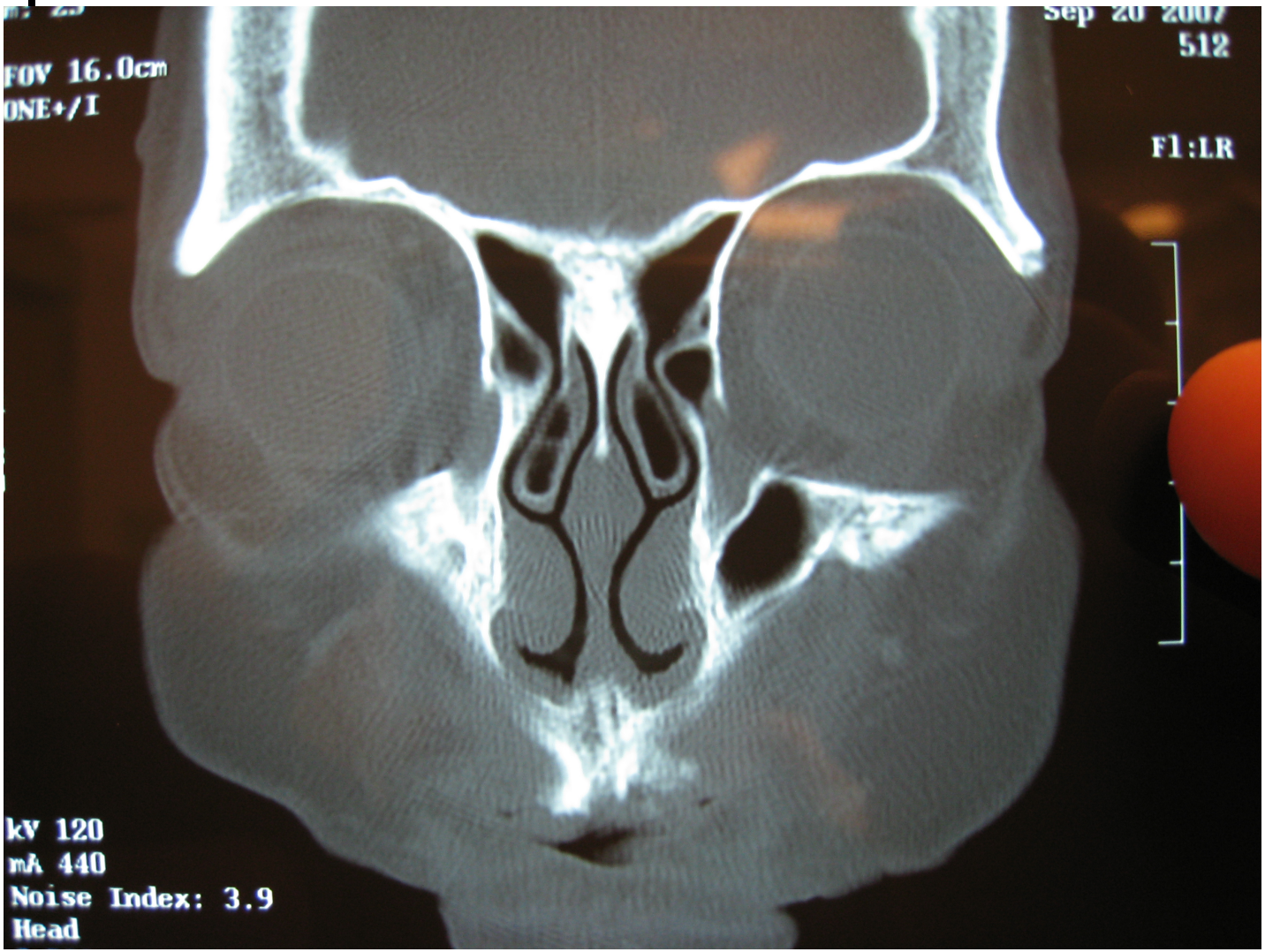
Part 5:
Middle Turbinate
Lamella #3

Middle Turbinate

- 3 Attachments
  - Anterior – in sagittal plane, attached to the lateral edge of the cribiform plate (skull base attachment)
  - Middle – in frontal plane, attached to lamina papryacea
  - Posterior – in axial plane, attached to lamina papryacea, medial wall of maxilla, and perpendicular process of palatine bone

Concha Bullosa

- MT pneumatization
- Not necessarily pathologic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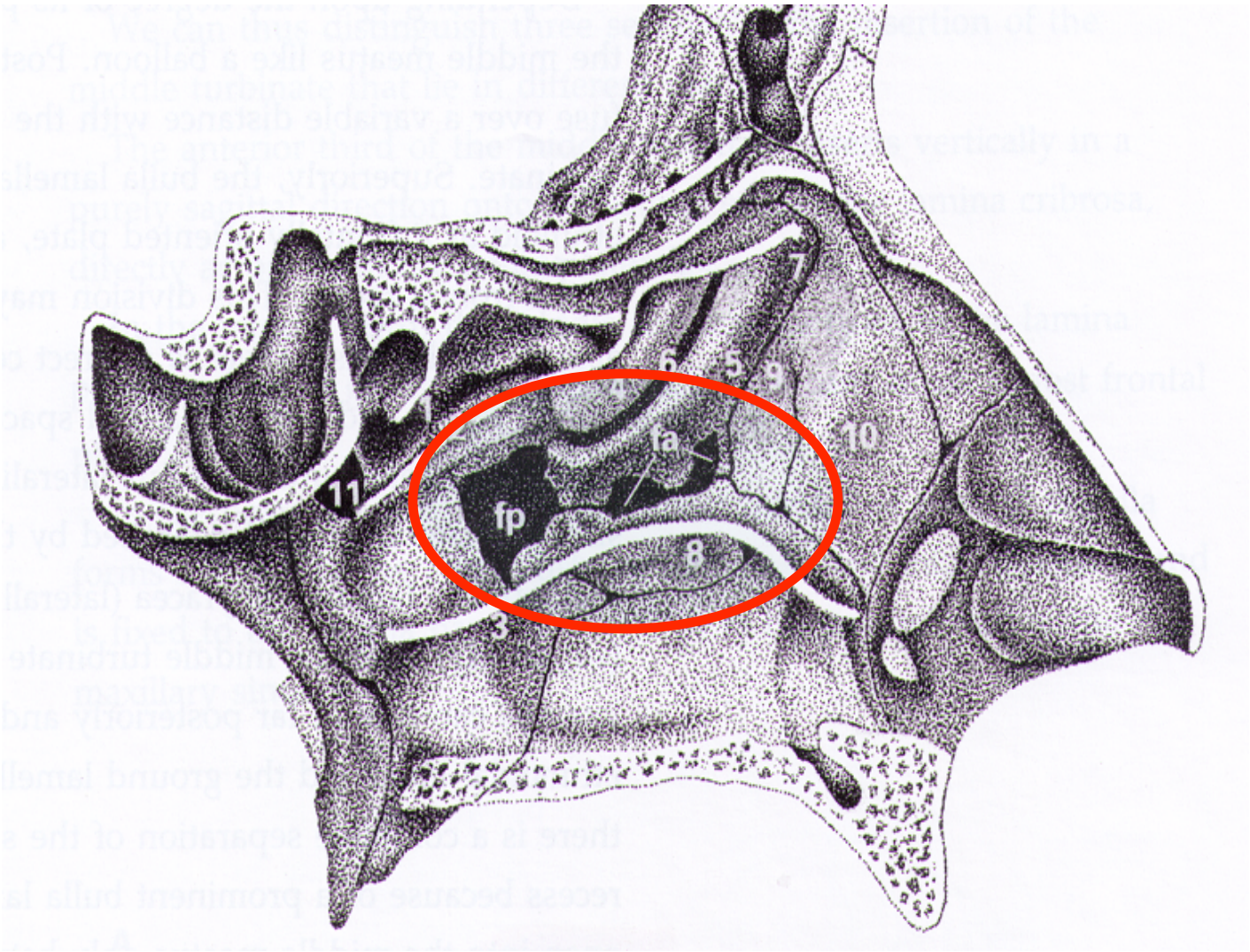
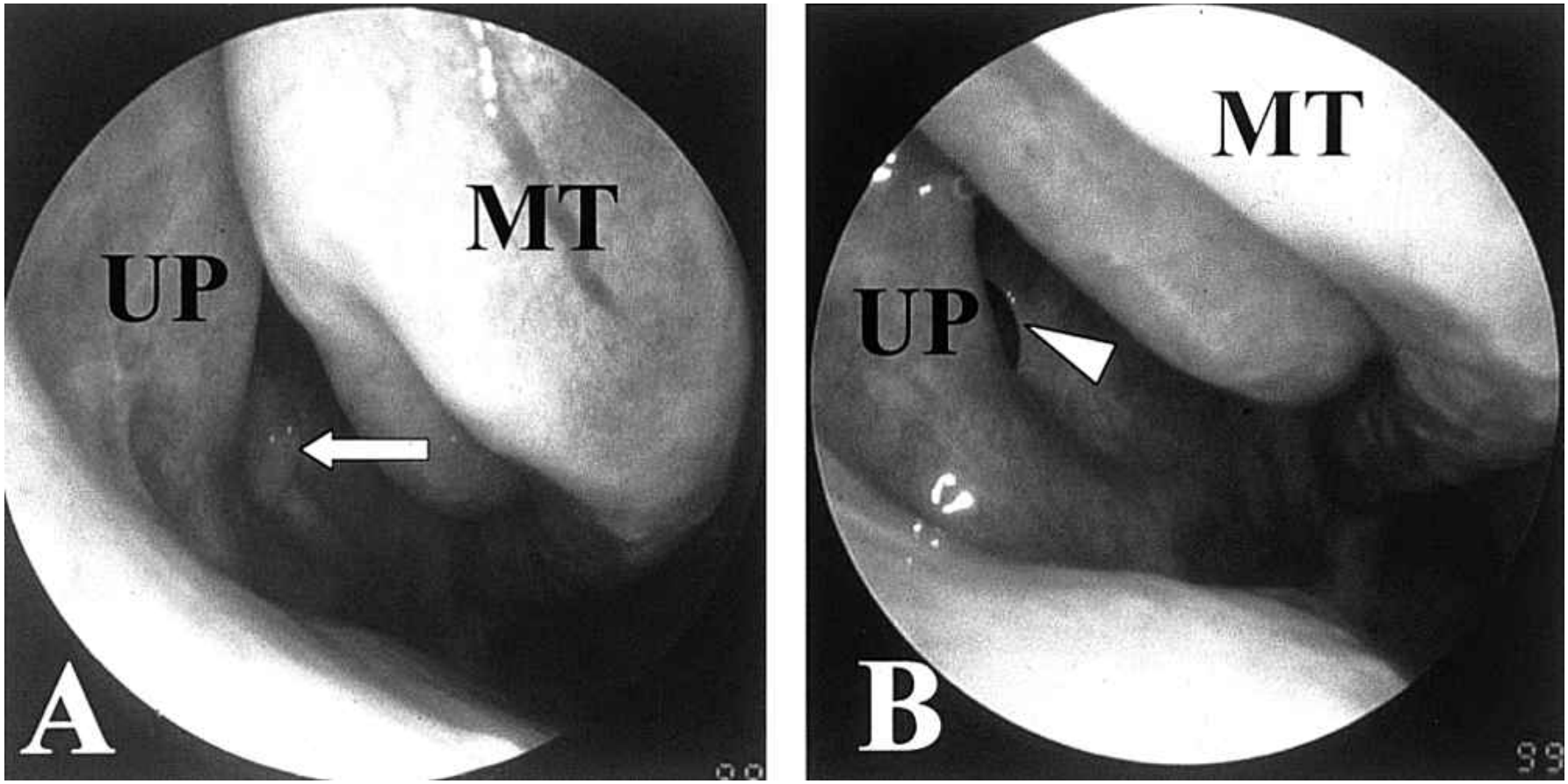
Head

Bony Lateral Nasal Wall

- Anterior fontanelle
- Posterior fontanelle
- Accessory maxillary ostia can occur in 20-50% of patients



Accessory Maxillary Ostium

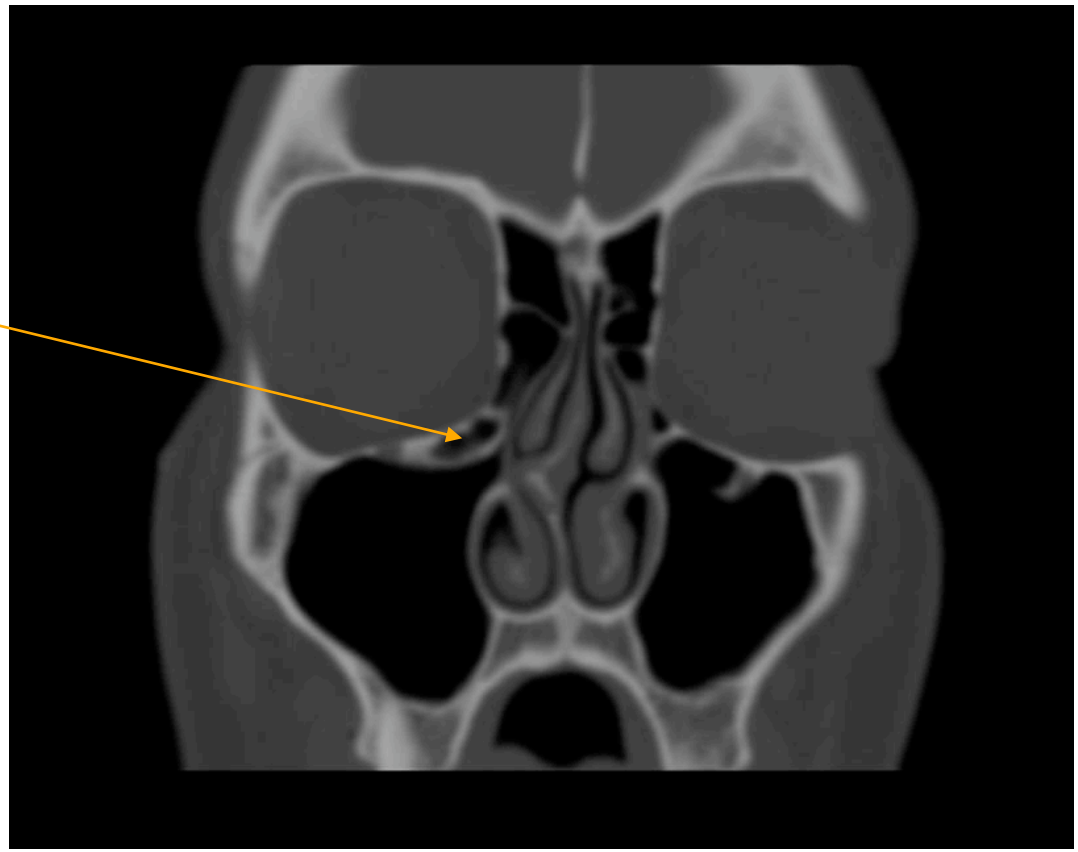


3 Random Korean Authors. CT findings of Mucus Recirculation between the natural and accessory ostial of the maxillary sinus. AJR 16 2002

Infraorbital Ethmoid Cell

- Aka Haller cell
- Close relationship to orbit and maxillary ostium
- Arise from anterior ethmoid air cell 88%

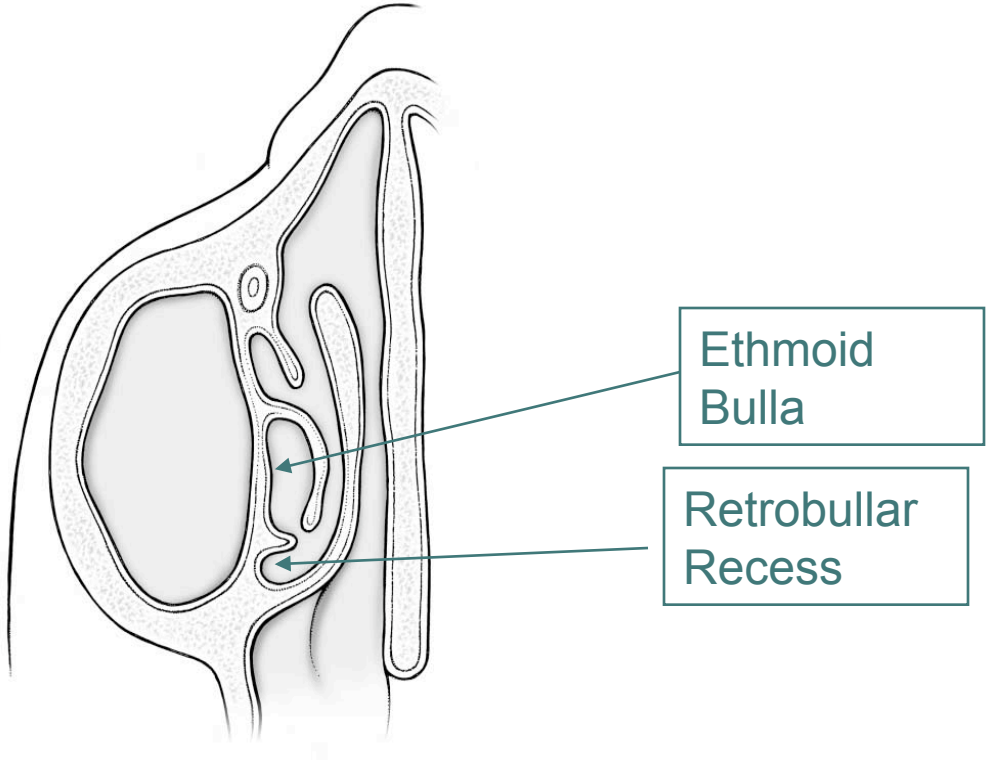
Sinus Anatomy



Sinus Anatomy

Axial View:

- Retrobullar Recess
- AKA sinus lateralis
- BUT No true ostium
- Highly variable

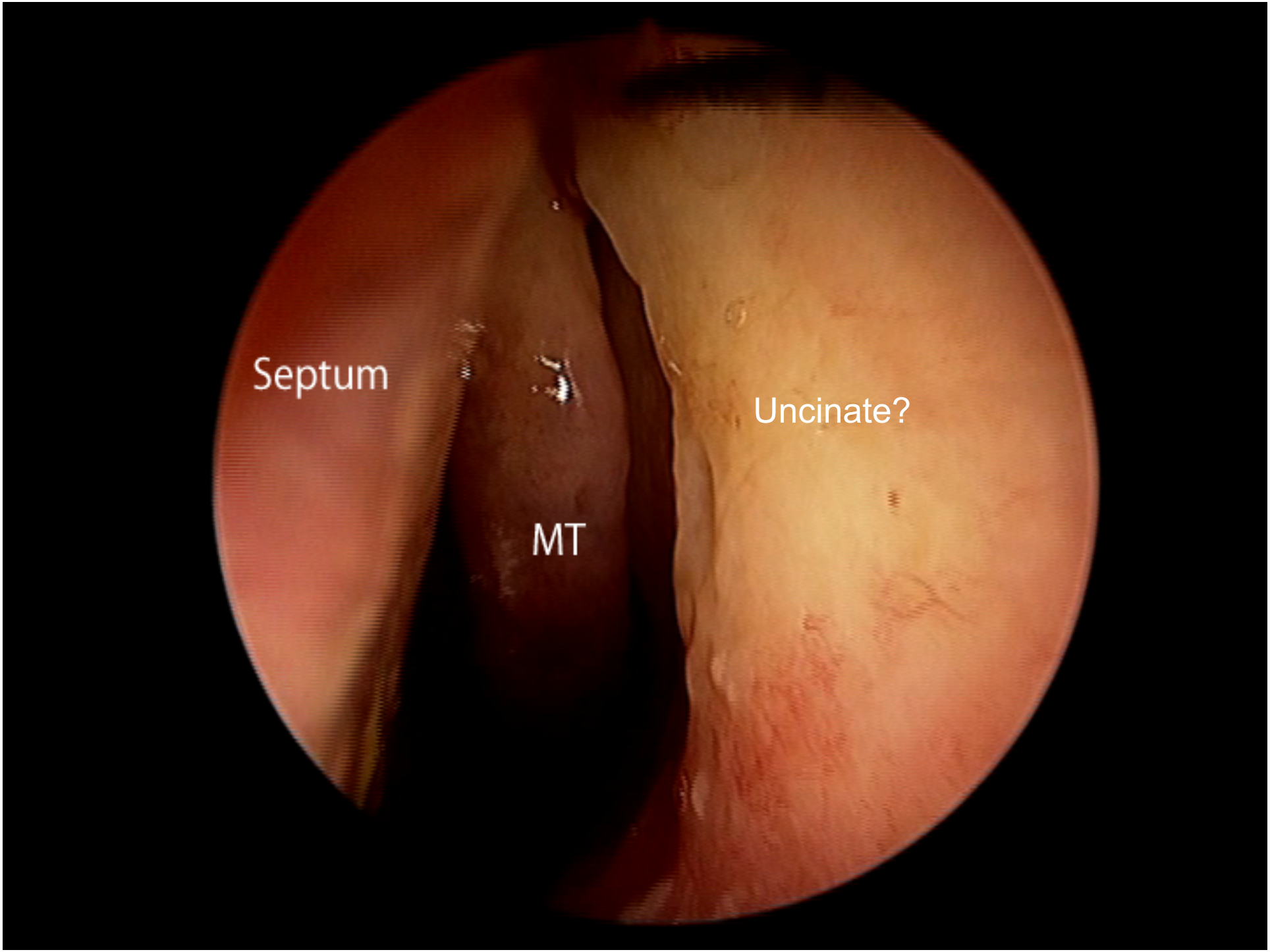


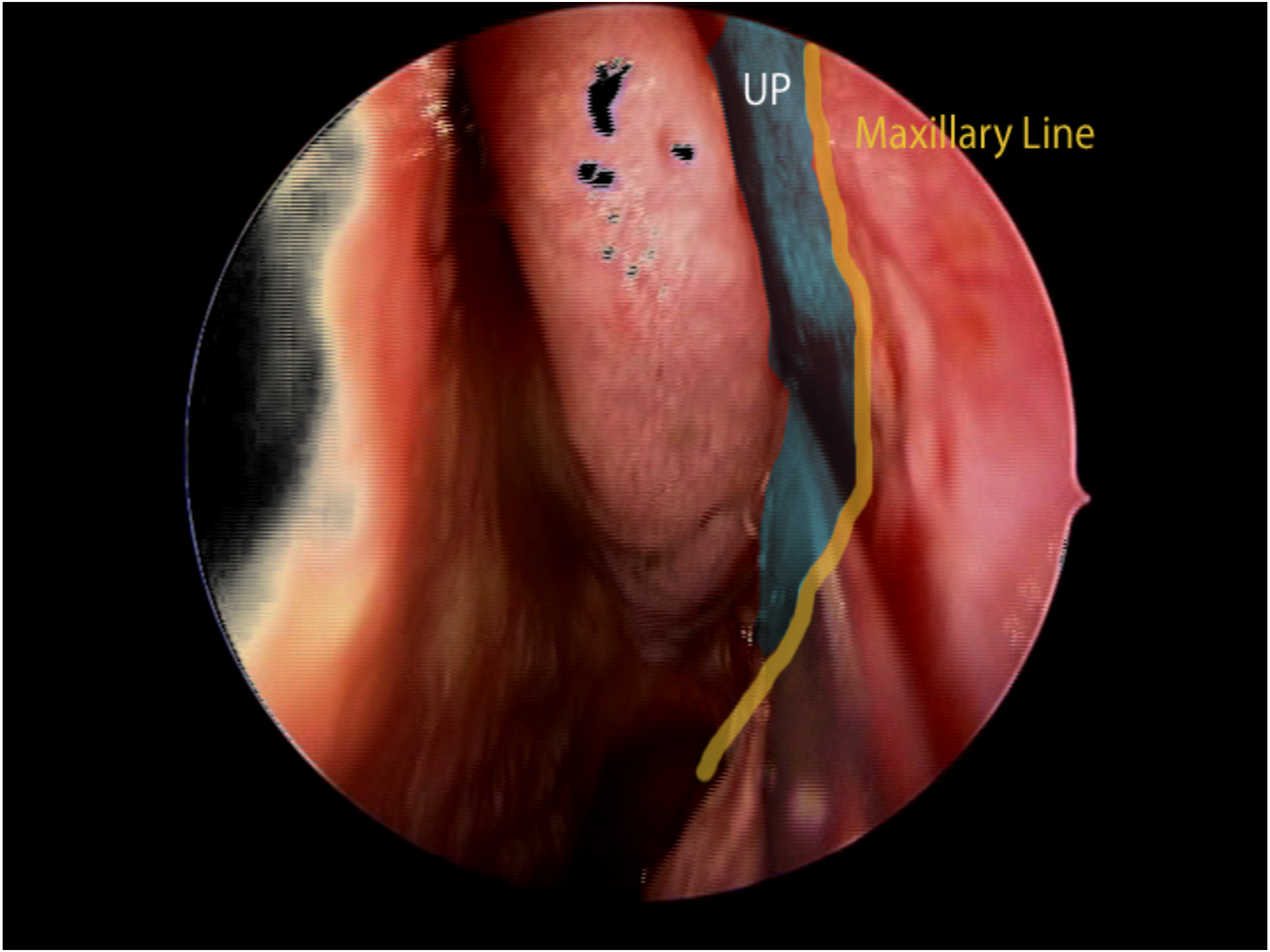
Review: Consistent Lamellae

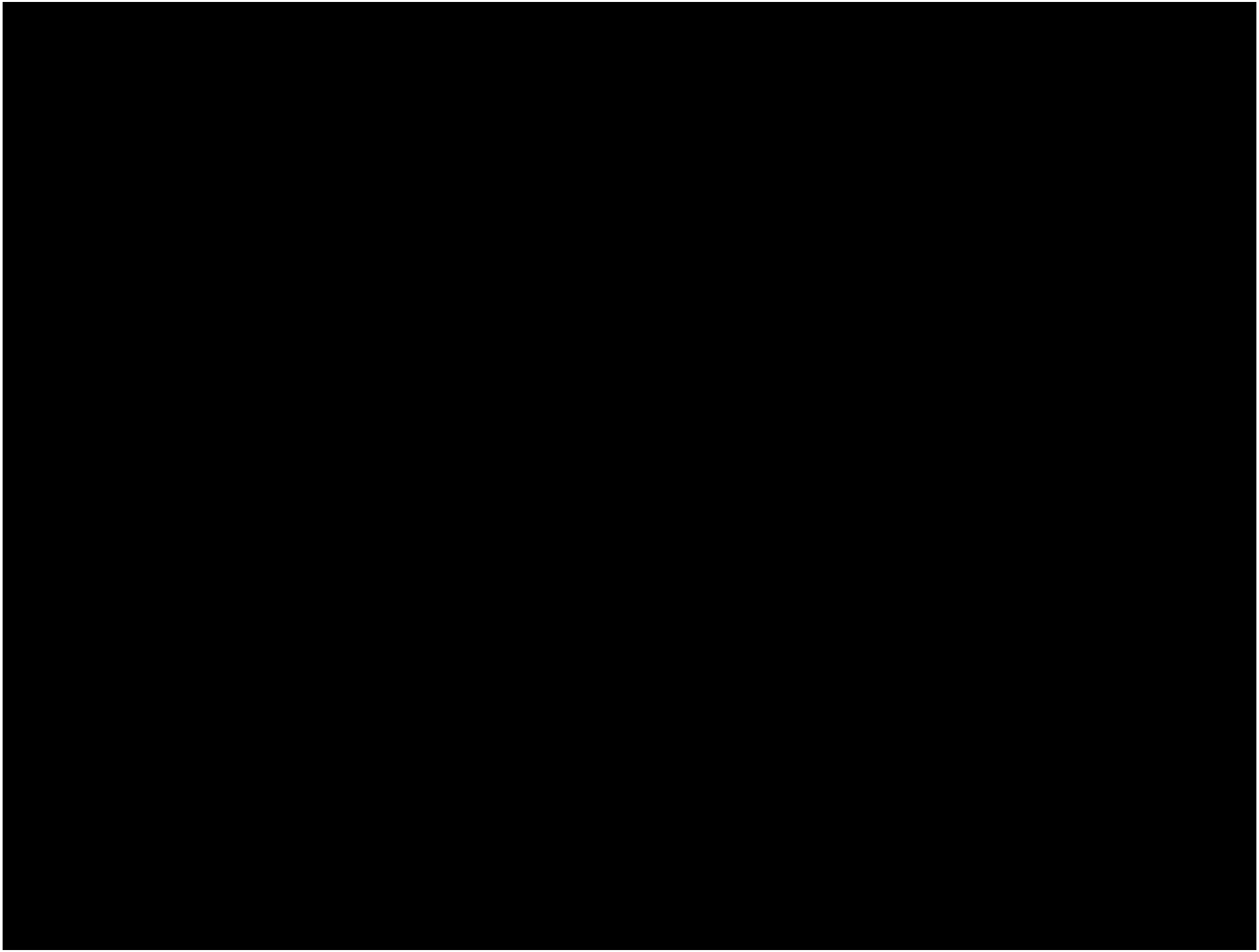
FROM

ANTERIOR To POSTERIOR

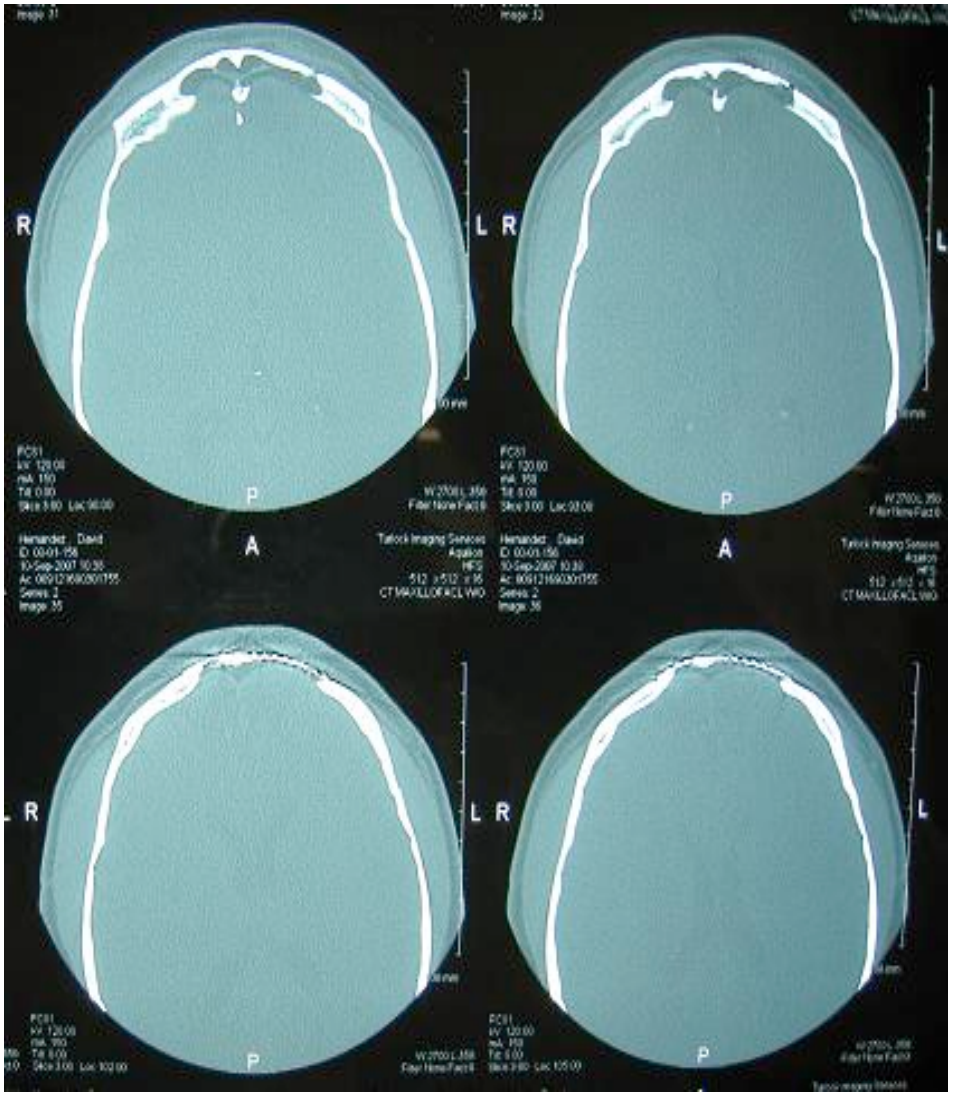
- Uncinate process
- Anterior wall of ethmoid bulla
- Basal Lamella of the middle turbinate
- Sphenoid face


Septum
Uncinate?
MT


UP
Maxillary Line



Frontal Sinus



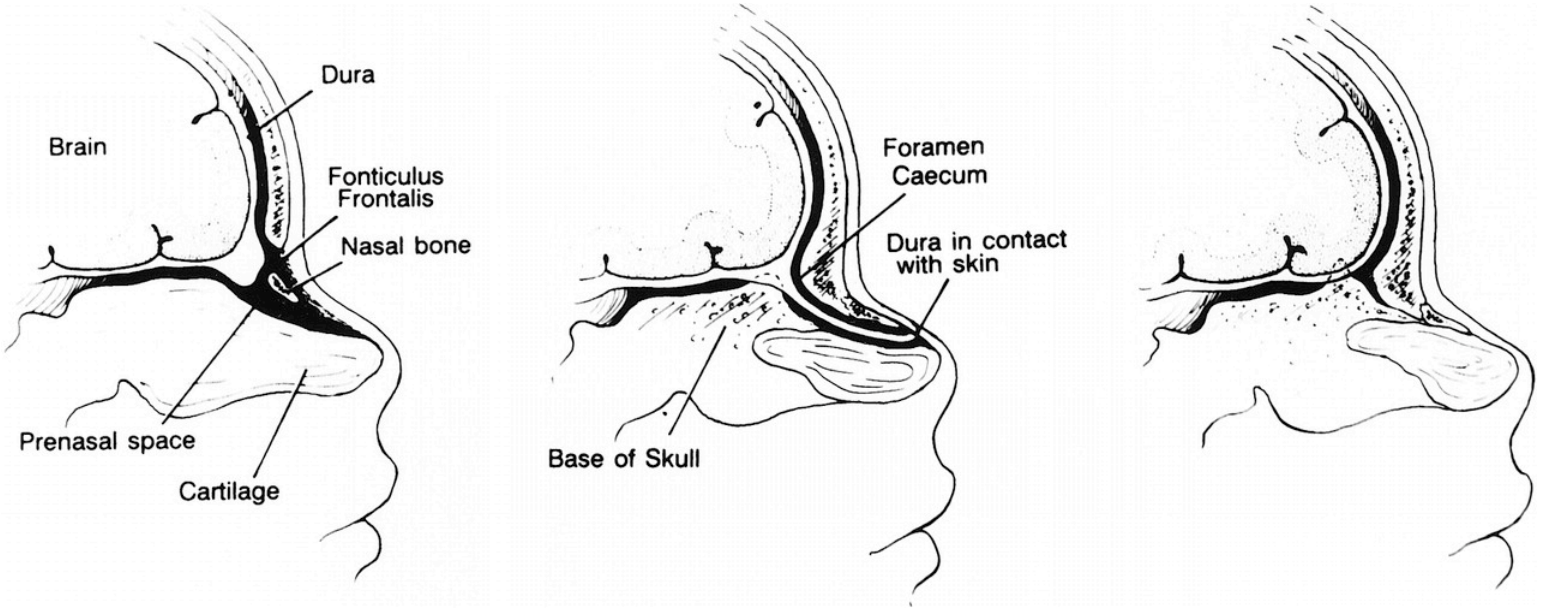
Frontal Sinus Surgery

- 1750 to 1884: Trephination
- 1893 to 1903: Ablation Procedures
- Early 1900s: Early intranasal attempts
- 1908 to present: Transorbital approaches
  - External Frontoethmoidectomy (Lynch)
  - External frontoethmoidectomy and intranasal ethmoidectomy (Lothrop procedure)
  - Osteoplatic flap with obliteration
- Intranasal Procedures

Frontal Sinus Surgery

- Present Day Frontal Sinus Surgery
  - **Draf 1**: Endoscopic frontal recess approach: complete removal of anterior ethmoid cells including ethmoid bulla and uncinate process
  - **Draf 2a:** Endoscopic frontal sinusotomy: removal of agger nasi and frontal recess cells (uncapping the egg)
  - **Draf 2b**: Resects frontal sinus floor and sup attachment of middle turbinate to create a unilateral opening
  - **Draf 3:** Modified lothrop procedure: maximizes frontal sinus drainage through a bilateral opening from a medial drainage procedure – includes removal of septum

Frontal Sinus Embryology



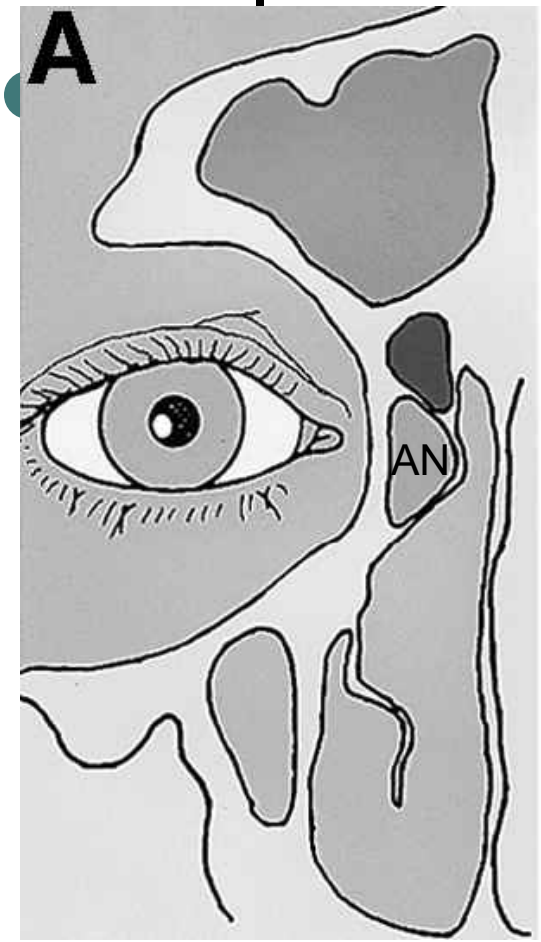
- Fronticulus Frontalis: embryologic space that normally fuses in the development of the frontal bones
- Foramen Cecum: Fronticulus frontalis does not close

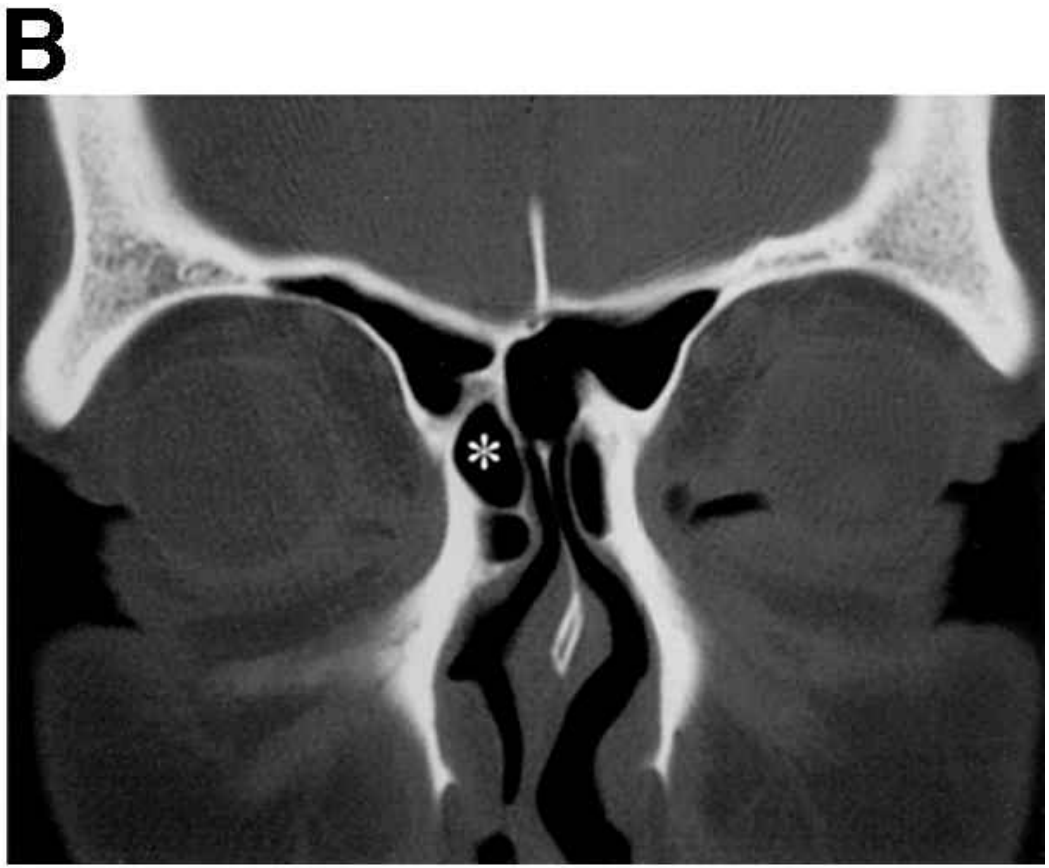
Frontal Sinus

- Numerous pneumatization patterns
- Key: frontal recess
- NOT nasofrontal duct
  - b/c not a tubular structure

Frontal Cells

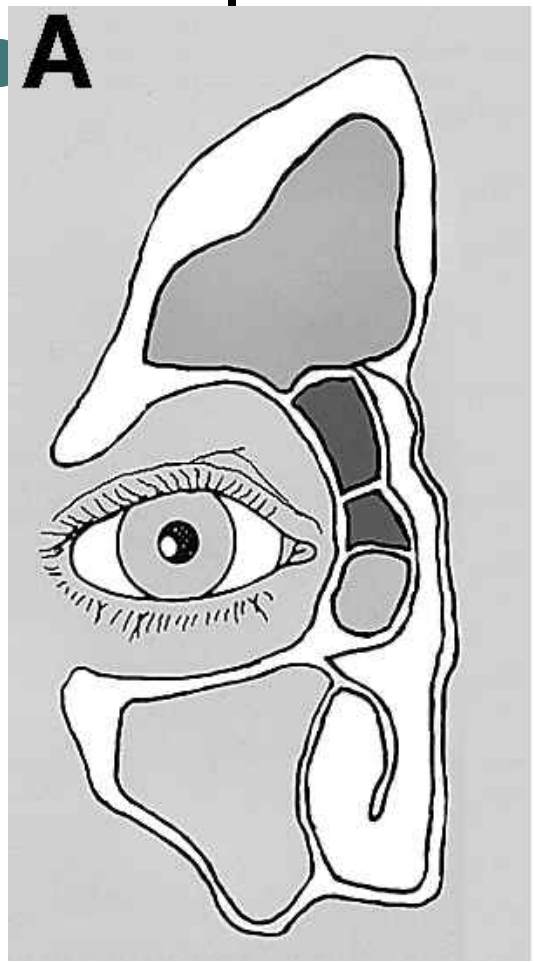
- Dr. Smith 2003 -> 20.4%
- Type I (single frontal recess cell above agger nasi cell)
- Type II (tier of cells above agger nasi cell)
- Type III (single massive cell)
- Type IV (single isolated cell)

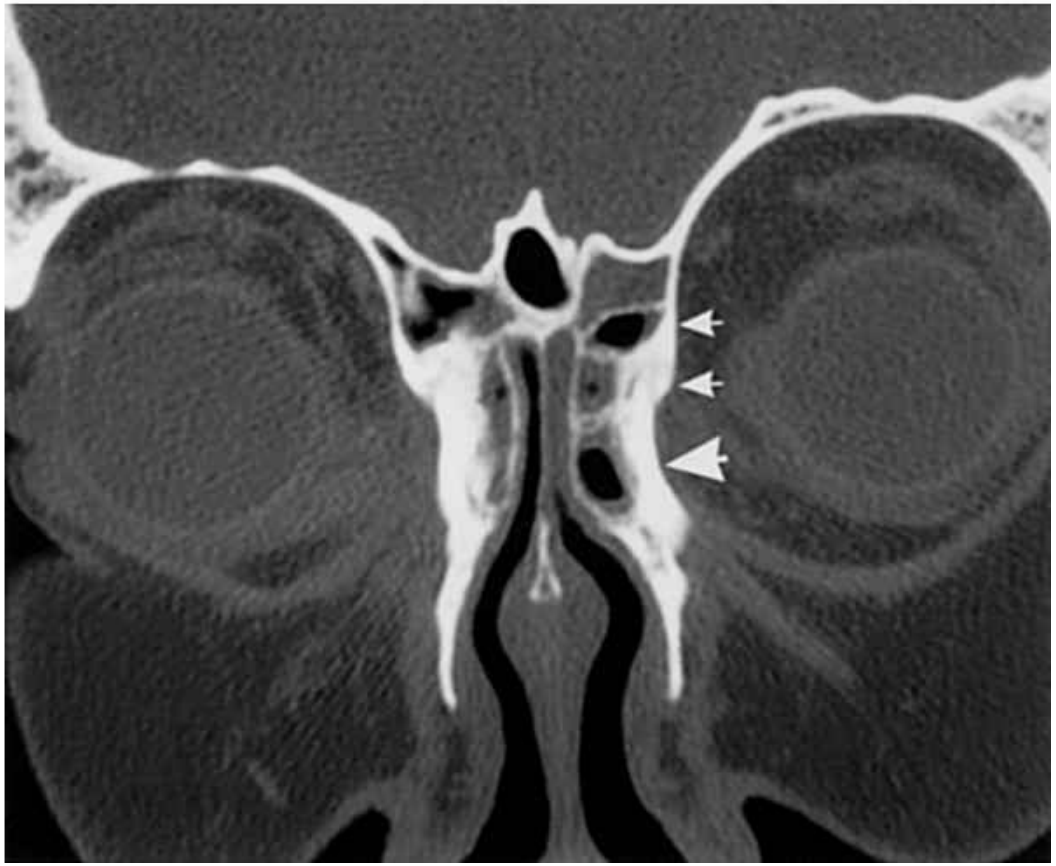




- Type 1 frontal cell (14.9%)

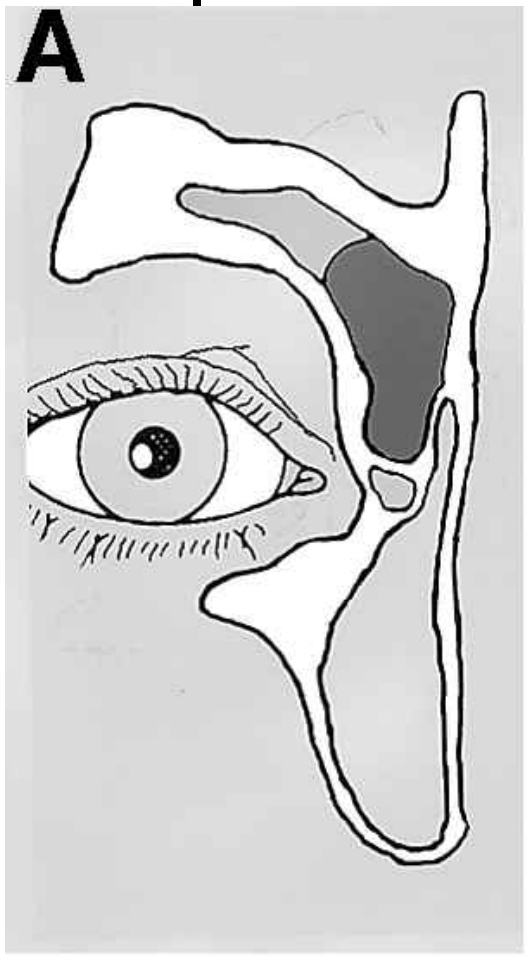
Timothy Smith. Coronal CT Analysis of Frontal Cells. American Journal of Rhinology 2003

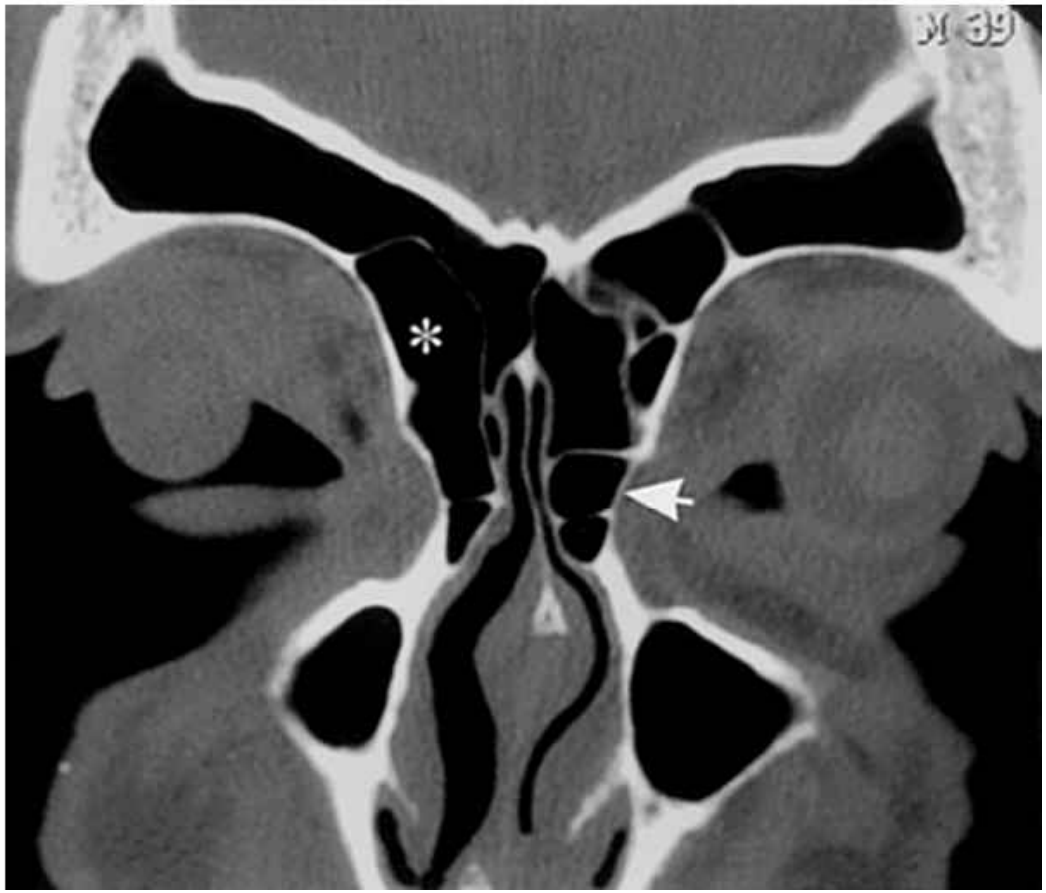




- Type 2 frontal cell (3.1%)

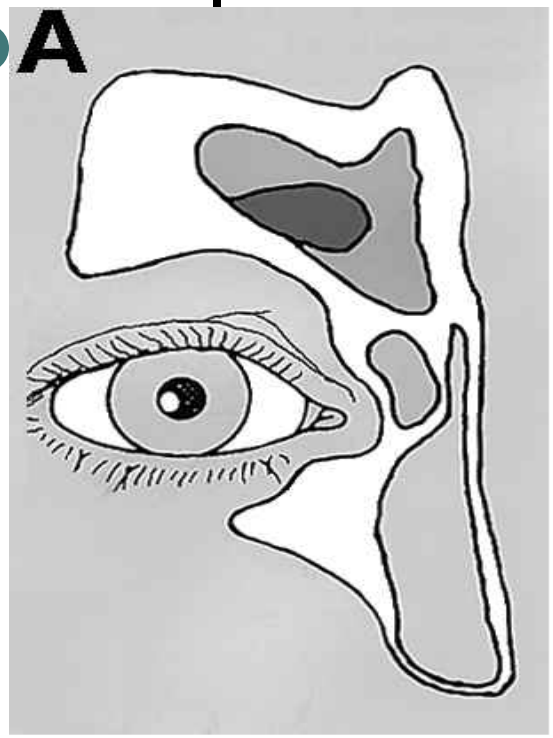
Timothy Smith. Coronal CT Analysis of Frontal Cells. American Journal of Rhinology 2003





- Type 3 frontal cell (1.7%)

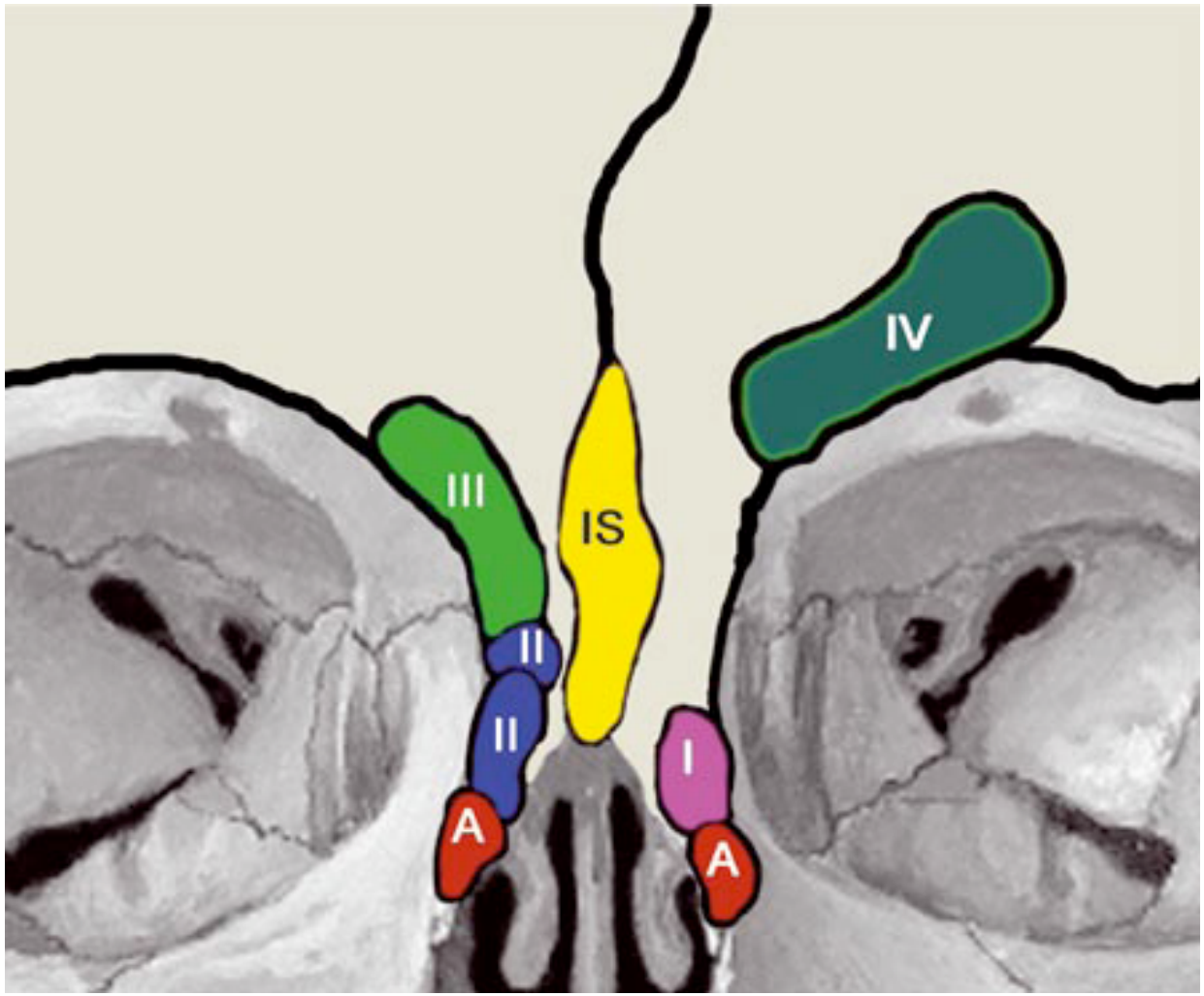
Timothy Smith. Coronal CT Analysis of Frontal Cells. American Journal of Rhinology 2003



- Type 4 frontal cell (2.3%)

Timothy Smith. Coronal CT Analysis of Frontal Cells. American Journal of Rhinology 2003

Frontal Sinus Cells



Sphenoid Sinus

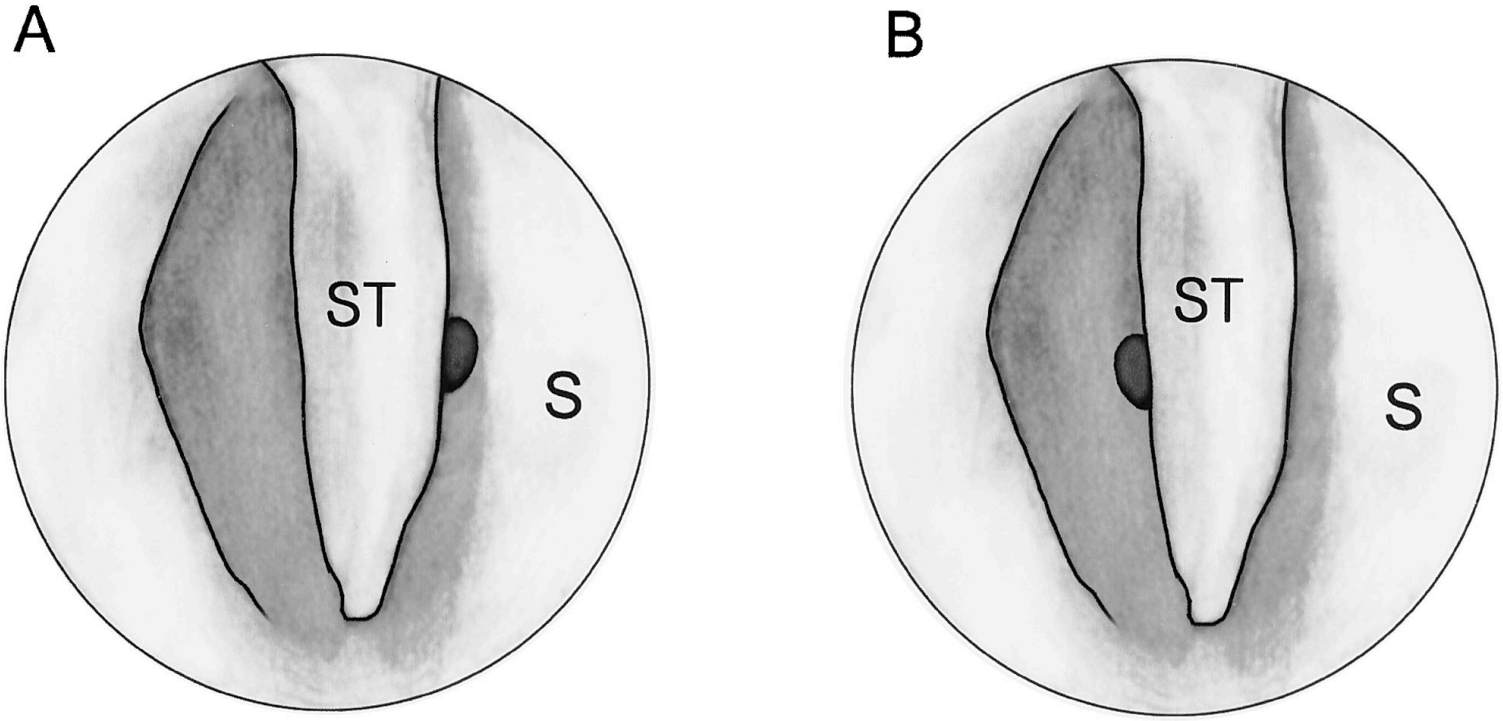
- Considerable variability
- Close relationship to cavernous sinus, ICA (lateral), optic nerve (superior), brain, etc
- Lateral walls may be dehiscent
  - Optic Nerve ~23%
  - Carotid Artery 0-23%

Baskin JZ. The anatomy and physiology of the sphenoid sinus. Operative Techniques in Otolaryngology – Head and Neck Surgery. Vol 14 3 2003. 168-172

Sinus Anatomy

- Sphenoid Sinus
  - 6-8 cm from anterior nasal spine
  - 30 degrees from choanal floor
  - 1/3 up from choana to skull base

Sphenoid Sinus Relationship to Superior Turbinate



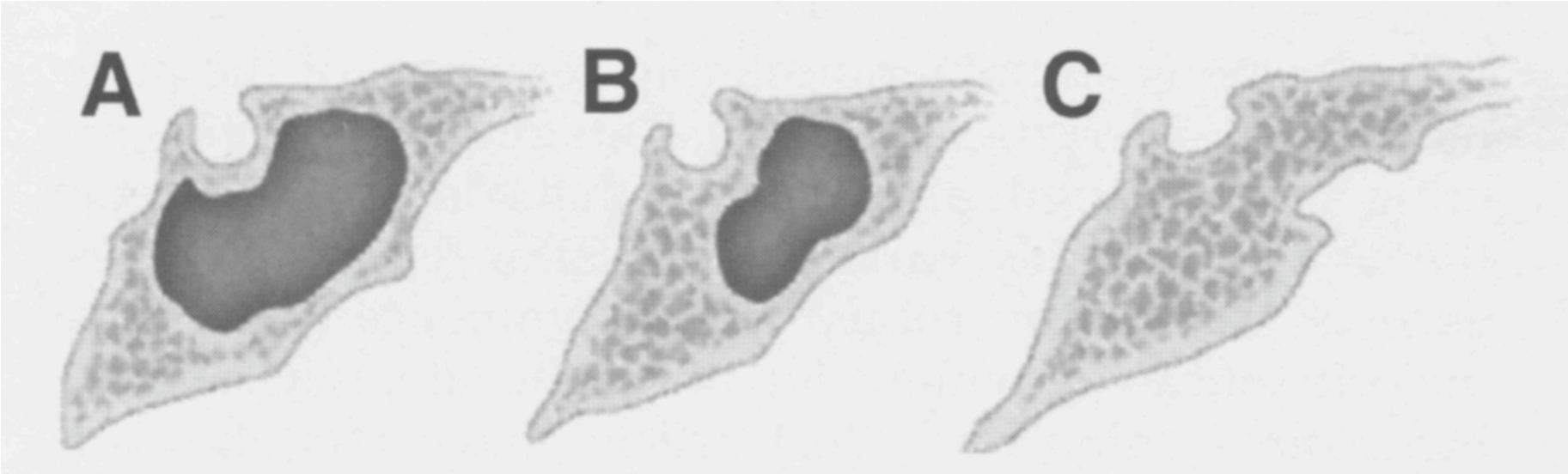
Medial to ST: 83%

Lateral to ST: 17%

D Kennedy. “Pediatric Sinus Surgery” Diseases of the Sinuses. 2001

Kim HU. Surgical anatomy of the natural ostium of the sphenoid sinus. Laryngoscope. 2001 Sep;111(9):1599-602.

Pneumatization Patterns of Sphenoid Sinus



- A) Sellar Type 86%
- B) Pre Sellar 11%
- C) Conchal 3%

Sphenoethmoid cell

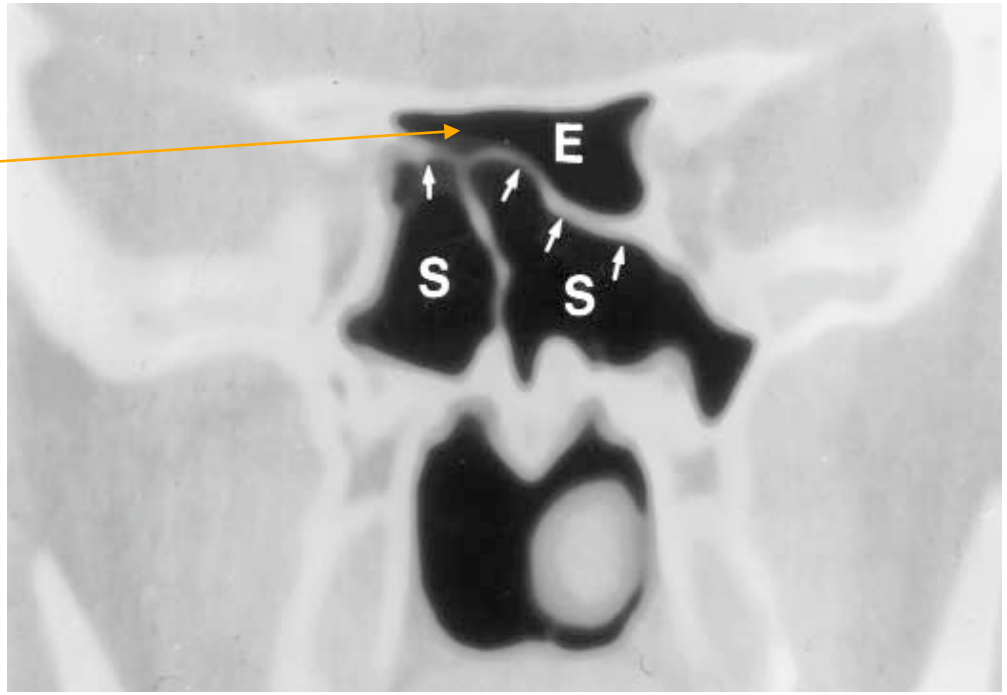
- Aka Onodi Cell
- Posterior ethmoid cell that extends over sphenoid sinus
- Close relationship to CN II

Sinus Anatomy

Onodi Cell

Sinus Anatomy

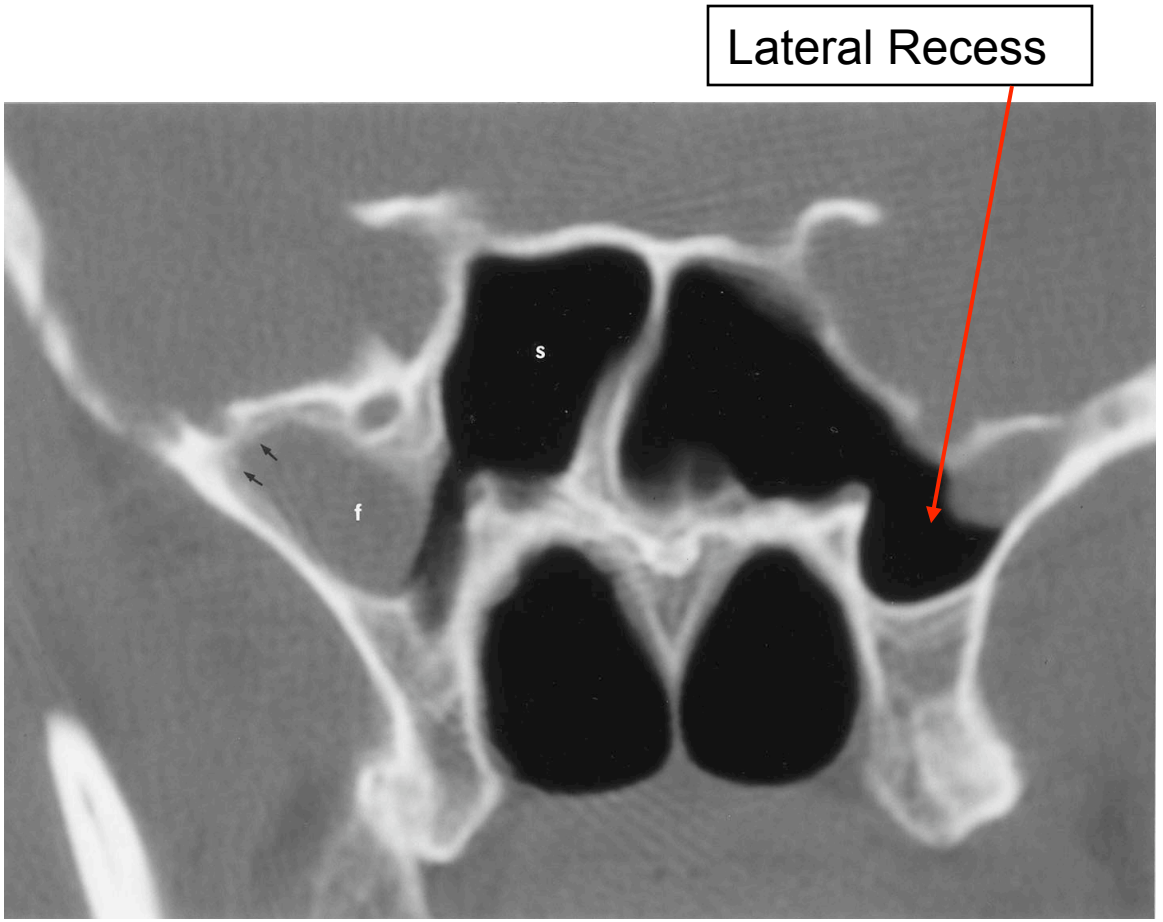
Onodi Cell



*Rely on sagittal CT if there is a horizontal septation in sphenoid sinus think onodi cell

CSF leaks, Sphenoid Sinus

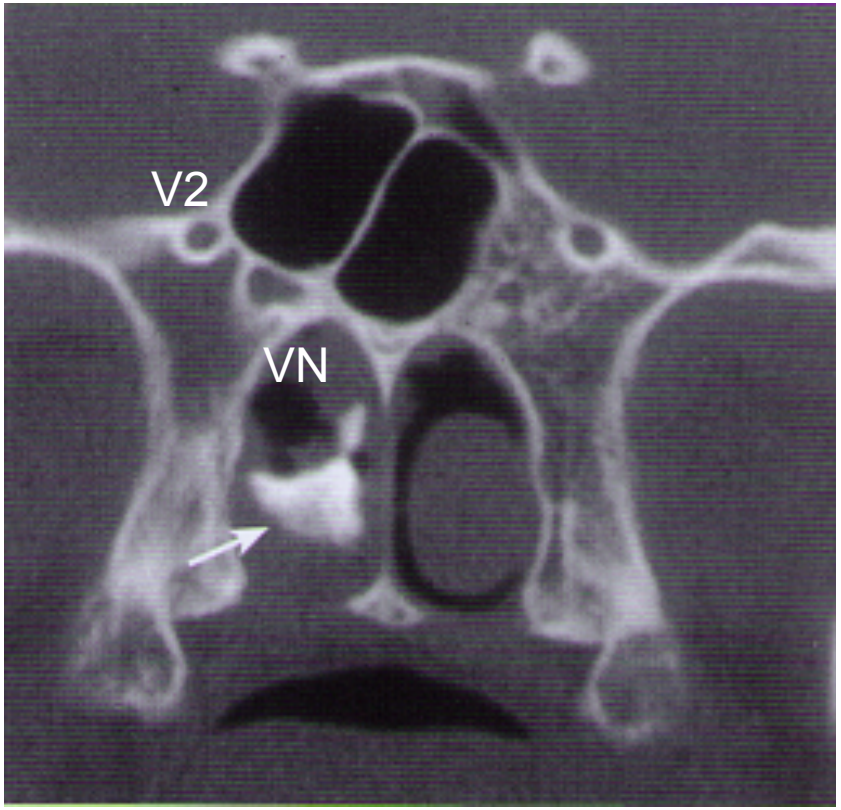
- The most common location for spontaneous CSF leaks and encephaloceles is the lateral recess of the sphenoid sinus
- Young to middle age obese women with benign intercranial hypertension (BIH)



Woodworth BA, Prince A, Chiu AG, et al. Spontaneous CSF leaks: a paradigm for definitive repair and management of intracranial hypertension. Otolaryngol Head Neck Surg 2008; 138:715–720.

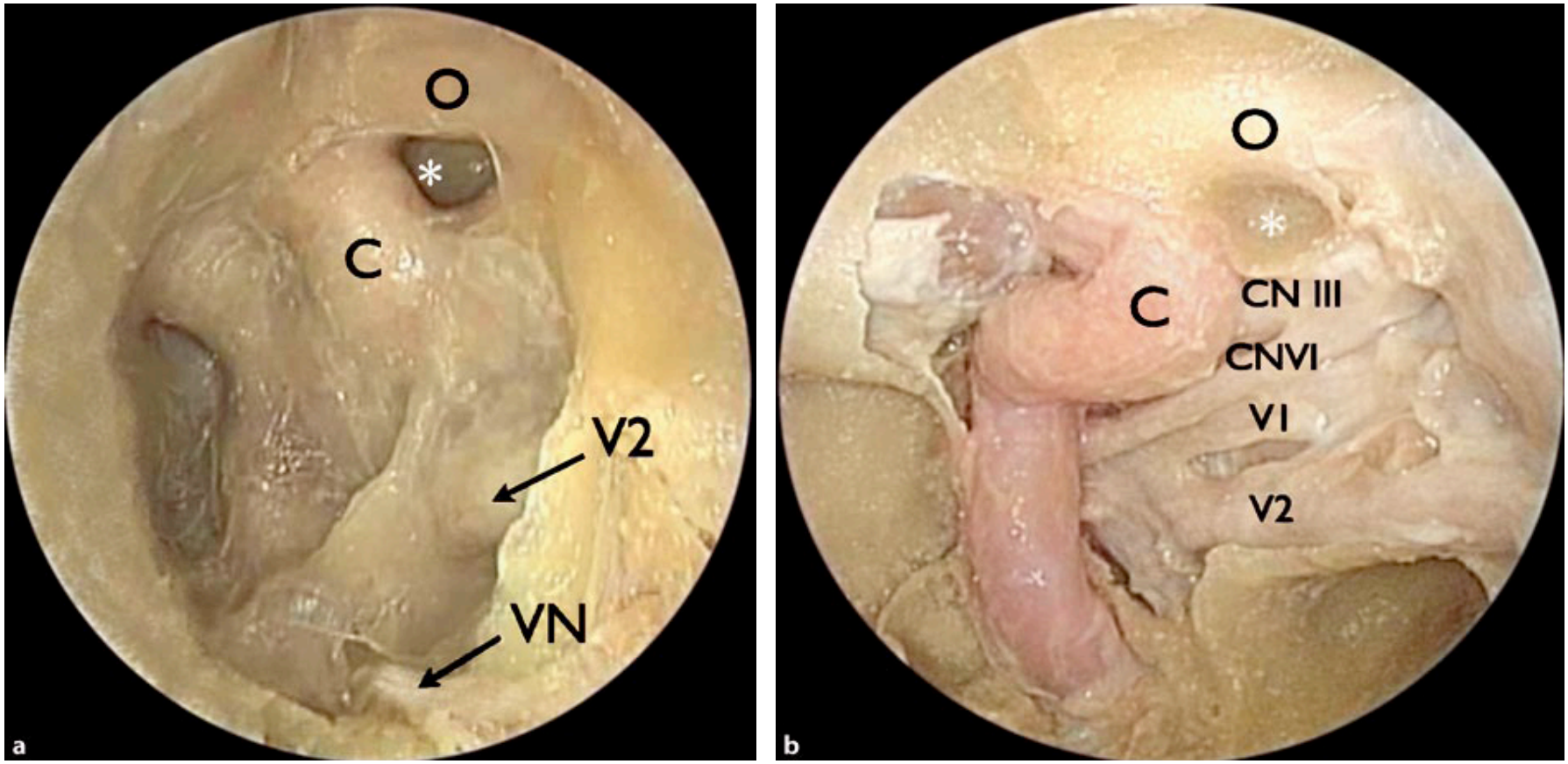
Relationship between Vidian and Maxillary Nvs.

- Vidian canal is <u>medial</u>
- Maxillary nerve (v2) from foramen rotundum is <u>lateral</u>



Endoscopic View of Cavernous Sinus

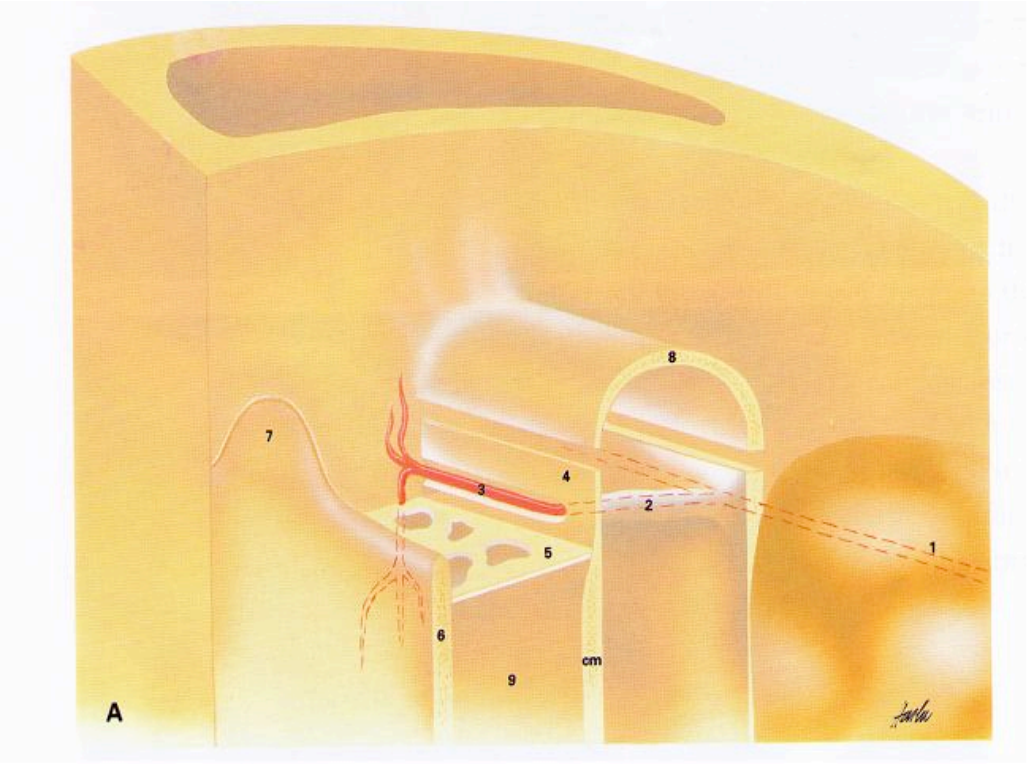
Picture: left sphenoid sinus (CN IV not shown)

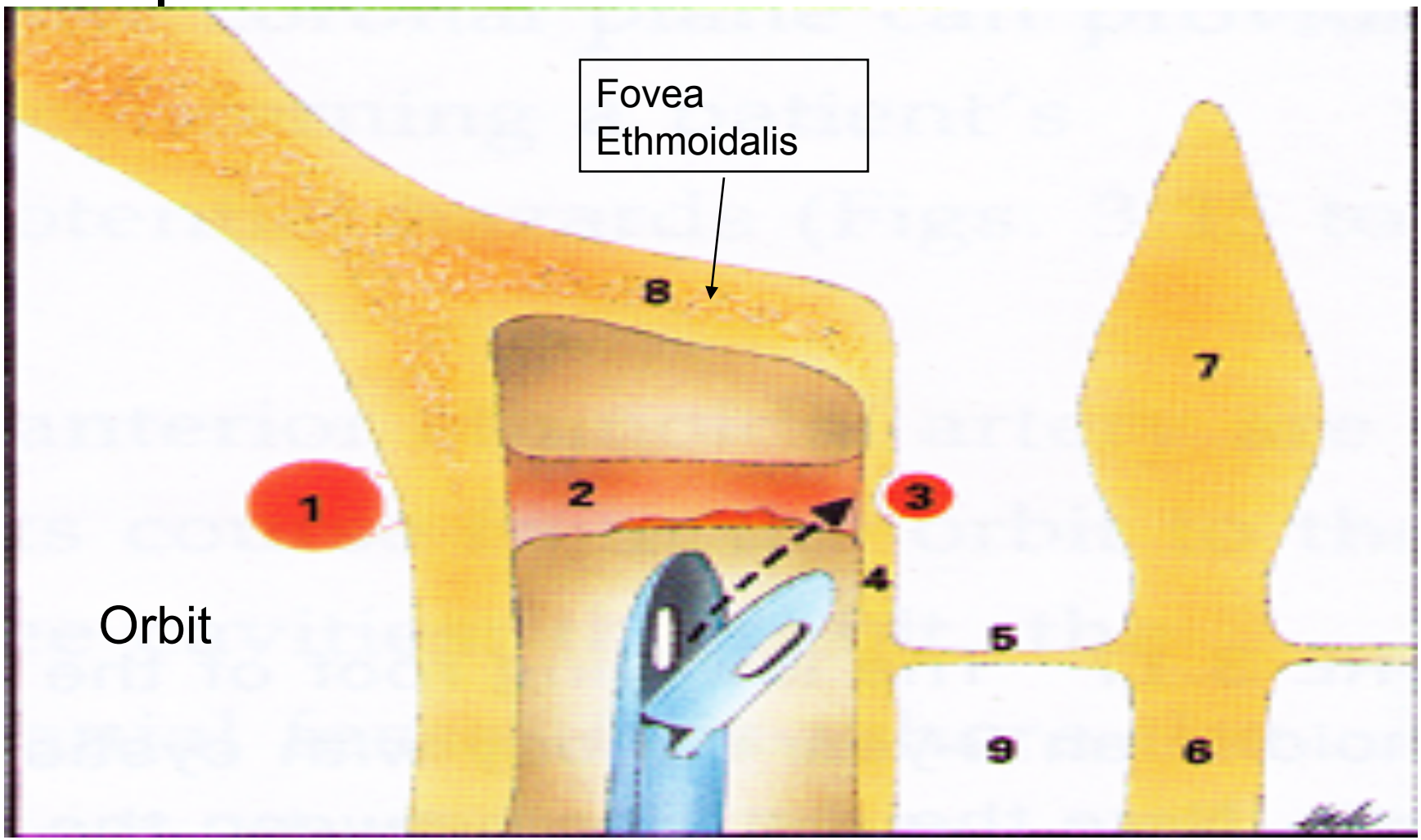


Casiano R. Surgical Anatomy in Revision Sinus Surgery. Chapter 7 p53-61

Anterior Ethmoid Artery

- Variable position
- Bony canal or mesentery (1-3+ mm below roof)
- Posterior boundary of frontal recess





- 1: Orbit
- 2: AEA (piercing lateral lamella of cribiform)

Conclusions

- Knowledge of anatomy is essential for a surgeon
- Learn consistent terminology
- Go to courses (USC course, Loma Linda Course, Sonoma Course, ARS section meetings at COSM)


SV-2
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“The petrous apex is best approached through the nose”

Akira Ishiyama, MD