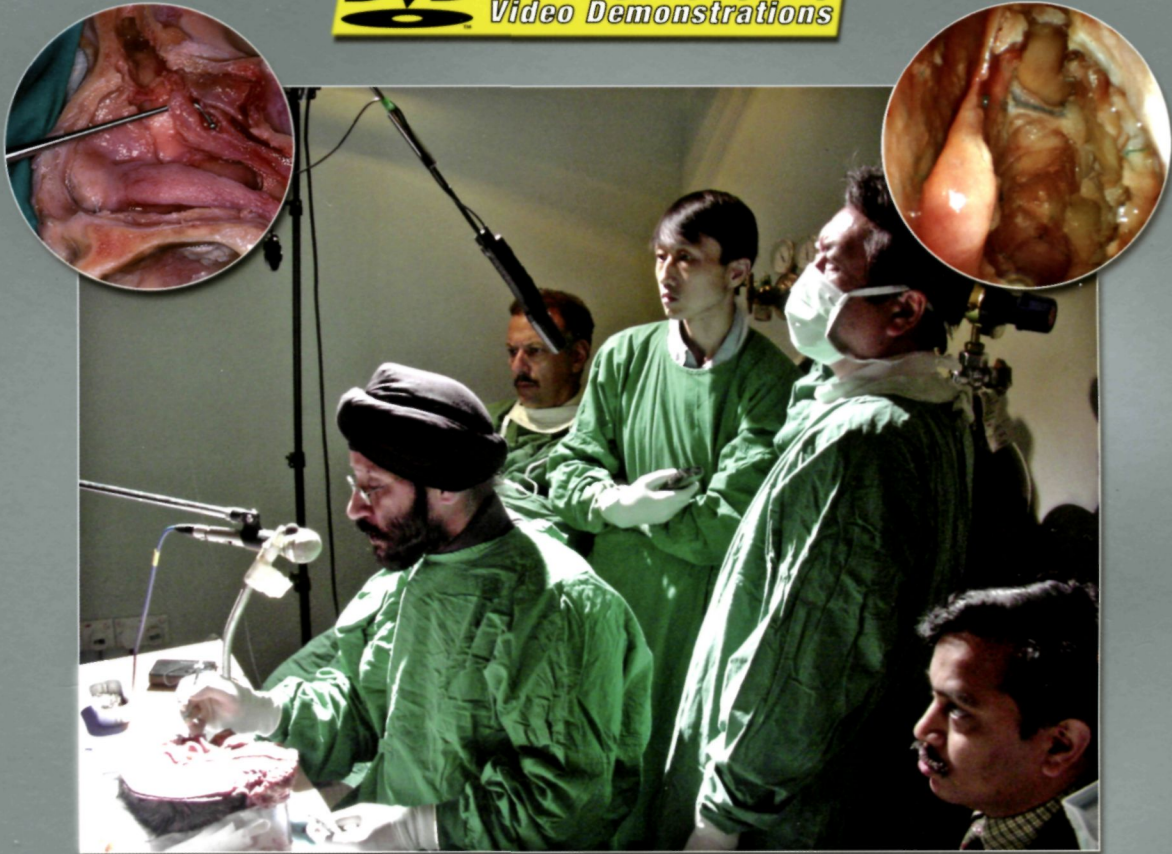


BASIC AND ADVANCED ENDOSCOPIC SINUS SURGERY TECHNIQUES

A Laboratory Dissection Manual

DVD including Step-by-Step
Video Demonstrations



Dharambir Singh SETHI, MBBS, FRCS (Ed), FAMS (ORL)

Department of Otorhinolaryngology,
Singapore General Hospital, Republic of Singapore

**Basic and Advanced Endoscopic Sinus Surgery Techniques
- A Laboratory Dissection Manual -**

Dharambir S. SETHI, FRCS (Ed) FAMS (ORL)

Department of Otorhinolaryngology
Singapore General Hospital
Republic of Singapore

Contact:

Dharambir S. Sethi, FRCS (Ed) FAMS (ORL)

Singapore General Hospital
Department of Otorhinolaryngology
Office: Block 6 Level 6
Outram Road
Singapore 169608, Republic of Singapore
Phone: +65 6321 4790
Fax: +65 6226 2079
Email: goldss2002@yahoo.com

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E-mail: Endopress@t-online.de

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Introduction

Since the introduction of endoscopic sinus surgery in the mid-1980s, there has been global interest in this technique. Although the method has been widely accepted, it has nevertheless been characterized as often being technically difficult, with a steep learning and often fraught with potentially serious complications in the hands of the inexperienced.

One of the keys to learning endoscopic sinus surgery is to acquire a sound knowledge of the anatomy of the nose and the paranasal sinuses. Hundreds of courses and workshops have been offered on the subject all over the world. Owing to the regulations governing the use of human tissue in different countries, however, cadaver dissection is not offered as part of all workshops. Because it is of paramount importance to perform some cadaver dissection before embarking on this type of training, surgeons are encouraged to attend workshops offering cadaver dissections.

This dissection manual has been written with the objectives of describing the gross and endoscopic sinus anatomy, and to act as a step-by-step guide for those who are learning endoscopic sinus surgery. The manual describes sequential steps in performing sinus dissection and offers tips on instrument handling techniques that will help surgeons avoid complications.

In the past two decades, various advanced endoscopic sinus procedures have evolved. This manual also describes the surgical anatomy and the dissection steps pertaining to the orbit, skull base, optic nerve, pituitary, parasellar region and the cavernous sinus.

Before performing an endoscopic dissection, it is vitally important to develop an understanding of the gross anatomy of the lateral nasal wall. In the past several years, we have introduced dissection of the lateral wall as part of our sinus surgery courses to offer participants an opportunity to dissect the lateral nasal wall and understand its relevance to endoscopic sinus surgery.

The dissection is best performed on a fresh human cadaver head. For our dissection courses, the cadaver heads are deep-frozen and subsequently thawed a few hours before the dissection. The head is cut sagittally with an electric saw through the nasal septum to provide two hemi-heads for lateral wall dissection. Once the gross lateral wall anatomy is understood, delegates proceed to performing endoscopic dissection of the sinuses.

This manual provides a pictorial overview of the gross anatomy of the lateral nasal wall and a step-by-step guide to endoscopic dissection of the nasal cavity and paranasal sinuses.

Pictorial Overview of the Lateral Wall and Endoscopic Dissection of the Nose and Paranasal Sinuses

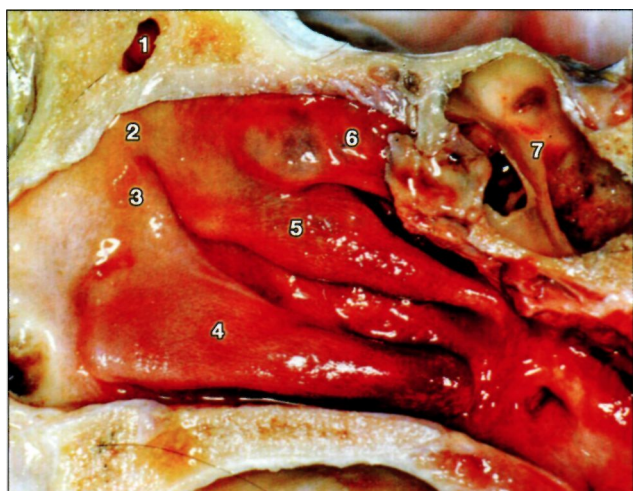


Fig. 1
Right lateral nasal wall showing the turbinates; inferior turbinate ④, middle turbinate ⑤ and superior turbinate ⑥. Note the frontal ① and the sphenoid sinus ⑦. Note the prominences of the **agger nasi** ② and the **nasolacimal duct** ③

Anatomy of the Lateral Nasal Wall

The lateral nasal wall consists of the following bones: the **frontal process of the maxilla**, **lacrimal bone**, **ethmoid bone** and **vertical plate of the palatine**.

Three prominent projections are seen on the lateral nasal wall. These are termed the **inferior**, **middle** and **superior turbinates** (Fig. 1). The inferior turbinate is an independent bone, whereas the middle and superior turbinates are part of the ethmoid complex. Occasionally, a fourth turbinate, called the **supreme nasal turbinate**, is present. The lateral recesses formed under these turbinates are called the meati, and are known as the **inferior**, **middle** and **superior meatus** (Fig. 3).

A prominence may be seen on the lateral wall, anterosuperior to the origin of the middle turbinate. This is the **agger nasi** (Latin for "nasal mound") (Fig. 1). It is pneumatized in 98% of specimens to form the agger nasi cell. This agger nasi cell is the most anterior and consistent of the ethmoid cells. It is bounded laterally by the lacrimal bone, anteriorly by the frontal process of the maxilla, medially by the uncinat process and posteriorly related to the ethmoid infundibulum. Superiorly, it forms the anterior boundary of the frontal recess.

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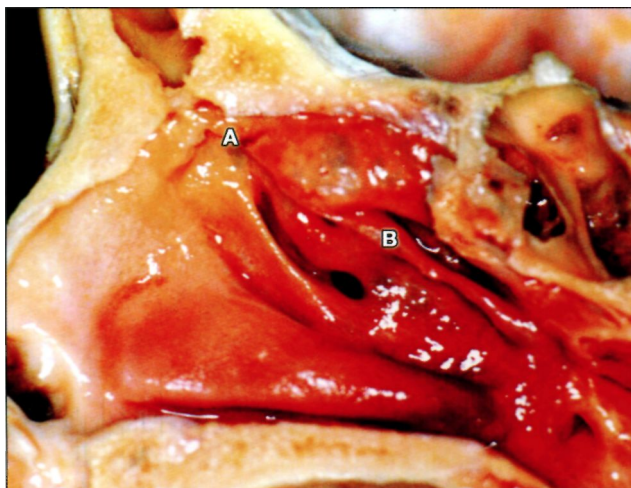


Fig. 4

The middle turbinate has been trimmed from its attachments. The anterior third of the **middle turbinate** is attached to the **skull base** (A) and the middle third and the posterior third curves laterally to form the **basal lamella** (B), which inserts onto the lamina papyracea. The basal lamella separates the anterior group of paranasal sinuses from the posterior group. Note the five lamellae: the uncinat process, bulla ethmoidalis, basal lamella of the middle turbinate, lamella of the superior turbinate and the anterior sphenoid wall.

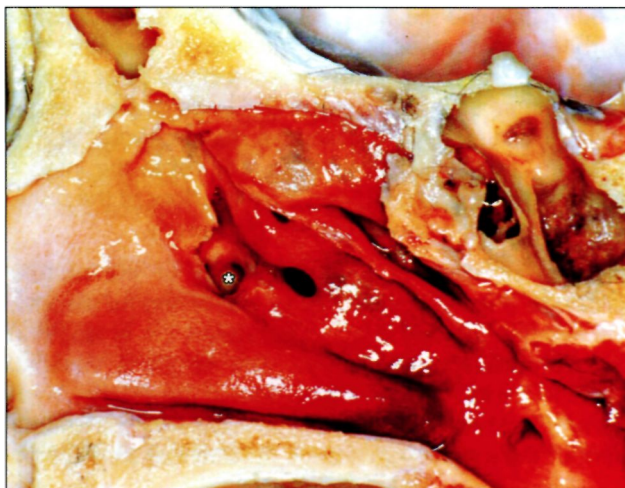


Fig. 5

Part of the uncinat process has been removed from the junction of its anterior superior part and posterior inferior part. This reveals the **natural maxillary sinus ostium** indicated by the asterisk (*).

pneumatized in 60 to 70% of cases. The bulla often may be highly pneumatized, extending to the skull base superiorly and to the ground lamella posteriorly. Its anterior wall forms the posterior limit of the ethmoid infundibulum, and its posterior wall is the anterior wall of the retrobullar recess (Fig. 8). The lateral wall of the ethmoid bulla is formed by the **lamina papyracea** (Figs. 4, 7, 9, 10). Superiorly, the anterior and posterior walls merge as the bulla lamella, and may attach to the skull base immediately anterior to the anterior ethmoid artery, which forms the posterior limit of the frontal recess. Inferiorly and posteriorly, it may fuse with the basal lamella, in which case the retrobullar recess may be obliterated or absent.

The two-dimensional cleft between the posterior free border of the uncinat and the anterior wall of the bulla ethmoidalis is termed the **hiatus semilunaris inferioris** (Fig. 2). A variable cleft called the **hiatus semilunaris superioris** (Fig. 8) may be identified between the posterior aspect of the bulla ethmoidalis and the basal lamella.

The hiatus semilunaris inferioris is located from 1-10 mm (43% of cases) to 11-20 mm (47% of cases) behind the anterior attachment of the middle turbinate. The length of the semilunar hiatus is between 14 and 22 mm and its medial-lateral extent 0.5 to 3 mm. The hiatus semilunaris inferioris opens laterally into a three-dimensional space, the **ethmoid infundibulum** (Fig. 6), bounded medially by the uncinat process, posteriorly by the anterior wall of bulla ethmoidalis and laterally by the lamina papyracea.

The **ethmoid infundibulum** is better examined following removal of the uncinat process (Fig. 7). The infundibulum may continue anteriorly and superiorly into the frontal recess in about 14% of cases. More commonly, in about 86% of cases, the infundibulum ends in a superior blind recess formed by the superior attachment of the uncinat process laterally to the lamina papyracea. This recess is termed the **recessus terminalis** (Fig. 6). In this situation, the frontal sinus will drain medial to the uncinat process and independent of the ethmoid infundibulum.

The following structures open into the ethmoid infundibulum: the anterior ethmoid cells that include the agger nasi cell and any frontal cells, the maxillary sinus and the frontal sinus **if** the uncinat attaches medially. The infundibulum was first identified by BOYER in 1805; therefore, in French-speaking countries, the cells opening in this area are known as Boyer's cells.

A small variable space may exist superior and posterior to the bulla ethmoidalis. This three-dimensional space separates the bulla ethmoidalis from the skull base and basal lamella, and is referred to as the **retrobullar recess** (Fig. 8). It opens medially through the hiatus semilunaris superioris.

The **maxillary sinus ostium** (Fig. 5) is normally hidden from view by an intact uncinat process. It is located at the junction of the anterosuperior and posteroinferior aspects of the infundibulum and may be visualized following removal of the uncinat process.

Another prominence is noted on the lateral wall, inferior to the agger nasi cell and anterior to the uncinate process. It is formed by the **nasolacrimal duct (Fig. 1)** as it courses from the lacrimal sac to its opening in the inferior meatus. The nasolacrimal duct is about 12 mm in length, and its opening (**Figs. 16, 19**) in the inferior meatus approximately 15mm from the floor of the nose. As it descends, it curves slightly posteriorly.

An understanding of the attachment of the **middle turbinate (Fig. 4)** is essential to preserving its stability. The middle turbinate is approximately 4 cm in length in its anteroposterior dimension. The height is variable, about 14.5 mm, 12.5 mm and 7 mm in the anterior, middle and posterior segments, respectively. The attachment of the middle turbinate is divided into three parts.

The **anterior third** of the **middle turbinate (Fig. 4)** is attached sagittally to the skull base and lateral to the cribriform plate. As the attachment continues posteriorly, it turns laterally to attach to the lamina papyracea, forming a coronally oriented plate called the **basal lamella (Figs. 2,4,8,10)**. The posterior third of the middle turbinate attachment is almost horizontal and attached along the lamina papyracea as far as the perpendicular plate of the palatine bone. The multiple orientation of the basal lamella accounts for its stability, which can be compromised by excessive resection.

The basal lamella of the middle turbinate is the demarcation between anterior and posteriorly draining groups of sinuses.

The **anterior drainage system** is anterior to the ground lamella and drains the frontal, maxillary and anterior ethmoids.

Medial and superior retraction of the middle turbinate reveals the structures forming the anterior drainage system.

The **uncinate process (Figs. 2, 3)** is a thin, almost sagittally oriented, boomerang-shaped bony leaflet that forms part of the lateral nasal wall between the middle and the inferior turbinates from an anterosuperior to posteroinferior position. It is attached anteriorly to the posterior edge of the lacrimal bone and inferiorly (by several bony pedicles) to the superior edge of the inferior turbinate. It has a free posterosuperior border. Superiorly, it may be attached to the lamina papyracea, roof of the ethmoid sinus or middle turbinate. The uncinate process may present many anatomical variations, including a medially and laterally bent uncinate process. The uncinate process represents the first basal lamella (together with the agger nasi).

The **bulla ethmoidalis (Fig. 2)** is the most prominent of the anterior ethmoid air cells and is readily identified posterior to the uncinate process. The term bulla indicates that this part of the bone is pneumatized. Where the bulla is not pneumatized, it is referred to as the lateral torus. The ethmoid bulla is about 18 (9-23) mm long and 5.4 (2-13) mm high. It may be variable in size and is

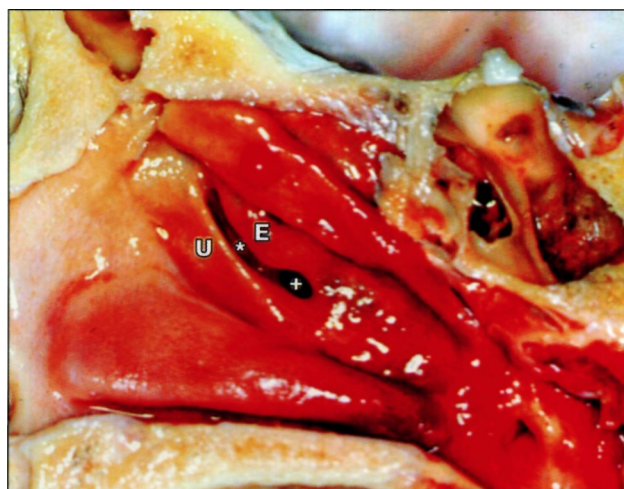


Fig. 2

The middle turbinate has been reflected to reveal the middle meatus. Note the **uncinate process (U)**, the **bulla ethmoidalis (E)**. The middle turbinate has been reflected upon its lateral attachment called the basal lamella. The uncinate process, bulla ethmoidalis, basal lamella and the anterior sphenoid wall form the four lamellae on the lateral wall. The cleft between the posterior free border of the uncinate process and the anterior wall of the bulla is the **hiatus semilunaris inferioris (*)**. Note an **accessory ostium (+)** in the posterior fontanelle. This is not the natural maxillary sinus ostium which is located in the ethmoid infundibulum and concealed by the uncinate process.

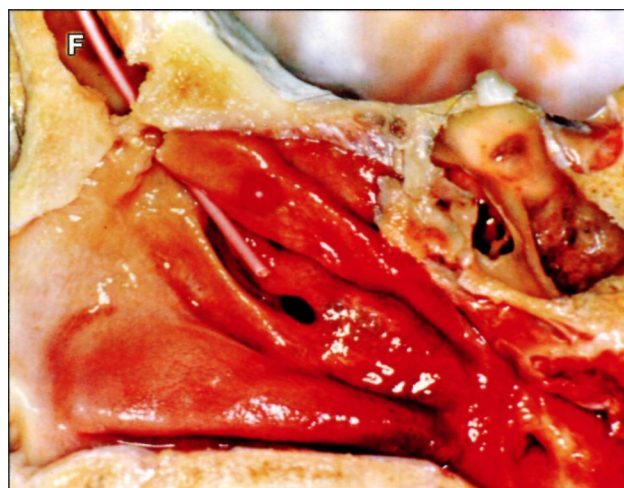


Fig. 3

A probe has been passed from the **frontal sinus (F)** through the frontal recess into the **middle meatus**. Note that it is emerging medial to the uncinate process indicating that frontal drainage is medial to the uncinate process in this specimen.

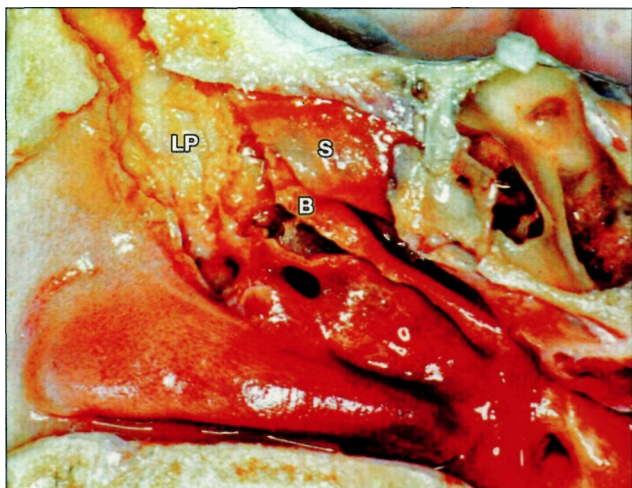


Fig. 9

All anterior ethmoid cells have been removed while retaining the attachment of the **basal lamella (B)** and delineating the **lamina papyracea (LP)**. The **superior turbinate (S)** is still intact.

The lateral wall of the ethmoid complex is formed by the **lamina papyracea (Figs. 4, 7, 9, 10)**, which is literally paper-thin, so the orbital fat imparts a yellowish color to it. The medial rectus muscle may occasionally be located in close contact with the lamina. The lamina thickens toward the orbital apex to form the optic tubercle protecting the optic nerve, which becomes medial and runs in close proximity to the medial orbital wall in this location.

The ethmoid complex on either side of the cribriform plate is roofed over by the **fovea ethmoidalis** of the frontal bone. Its average thickness is 5 mm and it slants posteriorly at 15 degree angle, forming the anterior two thirds of the **ethmoid roof**. Medially, it joins the lateral lamella of the lamina cribrosa, forming a very fragile junction that is very thin, about one-tenth the thickness of the lateral skull base. The vertical height between the cribriform fossa and the fovea ethmoidalis may vary up to 17 mm and may be asymmetric. The medial slope of the roof may also be variable. The thin lateral lamella is at risk of being penetrated during ethmoid dissection.

The size of the **sphenoid sinus (Figs. 1, 13, 15)** may vary, depending upon the degree of pneumatization.

There are three commonly described patterns:

Sellar type	76%	pneumatization beyond the anterior sellar wall
Pre-sellar type	21 %	pneumatization to the sellar wall (Fig. 12)
Conchal type	3%	poorly pneumatized

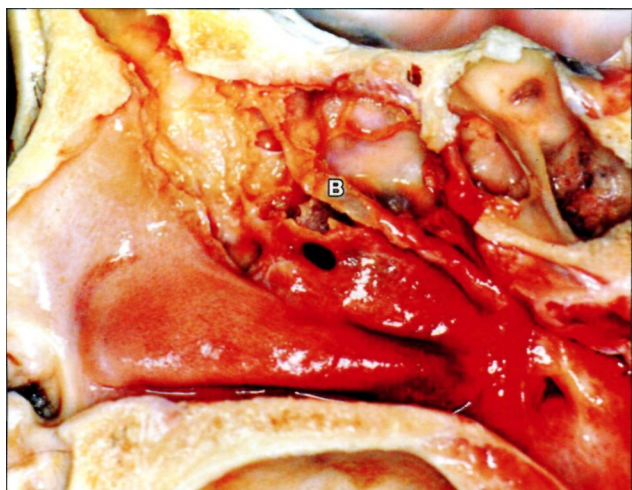


Fig. 10

The superior turbinate and posterior ethmoid cells have been removed, keeping the **basal lamella** intact (**B**). Note how the basal lamella attaches to the lamina papyracea separating the anterior group of the paranasal sinuses from the posterior group.

The **sphenoid sinus ostium (Fig. 12)** is located high in the sphenoethmoid recess on the anterior sphenoid wall and is just medial to the superior turbinate.

The **anterior sphenoid wall (Figs. 4, 13)** has a variable degree of obliquity running in an anteromedial to posterolateral direction. In the presence of a sphenoethmoidal (Onodi) cell, the anterior wall will not extend to the skull base (i.e., the sphenoethmoid or Onodi cell is superior and lateral to the sphenoid sinus).

The roof of the sphenoid is level anteriorly with the skull base. It is fairly flat and is called the **planum sphenoidale (Fig. 31)**.

The junction of the planum sphenoidale and posterior sphenoid wall is thickened to form the tuberculum sella. The optic chiasm is about 2 - 7 mm posterior to the tuberculum sella. Inferior to the tuberculum sella, the posterior wall forms the anterior wall of the sella turcica (Figs. 12, 31, 32). The pituitary gland is located within the sella turcica. Inferiorly, the posterior wall separates the clivus.

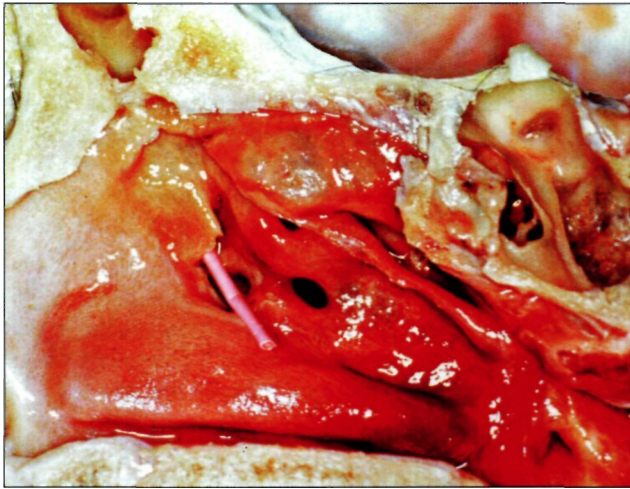


Fig. 6
A probe has been passed into the ethmoid infundibulum to feel the superior attachment of the uncinate process. In this case, the **ethmoid infundibulum** ends superiorly in a blind recess called the **recessus terminalis**, indicating the superior attachment of the uncinate process onto the lamina papyracea.

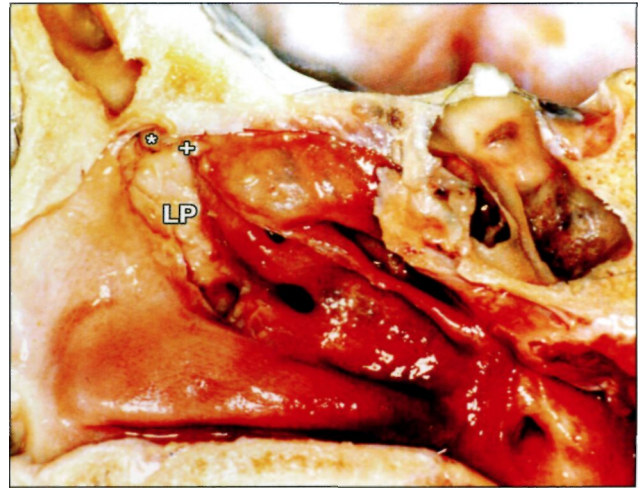


Fig. 7
The uncinate process has been removed, opening the **ethmoid infundibulum**. Note the lateral wall of the ethmoid infundibulum formed by the **lamina papyracea (LP)**. The **frontal recess** is indicated by the asterisk (*). Note that the ethmoid bulla lamella inserts superiorly on the skull base (+). This forms the posterior limit of the frontal recess.

The maxillary sinus ostium is elliptically shaped and approximately 7 to 11 mm long and between 2 and 6 mm wide. It may be as deep as 18-20 mm and forms a short canal running inferiorly and laterally into the maxillary sinus. The ostium is in a slanted plane that is oriented almost 90 degrees to the hiatus semilunaris.

The **anterior** and **posterior fontanelles** (Fig. 2) are membranous areas in the lateral nasal wall, formed by a doubled layer of mucosa filling in the gaps of the bony lateral nasal wall. The small anterior fontanelle is antero-superior to the hiatus semilunaris. The larger posterior fontanelle is posteroinferior to the hiatus semilunaris. It forms the medial wall of the antrum between the natural ostium and the vertical plate of the palatine bone. Often an **accessory ostium** (Fig. 2) is seen in this area (10-50% of cases).

The **posterior ethmoid cells** are posterior to the basal lamella. The **posterior ethmoid cells** drain under the superior turbinate into the superior meatus. The size of the posterior cells depends on the degree of encroachment by the anterior ethmoid cells and posteriorly by the sphenoid. They are generally larger and fewer, varying from 1 to 5 in number.

A posterior ethmoid cell may pneumatize posterolaterally and posterosuperiorly in relation to the anterior wall of the sphenoid. This is a **sphenoethmoid cell**, also known as an **Onodi cell**. In this situation, the sphenoid sinus will be located inferior and medial to this cell, **but NOT** posterior to it.

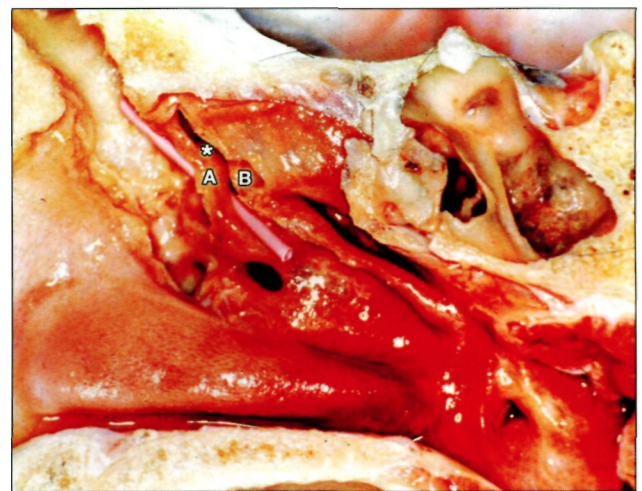


Fig. 8
The bulla ethmoidalis has been removed while retaining the posterior wall. A probe has been passed through an opening in the posterior wall of the bulla, which drains the ethmoid bulla into the **retrobullar recess**. Note the cleft (*) between the posterior wall of the **ethmoid bulla (A)** and the **basal lamella (B)**. This two-dimensional cleft is termed the **hiatus semilunaris superioris**. It leads into a three-dimensional space called the **retrobullar recess**.

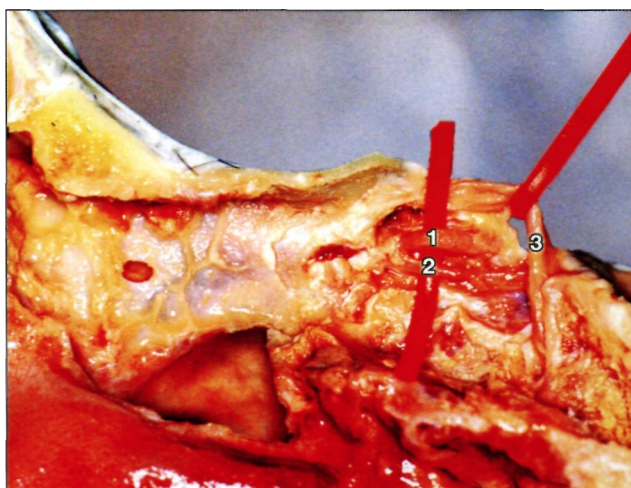


Fig. 14

The medial wall of the cavernous sinus has been opened to expose the contents of the cavernous sinus. The cavernous portion of the **internal carotid artery (3)** is the most medial structure in the cavernous sinus. It has been retracted to show the **III. (1)** and the **VI. (3) cranial nerves**, which are lateral to the carotid artery.

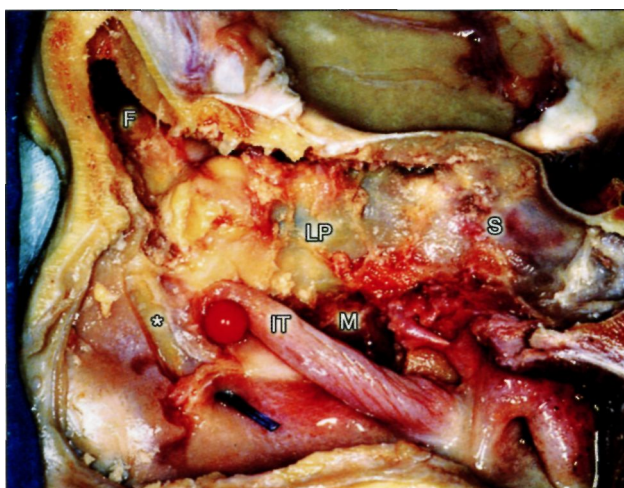


Fig. 15

A complete frontal-ethmoid-sphenoid dissection has exposed the **frontal sinus (F)**, **lamina papyracea (LP)**, **sphenoid sinus (S)** and **maxillary sinus (M)**. The anterior end of the **inferior turbinate (IT)** has been truncated and retracted superiorly to expose the inferior meatus. The **opening of the nasolacrimal duct** in the inferior meatus can be identified by the blue probe that has been passed through it. The mucosa overlying the nasolacrimal duct has been removed to show the **anterior bony covering (*)**.

Frontal ethmoid cells, as described and classified by KUHN, are additional anterior ethmoid cells located superior to the agger nasi. When present, they can cause further narrowing of the frontal recess from the anterior. Frontal cells are classified as types 1 to 4 (refer to the literature by KUHN)

The **anterior ethmoid artery (Figs. 28, 30)**, a branch of the ophthalmic artery, lies in the roof of the ethmoid sinus and forms the posterior limit of the frontal recess. This artery is in the same coronal plane as the anterior aspect of the ethmoid bulla or just behind. Therefore, the anterior wall of the bulla may be considered to be the posterior extent of the frontal recess. After leaving the orbit through the anterior ethmoid foramen, the anterior ethmoid artery crosses the anterior ethmoid complex in a medial and anterior direction, then exits the ethmoid complex to run anteriorly in the olfactory groove. It then passes through a slit by the side of the crista galli and returns through the cribriform plate to re-enter the nasal cavity.

The **nasolacrimal system (Fig. 16)** comprises the **lacrimal sac** and the **nasolacrimal duct**. The **lacrimal sac** is formed by the lacrimal bone, and the anterior and posterior lacrimal crests. It is located lateral to the agger nasi.

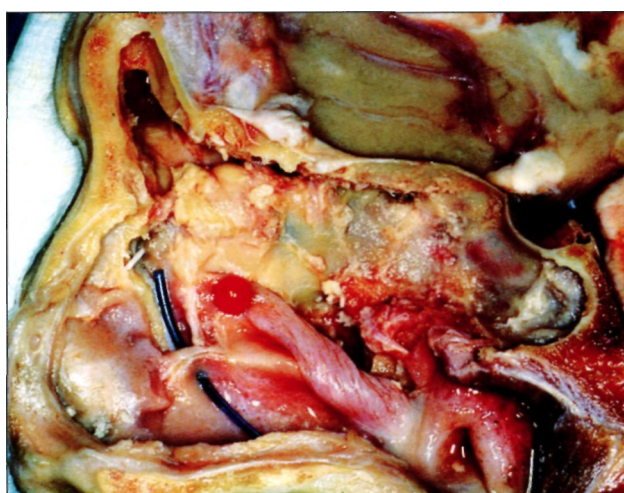


Fig. 16

The lacrimal sac and nasolacrimal duct have been incised open. The **nasolacrimal duct** and its opening are indicated by the blue probe. The location of the **common canaliculus** in the lateral wall of the lacrimal sac is shown by the white probe.

The **nasolacrimal duct** forms a prominence on the lateral nasal wall in the very anterior aspect of the medial wall of the maxillary sinus. The lacrimal bone is very thin posteriorly and thick anteriorly. The nasolacrimal duct opening is located in the inferior meatus.

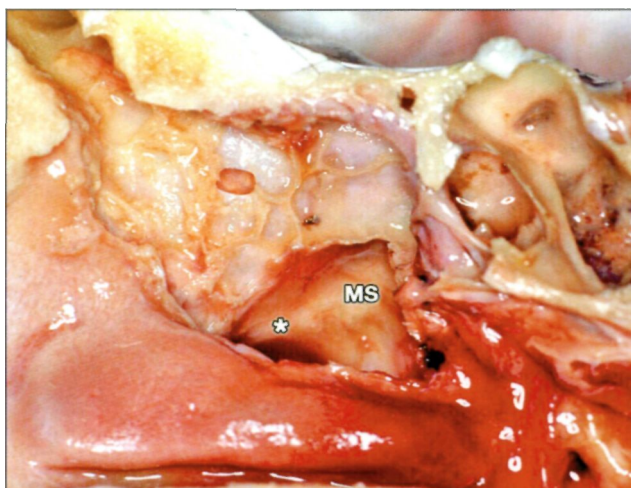
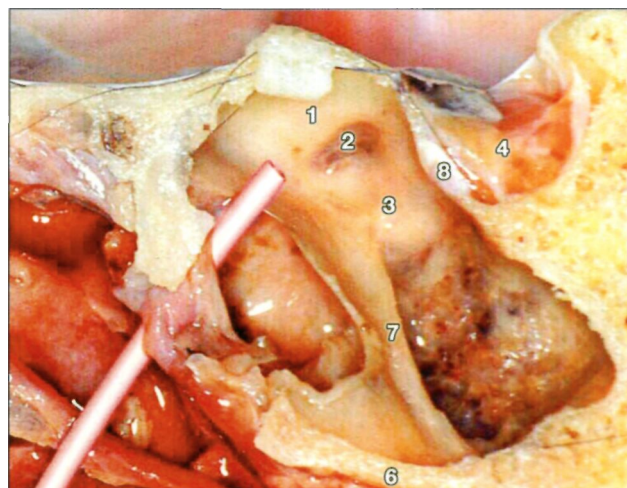


Fig. 11

The basal lamella has been removed, delineating the entire lamina papyracea. A wide middle meatal antrostomy has been created, opening the **maxillary sinus (MS)**. Note the position of the **inferior orbital nerve (*)**.



A **presellar type of sphenoid sinus** is noted as the pneumatization of the **posterior wall of the sphenoid sinus (5)** does not extend posterior to the **anterior sellar wall (8)**. The anterosuperior prominence on the lateral wall is the **optic nerve (1)** and the posteroinferior prominence is the **cavernous carotid artery (3)**. Note a dimple-like recess between the two structures. This is termed the **opticocarotid recess (2)**. Also, note the **intersinus septum (7)** inserted on the carotid artery. The **floor of the sphenoid sinus (6)** separates it from the nasopharynx. The pituitary gland lies in the **sella turcica (4)**. A probe has been passed through the sphenoid ostium.

The lateral wall may reveal two prominences. The anterosuperior prominence on the lateral wall is formed by the **optic nerve**. The posteroinferior prominence is formed by the **cavernous carotid artery (Fig. 12)**. In a well-pneumatized specimen, these structures may be dehiscent (the optic nerve is dehiscent in 4-5% of cases, and the carotid in up to 20%). Occupying the space between the two is a small recess called the infraoptic recess, also referred to as the **opticocarotid recess (Fig. 12)**.

The **frontal recess (Figs. 3, 7, 25-27)** is a complex anatomical area leading from the anterior ethmoids up to the frontal ostium. Its anatomic boundaries are:

Anterior	agger nasi cell
Posterior	anterior ethmoid artery
Medial	anterior portion of the middle turbinate
Lateral	lamina papyracea

The superior attachment of the uncinate process determines the drainage pattern of the frontal sinus.

In 86% of patients, the uncinate process is attached to the lamina papyracea and the infundibulum ends superiorly against the lamina papyracea as the **recessus terminalis**. **In such cases, the frontal recess drains into the space between the uncinate and the middle turbinate (Fig. 3).**

In 14% of cases, the uncinate either attaches superiorly to the skull base or laterally to the middle turbinate. The

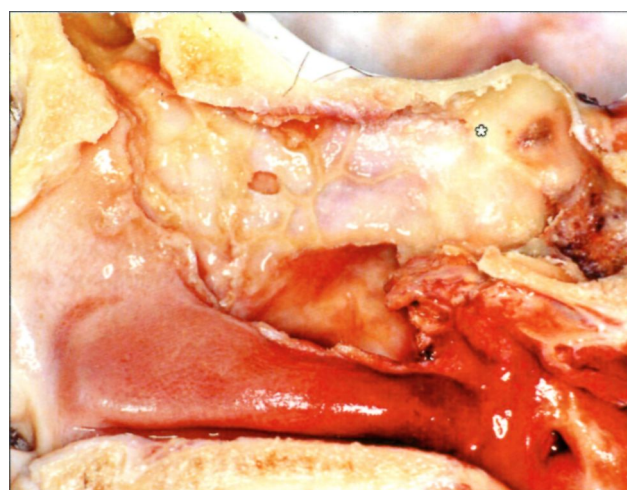


Fig. 13

The anterior wall of the sphenoid sinus has been removed, revealing the location of the **orbital apex (*)**.

frontal sinus will drain directly into the infundibulum in these configurations.

The **agger nasi cell (Fig. 1)** forms the anterior limit of the frontal recess. It is in approximately the same coronal plane as the nasolacrimal duct. An enlarged agger nasi cell may impinge on the frontal sinus, narrowing the frontal recess.

5 Middle Meatal Antrostomy

Engage an iridectomy scissors in the maxillary ostium, and make two cuts in the posterior fontanelle. The first cut is superior flush, with the roof of the maxillary sinus. The other cut is inferior, flush with the inferior turbinate. Remove the posterior fontanelle to create a wide middle meatal antrostomy.



Identify:

Study the anatomy of the maxillary antrum. **Identify** the infraorbital nerve.

6 Dissection of the Frontal Recess

Study the boundaries of the frontal recess. These are: anteriorly, the agger nasi cell; posteriorly, the anterior wall of the bulla ethmoidalis; laterally, the lacrimal sac and lamina papyracea; and, medially, the middle turbinate (removed).

Remove the posterior and medial wall of the agger nasi to identify the frontal opening and drainage pattern.

Note that the lateral wall of the agger nasi is related to the lacrimal fossa. Identify the frontal beak and remove it using a curette or drill to widen the frontal opening.

The frontal opening is exposed from the anterior wall of the agger nasi to the anterior wall of the bulla.

7 Dissection of the Anterior Ethmoid

Remove the anterior wall of bulla ethmoidalis, keeping the posterior wall intact. With a ball probe, look for any opening in the posterior wall. The bulla usually drains in the retrobullar recess through an opening in the posterior wall.

Remove the bulla completely as well as all anterior ethmoid cells anterior to the basal lamella, while keeping the basal lamella intact.



Identify:

- the ethmoid roof from the posterior table of the frontal sinus to the basal lamella,
- the anterior ethmoidal artery. It may be closely applied to the skull base, on a mesentery or running freely across the ethmoid cavity. Note that the artery runs from posterolateral to anteromedial direction.

8 Dissection of the Posterior Ethmoid

Remove the superior turbinate.

Study the attachments of the basal lamella.



Identify:

- the sphenoid ostium, and note whether the anterior or sphenoid wall extends up to the skull base.

Note the presence or absence of any sphenoethmoid cells, and look for the prominence of the optic nerve.

Remove the basal lamella and all posterior ethmoid cells.



Identify:

- the posterior ethmoid artery. It may not be always identifiable as it runs in the skull base.

Skeletonize the lamina papyracea from the nasolacrimal duct to the optic tubercle.

9 Skull Base



Identify:

- the skull base from the posterior table of the frontal sinus to the planum sphenoidale.

Note that the skull base slopes inferiorly from anterior to posterior, being more flattened toward the posterior ethmoids/sphenoid.

Dissection of the Lateral Nasal Wall

- 1** Remove the nasal septum completely and study the lateral nasal wall.

Use a ball probe to palpate the various bony prominences, soft tissue and sinus openings.



Identify:

- Frontal sinus
- Agger nasi
- Nasolacrimal prominence
- Inferior, middle and superior meatus
- Sphenoethmoid recess, sphenoethmoid cell (if any)
- Sphenoid sinus

Note the attachment of the middle turbinate anteriorly to the skull base and posteriorly to the lateral nasal wall.

- 2** Reflect the middle turbinate medially and superiorly, and



Identify the:

- Uncinate process
- Bulla ethmoidalis
- Hiatus semilunaris inferioris and superioris
- Ethmoid infundibulum
- Retrobullar/suprabullar recess
- Posterior fontanelle

With a ball probe, palpate the boundaries of the ethmoid infundibulum. Medially, the uncinate process; laterally, the lamina papyracea; and, posteriorly, bulla ethmoidalis.

Gently palpate the attachments of the uncinate process.

Pass a ball probe in the ethmoid infundibulum lateral to the uncinate, and try to palpate its superior attachment. Is there a recessus terminalis? (86% of cases)

Pass a probe from the frontal sinus through its ostia and note where it appears in relation to the uncinate process.

Is it medial to the uncinate (86% of cases), or is it lateral (14% of cases)?

- 3** Remove the middle turbinate with iridectomy scissors, trimming its anterior attachment from the skull base and then the basal lamella.

Note the five lamellas:

- Uncinate process
- Bulla ethmoidalis
- Basal lamella of the middle turbinate
- Basal lamella of the superior turbinate
- Anterior wall of the sphenoid

Study the superior attachment of the uncinate process.

Note the bulla ethmoidalis and its relationships. Does it extend superiorly to the skull base? Is there a suprabullar recess?

Study the attachment of the basal lamella.

Palpate the boundaries of the retrobullar recess. Anteriorly, the bulla ethmoidalis; posteriorly, the basal lamella; superiorly, the ethmoid roof.

4 Uncinectomy

Using a reverse-cutting forceps, remove the part of the uncinate process from the junction of the anterior superior part of uncinate with the inferior posterior part. Note that the natural maxillary ostium is located in the ethmoid infundibulum. Pass a probe superiorly into the ethmoid infundibulum to feel the superior attachment of the uncinate process.

Using a #11 blade, detach the anterior, inferior and superior attachments of the uncinate process and remove it.



Identify:

- Lamina papyracea
- Natural maxillary ostium
- Posterior fontanelle

Look for any Haller (infraorbital ethmoid) cell or accessory ostia.

Endoscopic Sinus Dissection

Prior to beginning a dissection, it is important to clean any debris and secretions from the nasal cavity of the specimen.

Debris in the intranasal cavity may be cleaned using suction or unfolded 4 x 4 gauze grasped with a Blakesley forceps.

After the nasal cavity is cleaned, a 30°-telescope, 4 mm in diameter, is introduced into the nasal cavity.

1 Nasal Endoscopy

The first step is to perform a nasal endoscopy, which is performed by two passes.

First Pass

Begin by advancing the telescope into the nose, following the **nasal floor** and looking at the **inferior turbinate**, the **free edge** of the **middle turbinate** and the superior aspect of the nasal cavity. Approximately two thirds of the way through the nasal cavity, the posterior aspect of the middle meatus will come into view. This is the region of the **posterior fontanelle**. Continue to advance the scope posteriorly, identifying the **Eustachian tube orifice**, the **fossa of Rosenmuller** and the **nasopharynx**. As the scope is withdrawn, try to insinuate it under the inferior turbinate to examine the

inferior meatus. In some cases, the **nasolacrimal duct opening** or **Hasner's valve** can be visualized as either a small punctate or slit-like opening at the junction of the anterior and middle thirds of the inferior turbinate. To visualize this structure, a Freer elevator can be used to medialize the inferior turbinate.

Second Pass

The endoscope is reintroduced into the nose to more closely examine the **middle meatus**. Proceed to the anterior head of the middle turbinate and observe the structures within the anterior aspect of the middle meatus.

The middle meatus is often shielded from view by the uncinate process and middle turbinate. The insertion of the **uncinate process** can be identified by a shallow groove just behind the lacrimal fossa.

Note the bulla **ethmoidalis** and identify the **hiatus semilunaris inferioris** and **superioris**. Notice whether the ethmoid bulla inserts to the skull base.

It may be possible to identify the **frontal opening** and the **retrobullar recess**.

The **natural maxillary ostium** is hidden from view as it lies within the infundibulum. The **uncinate process** has to be removed to visualize it.

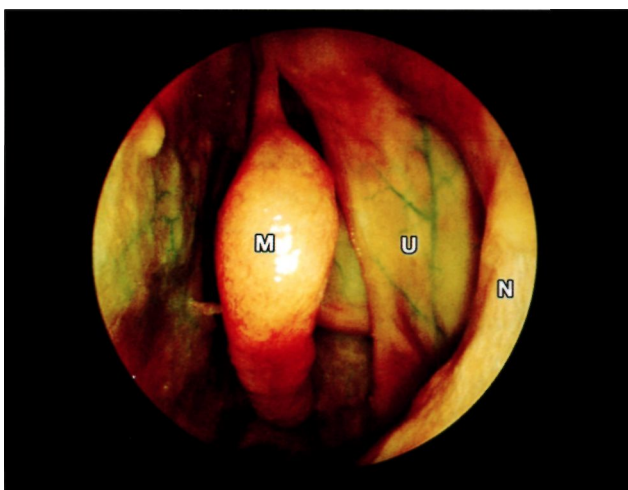


Fig. 17

Endoscopic view of the left nasal cavity. The prominences of the **nasolacrimal duct (N)** and **uncinate process (U)** are visible. Note the groove between the two structures. This corresponds to the attachment of the uncinate process to the nasolacrimal duct. M - middle turbinate.

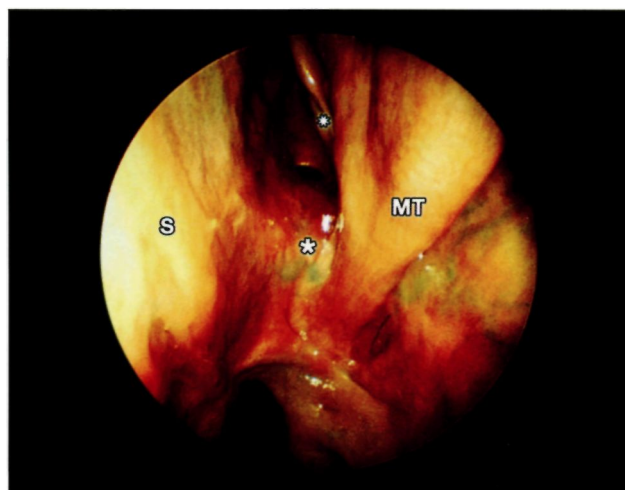


Fig. 18

Endoscopic view of the left sphenothmoid recess (SER). The SER (*) is bounded medially by the nasal septum (S) and laterally by the **superior turbinate (*)**. The sphenoid ostium is usually located in this recess about 1.5 cm superior to the posterior choana. MT - middle turbinate; ET - Eustachian tube.

10 Sphenoid Sinus



Identify:

- the sphenoid ostium,
- anterior sphenoid wall,
- planum,
- tuberculum sella and
- sella turcica.



Identify:

- the optic nerve and the cavernous carotid artery on the lateral wall of the sinus, and **study** its relationship to the cavernous sinus.

Remove the anterior wall of the sphenoid sinus.

Using a diamond burr, remove the bone overlying the soft tissue on the lateral wall of the sphenoid sinus.



Identify:

- the medial layer of the cavernous sinus, which can be extremely thin.

Gently slit the medial layer of the cavernous sinus to expose its contents.

Note that the cavernous portion of the internal carotid artery is the most medial structure in the cavernous sinus.



Identify:

- the entire course of the cavernous carotid artery from the petrous apex, and note its relationship with the sella turcica.

Mobilize and retract the artery superiorly and medially.



Identify:

- the oculomotor, abducent and the trochlear nerves, which are lateral to the artery.

11 Nasolacrimal Drainage System

Detach the anterior end of the inferior turbinate, and look for the opening of the nasolacrimal duct in the inferior meatus. It is often covered by a mucosal flap called the Hasner's valve.

Pass a probe through the Hasner's valve into the nasolacrimal duct.

Study the bony canal of the nasolacrimal duct.

Note that, the bone is thicker anteriorly, formed by the frontal process of the maxillary, and it is thinner posteriorly, formed by the ethmoid bone.

Remove the bony wall to expose the nasolacrimal duct. The thinner posterior portion may be removed with a curette, and the thicker anterior part with a rongeurs.

Note the dimensions of the nasolacrimal duct. Slit open the duct and the lacrimal sac, and look for the opening of the common canaliculus of the lateral wall of the lacrimal sac.

Note that the superior limit of the lacrimal sac is about 5 mm superior to the opening of the common canaliculus.

It is important to ascertain whether the blade is inside the infundibulum prior to engagement so that the backbiting cut will go cleanly through the entire thickness of the uncinate without stripping mucosa.

The small backbiter is brought forward for a further bite. If solid, unyielding bone is encountered by the backbiter, then one is approaching the area of the nasolacrimal duct. Backbiting a third time is therefore unsafe.

The upper uncinate process can now be mobilized with a ball probe, rotating medially around the agger area as the fulcrum. This makes it easier for the edge to be grasped.

A 90 degree upturned BLAKESLEY forceps is used to grasp the mobilized uncinate, holding it as close to the lacrimal crest attachment as practical. The uncinate can then be avulsed cleanly with a quick posteriorly directed push.

Any residual superior uncinate, either bone or mucosa, can be cleaned with the microdebrider.

Recommendations

- ☞ It is important to resect the uncinate process in its entirety, especially superiorly and inferiorly, in order to adequately visualize the frontal recess and the maxillary ostium, respectively.
- ☞ Engage the uncinate free edge as low as possible prior to backbiting. The natural ostium is located inferiorly in the infundibulum and may be obscured by a tall uncinate remnant.

- ☞ An inferior uncinate remnant may be removed by first attempting to fillet out the bony core using a fine ball probe. This should be done prior to shaving down the mucosa with a microdebrider.

3 Middle Meatal Antrostomy

Aims



Identify:

- the natural maxillary ostium and widen it posteriorly to form a middle meatal antrostomy.

Anatomy

After removal of the uncinate process, the ethmoid bulla and **maxillary ostium** should be visible. The ostium lies at the junction of the anterior and inferior walls of the ethmoidal bulla.

If the ostium is not seen clearly with a 30°-telescope, it may be very laterally located. In such situations, use a 45°- or 70°-telescope to examine the lateral nasal wall and identify the natural maxillary ostium. If the ostium is incompletely visualized, it may be necessary to take a curette and remove any residual uncinate process.

Examine the posterior fontanella for any accessory ostium.

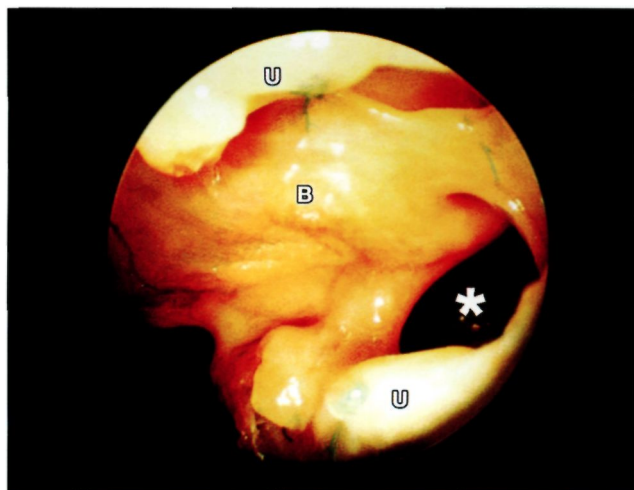


Fig. 21
A 70°-telescope is used to visualize the left **natural maxillary sinus ostium** (*). The **uncinate process** (U) has been partially removed. Note that the ostium is at the junction of the anterior and inferior aspects of the **bulla ethmoidalis** (B).

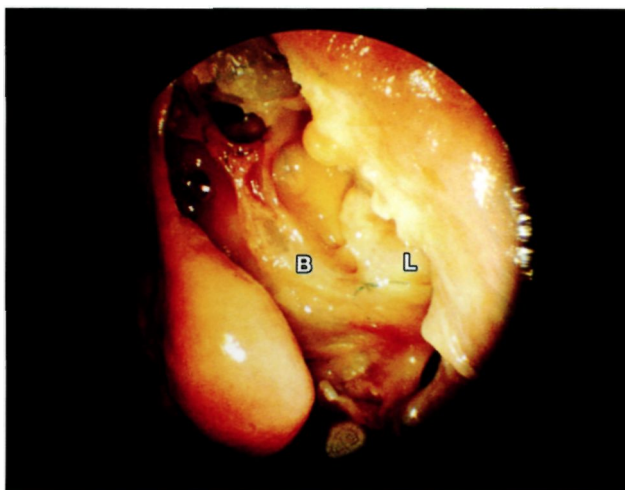


Fig. 22
The uncinate process has been completely removed, opening the ethmoid infundibulum, which is bounded laterally by the **lamina papyracea** (L). The **ethmoid bulla** (B) that forms the posterior wall of the ethmoid infundibulum is still intact.

Continue slightly more posteriorly, gaining a better view of the **posterior fontanelle**. **Accessory ostia** can often be seen in this region and may indicate maxillary disease caused by mucus recirculation.

When the posterior aspect of the middle meatus has been examined, direct the telescope just **medial to the middle turbinate** and advance it slightly more posteriorly. The region between the nasal septum and the middle turbinate can be somewhat difficult to access. High up on the sphenoid rostrum, at about the level of the superior turbinate or slightly inferiorly, the **sphenoid ostium** can be visualized just medial to the turbinate.

2 Infundibulotomy

Aims

- to gain access to the ethmoid infundibulum
- to identify the lamina papyracea
- to identify the natural ostium of the maxillary sinus
- to identify the recessus terminalis, if any
- to identify the frontal recess

Anatomy

With a Freer elevator, gently medialize the middle turbinate and study the anatomy of the **ostiomeatal complex**, which comprises the uncinate process, ethmoidal bulla, middle turbinate and frontal recess.

Visualize the entire **uncinate process** and delineate its posterior free margin. Study the attachments of the uncinate process.

Just posterior to the uncinate process is the **ethmoidal bulla**, which can assume a variety of configurations and does not always have to be pneumatized.

Identify the cleft between the uncinate process and the ethmoidal bulla, which forms the **hiatus semilunaris inferioris**. Notice that the posterior free edge of the uncinate slopes inferiorly as it runs backward to lie just above the inferior turbinate.

With an endoscope, examine the small cleft between the uncinate process and the anterior insertion of the middle turbinate into which the **frontal recess** opens in most situations (86% of cases), if a recessus terminalis is present.

Technique

Having confirmed the position of the hiatus semilunaris inferioris with a ball probe and palpated the infundibulum, a small backbiter is inserted into the middle meatus. The instrument is turned 90 degrees so that the biting blade is opened upward, in the vertical plane of the meatus.

The open blade is then rotated back 90 degrees to engage the posterior free edge of the uncinate.

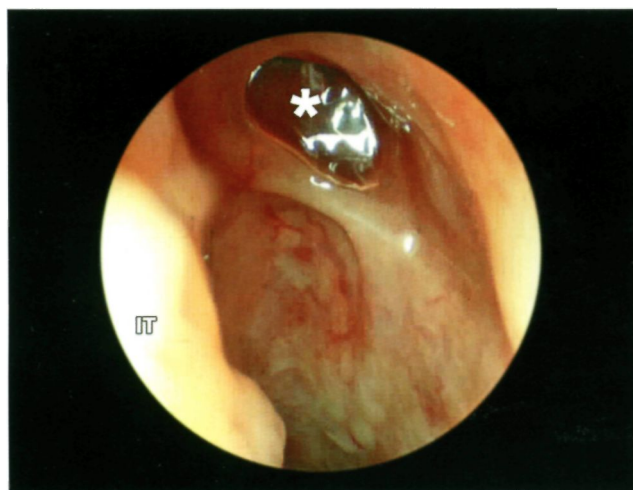


Fig. 19
Endoscopic view of the **nasolacrimal duct opening** in the left inferior meatus. IT - left inferior turbinate; * - nasolacrimal duct opening.

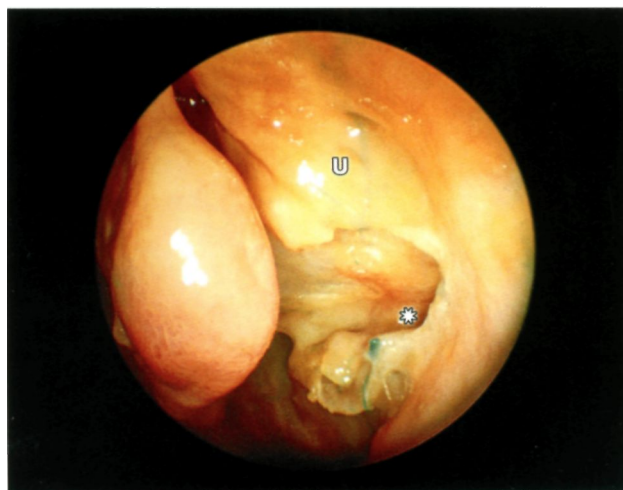


Fig. 20
The **uncinate process (U)** has been partially removed at the junction of its anterosuperior portion with its posteroinferior part. * - the location of the **natural maxillary ostium**, which is only partially visible with a 0°-telescope.

4 Dissection of the Anterior Ethmoid

Aims

- to remove the ethmoidal bulla and ethmoidal cells anterior to the ground / basal lamella
- to identify the anterior skull base, anterior ethmoidal artery and retrobullar recess
- to maintain an intact ground lamella

Anatomical Boundaries

The boundaries of the dissection are:

- anteriorly, the ethmoid infundibulum
- laterally, the lamina papyracea
- medially, the middle turbinate
- superiorly, the skull base
- posteriorly, the ground lamella

Technique

Infraction and remove the anterior wall of the ethmoidal bulla. Remove the inferior and medial walls completely, while attempting to keep the posterior wall intact.



Identify:

- the **lamina papyracea**, which forms the lateral wall of the ethmoidal bulla. This forms the lateral landmark of the dissection in the anterior ethmoid cavity. Its plane may be gauged by visualizing via the antrostomy where the orbital floor turns up to the medial orbital wall.

Identification of the **anterior skull base** is the next step. Begin the dissection from posterior to anterior to define the skull base. There are often some small cells sitting superior to the ethmoidal bulla, which are termed the **suprabullar cells**.

As the skull base begins to curve superiorly, it forms a structure called the **ethmoidal dome**. On the more anterior aspect of this structure, the anterior ethmoid artery is visible crossing transversely.

The **anterior ethmoid artery** can either be freely exposed, attached on a bony mesentery or contained within a bony canal flush with the ethmoidal dome. There is often a triangular cell just cephalad to the anterior ethmoid artery. This triangular cell sits behind the back wall of the frontal sinus opening and is called the **supraorbital cell**. The anterior ethmoid artery does not necessarily have to be perfectly transverse, but can actually be oblique to the sagittal plane. Accompanying the anterior ethmoid artery is the anterior ethmoid nerve.

Next, carefully perforate the **posterior wall of the ethmoidal bulla**. In those circumstances where the posterior wall is not fused with the ground lamella of the middle turbinate, the **retrobullar recess** can be identified just behind the bulla.

Carefully remove the entire posterior wall to clearly identify the **retrobullar recess**. This recess is an excellent anatomic landmark that is helpful for identification

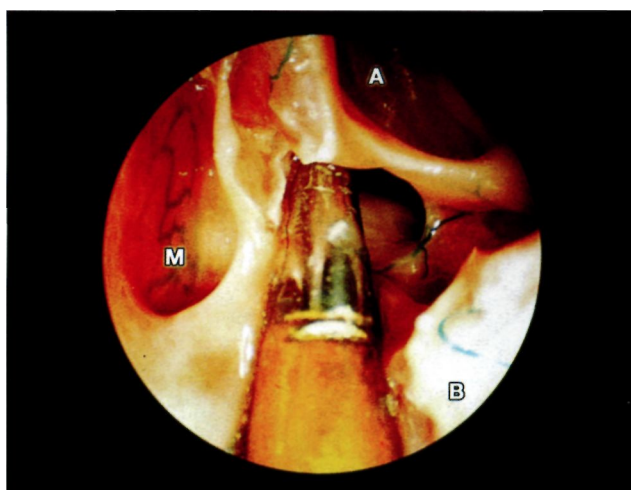


Fig. 25
Endoscopic view of the frontal recess. Note the relationship of the **aggr nasi (A)** with the frontal recess. A curette has been passed through the frontal recess into the frontal sinus. **M** - **middle turbinate**; **B** - the location of the **ethmoid bulla**.

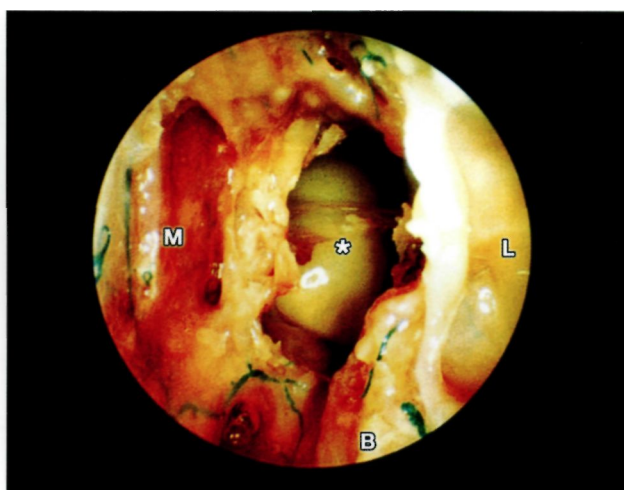


Fig. 26
The medial, posterior and superior wall of the aggr nasi has been removed to open the **frontal sinus (*)**. The **ethmoid bulla (B)** is still intact. **M** - the position of the **middle turbinate**, which forms the medial boundary of the frontal recess; **L** - the **lamina papyracea**, which forms the lateral boundary.

Technique

Once the maxillary ostium is identified, take a straight scissors. Engage one blade of the scissors in the maxillary ostium and the other outside it, and cut into the posterior fontenelle, flush with the roof of the maxillary sinus as far back as the posterior wall of the maxillary sinus.

Make a similar cut flush with the superior margin of the inferior turbinate.

Remove the posterior fontenelle between these **two** cuts with a through-cutting Blakesley forceps as far back as the palatine bone (posterior wall of the maxillary sinus).

If the ostium is fairly lateral and not accessible with a straight scissors, use a right-curved scissors for the left side, and a left-curved scissors for the right side. The curvature of the blades may help to reach the ostium.

If an accessory ostium is visualized, a backbiting forceps may be used to perform the middle meatal antrostomy. The forceps engages the accessory ostium and backbites forward to join the natural ostium.

Alternatively, a backbiting forceps can be used to remove the inferior margin of the antrostomy, and an upbiting Blakesley can be used to remove the superior portion of the fontenelle adjacent to the ostium.

These maneuvers should provide wide exposure to the maxillary sinus. In real cases, the antrostomy is, of course, not as large.

Examine the interior of the maxillary sinus, using 30°-, 45°- and 70°-telescopes. The ridge of the inferior orbital nerve along the antral roof can be visualized.

Recommendations

- ✎ Ascertain that the natural ostium is contiguous with the remainder of the antrostomy in order to prevent recirculation.
- ✎ Using backbiting forceps, gently remove any residual uncinate process adjacent to the maxillary ostium. Do not engage too far forward, however, to avoid injury to the nasolacrimal duct.
- ✎ Any heavy bone that is encountered in the course of this dissection should not be resected because this is usually the firm bone that sits around lacrimal sac and duct.
- ✎ Although the antrostomy can be performed at any time, it is preferably done before opening the bulla. Maintaining the bulla provides a landmark for the junction of the medial and inferior orbital walls, thus enabling the surgeon to easily find the adjacent ostium and prevent damage to the lamina papyracea in situations where the ostium is difficult to find.

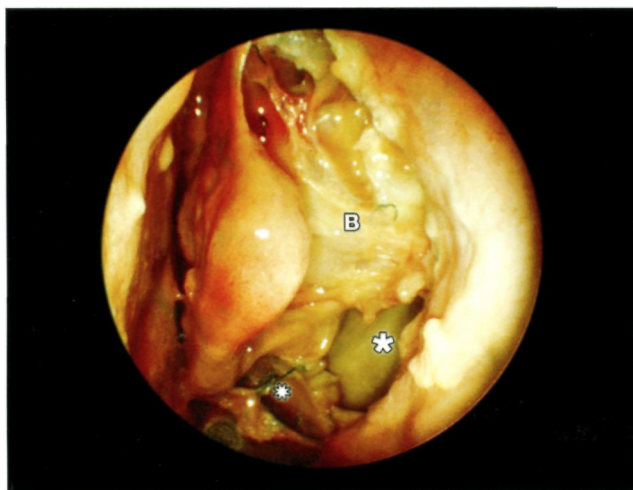


Fig. 23

A middle meatal antrostomy (★) has been created by extending the natural maxillary ostium into the posterior fontenella. **B - ethmoid bulla**. Note the location of the **sphenopalatine foramen** (★) and a branch of the sphenopalatine artery entering the nasal cavity.

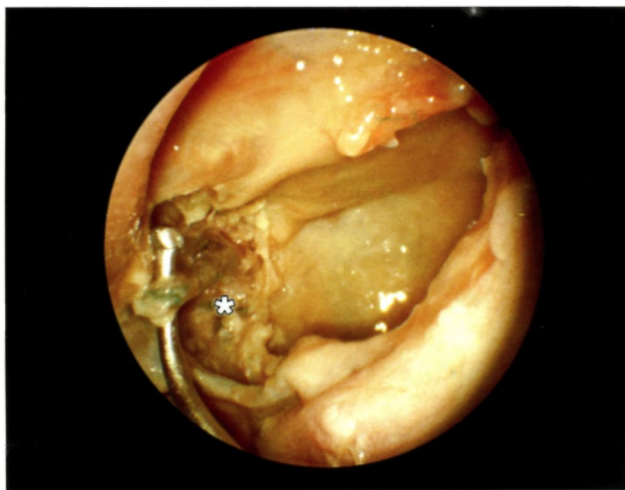


Fig. 24

The sphenopalatine foramen has been opened into the **pterygo-palatine fossa** (★) to expose the **sphenopalatine artery** hooked by a ball probe.

Recommendations

- ✎ To enter the posterior ethmoid cells, perforate the ground lamella inferiorly and medially.
- ✎ To ensure good access to the sphenoid sinus, it is important that the ground lamella and any residual posterior wall of the ethmoidal bulla be taken down to their most inferior extent.
- ✎ Once the posterior ethmoid dissection is complete, carefully examine the lateral superior aspect of the posterior ethmoid cell.

Two structures in this region are of interest:

First, the optic nerve can indent into the posterior ethmoid sinus in this region. The **optic nerve** appears as a whitish structure very similar to the skeletonized facial nerve in the mastoid cavity.

The second structure of interest in this area is the **sphenoid cell** or **Onodi cell**, a posterior ethmoid cell that pneumatizes lateral and superior to the sphenoid, extending beyond the anterior wall of the sphenoid. It is pyramidal in shape with three walls consisting of the anterior wall of the sphenoid, skull base and medial orbital wall. The optic nerve runs in the lateral wall.

6 Dissection of the Sphenoid Sinus

Aims

- to perform a sphenoidotomy
- to remove the anterior sphenoid wall
- to examine the intrasphenoid anatomy

Anatomy



The following structures should be **identified**:

Laterally: Posterosuperiorly, the optic nerve

Posteroinferiorly, the cavernous internal carotid artery

Inferiorly, the maxillary branch of the trigeminal nerve and the vidian nerve

Superiorly: Planum sphenoidale

Posteriorly: from superiorly to inferiorly, the tuberculum sellae, anterior sellar wall and clivus

Technique

Sphenoidotomy

Accurately identifying the anterior sphenoid wall is **most important**. Several maneuvers are helpful in identification of the **anterior sphenoid wall**

- ✎ The anterior wall is often found 7 cm from the anterior nasal spine at 30 degrees inclination from the floor of the nose. This is quite variable and must be recognized as a guide only.

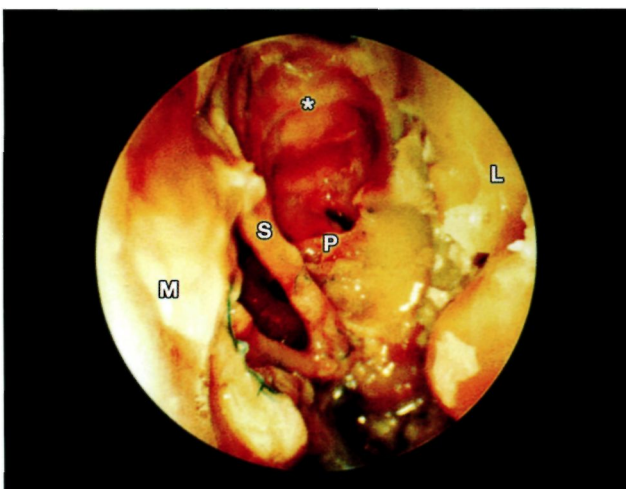


Fig. 29
Endoscopic view of the boundaries of the **posterior ethmoid cells (P)**, bounded medially by the **superior turbinate (S)**, laterally by the **lamina papyracea (L)** and superiorly by the **skull base (*)**. Note that the skull base is flat posteriorly. Also note the sphenoid ostium medial to the superior turbinate in the sphenoethmoid recess. **M** - middle turbinate.

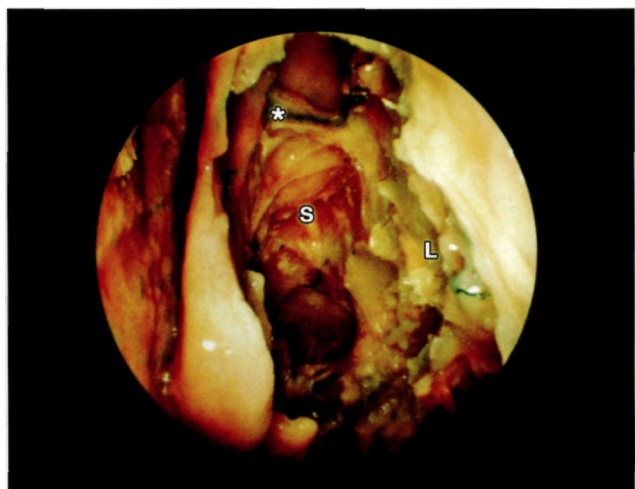


Fig. 30
A complete ethmoidectomy has been performed by removing the posterior ethmoid cells to expose the **skull base (S)** and **lamina papyracea (L)**. ***** - anterior ethmoid artery.

of the skull base. The skull base forms the superior limit of this variable funnel-shaped space. If this maneuver is successfully performed, then the ground lamella of the middle turbinate will be left intact.

Carefully examine the **ground lamella** and note how it connects the middle turbinate to the lamina papyracea in its more posterior portion. Anterosuperiorly, the ground lamella turns up to join the skull base and inserting at the junction of the cribriform plate and the fovea ethmoidalis just posterior to the anterior ethmoid artery.

5 Dissection of the Posterior Ethmoid

Aims

- to dissect the posterior ethmoidal cells
- identify the skull base, posterior ethmoidal neurovascular bundle, anterior sphenoid wall, superior turbinate and sphenoid ostium

Anatomical Boundaries

The ground lamella of the middle turbinate forms a partition between the anterior and posterior ethmoid cells.

The anatomical boundaries are:

- anteriorly, the ground lamella
- posteriorly, the anterior sphenoid wall
- laterally, the lamina papyracea
- superiorly, the skull base
- medially, the superior turbinate

Technique

Perforate the ground lamella to delineate the **posterior ethmoid cells**. Notice that the posterior ethmoidal cells are generally larger than the anterior ethmoid cells. The safe area to perforate is medially and interiorly, just above the point where the ground lamella turns from vertical to horizontal.



Identify:

- the lamina papyracea and the skull base, then carefully remove the septations of the posterior ethmoid cells from the medial orbital wall and the skull base.



Identify:

- the posterior **ethmoid artery and nerve**, which is present in approximately 70% of cases. This landmark is very helpful in that it lies several millimeters just anterior to the anterior wall of the sphenoid.

Examine the **anterior wall of the sphenoid**. When it is demucosalized, it has a slightly bluish hue compared with the yellowish color of the medial orbital wall and skull base. Also, notice how the **skull base** descends inferiorly as it moves in an anterior to posterior direction. Failure to recognize the descent of the anterior cranial fossa can result in cranial breach just anterior to the anterior sphenoid wall.



Identify:

- the **superior turbinate** medially.

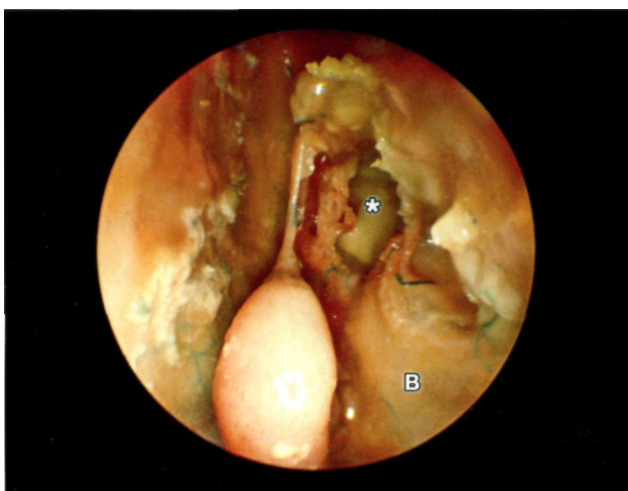


Fig. 27
Endoscopic view of the **frontal recess** (*) with the **ethmoid bulla** (B) intact.

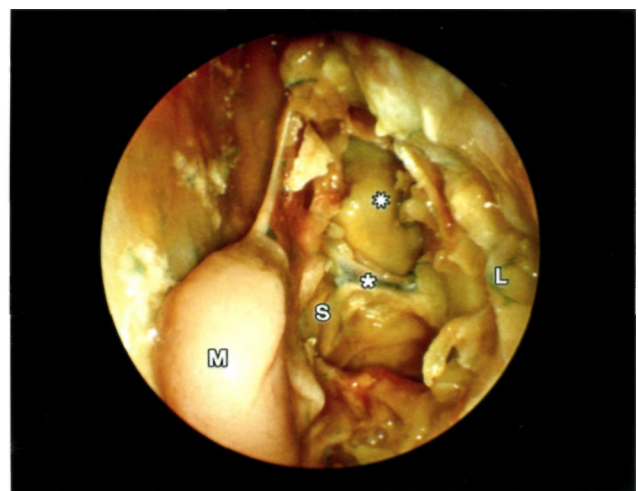


Fig. 28
The ethmoid bulla has been removed to expose the skull base (S) and the **anterior ethmoid artery** (*), which usually traverses the skull base obliquely from a posterolateral to anteromedial direction. The point where the anterior ethmoid artery enters the lamina cribrosa is the weakest point of the entire skull base. It has about one tenth of the thickness of the skull base. M - middle turbinate; L - lamina papyracea; (*) - frontal sinus.

Intersinus Septi

Note the presence within the sphenoid sinus of any intrasinus septi. These intersinus septi often insert on the bone forming the carotid canal. Rupturing one of these septi during live surgery could cause catastrophic injury to the carotid artery.

With the anterior wall of the sphenoid removed, gently try to free its mucosa from the superior and lateral aspects in order to observe lateral wall structures and their relationships. Note the optic nerve, internal carotid artery and maxillary branch of trigeminal nerve.

Optic Nerve

When the optic nerve indents into the paranasal sinus, it most often does so within the sphenoid sinus. This indentation is placed superolaterally. If this optic canal is followed medially and posteriorly, the bone overlying the optic chiasm, the tuberculum sella, can be identified.

Internal Carotid Artery

The internal carotid artery is the most medial structure within the cavernous sinus. It rests directly against the lateral surface of the body of the sphenoid, producing a prominence within the sphenoid sinus that is posterolaterally placed. This prominence is most pronounced in those specimens with maximal pneumatization of the sphenoid. It varies in size from a small focal bulge to a serpiginous elevation, marking the full course of the carotid artery.

Lateral Optic Recess

The carotid indentation and the optic nerve form a triangle with its base placed anteriorly. An indentation in this triangle forms the lateral optic recess. Carefully palpate the carotid artery because dehiscence can often be present in this region (20% of cases). Note how often the bone over the carotid is quite thin and rarefied.

Maxillary Branch of the Trigeminal Nerve (V2)

In a well-pneumatized sphenoid, it may be possible to identify the maxillary branch of the trigeminal nerve (V2) as it courses the lateral confines of the sphenoid sinus inferiorly. Look for it using 30° and 70° telescopes.

Next, identify the tuberculum sella, the anterior sellar wall and the clivus posteriorly.

The tuberculum sella is thickened part of the posterior sphenoid wall, superior to the anterior sellar wall. It protects the optic chiasma that lays few millimeters posterior to it.

Anterior Sellar Wall

The anterior wall of the sella is recognized by its midline bulge inferior to the tuberculum sella. The appearance of the dura through the thin anterior sellar wall imparts a bluish hue to the sella that aids in its identification.

Planum Sphenoidale

With a 30° endoscope look at the planum sphenoidale, which forms the roof of the sphenoid sinus and continues anteriorly as the skull base.

7 Dissection of the Frontal Recess

Aims

The underlying principle of dissection in the frontal recess is:

- to understand the anatomical boundaries of the frontal recess and to expose the frontal recess

Dissection of the frontal recess is achieved by:

- Completely removing the agger nasi cell
- Completely removing cells within the frontal recess, while preserving the mucus membrane of the frontal recess and maintaining the stability of the middle turbinate

Anatomical Boundaries

- anteriorly, the agger nasi
- posteriorly, the anterior ethmoid neurovascular bundle
- Medially, the middle turbinate
- Laterally, the lacrimal fossa

Technique

Dissection of the frontal recess is addressed last in the dissection procedure. It enables the surgeon to identify the skull base posteriorly, which is the most useful landmark. The skull base is followed from posterior to anterior, identifying the anterior ethmoidal neurovascular bundle that forms the posterior boundary of the frontal recess.

Identification of the anterior ethmoid neurovascular bundle provides a reliable landmark as the posterior limit of the frontal recess.

The **opening to the frontal sinus** can sometimes be visualized by following the middle turbinate (medial) and residual uncinate process (lateral) in dissecting toward the skull base.

- ✎ Another helpful identification method is placing a straight suction tube onto the anterior sphenoid face medial to the middle turbinate, then grasping the tube where it is even with the columella. While holding onto the suction tube at this point, remove it from the nose and then place it lateral to the middle turbinate and advance it into the resected ethmoid cavity. When the fingers on the suction tube are at the level of the columella, the tip of the tube should mark the anterior wall of the sphenoid sinus.
- ✎ The posterior ethmoidal neurovascular bundle and the superior turbinate are important landmarks for the anterior sphenoid wall.
- ✎ The most reliable method is to identify the sphenoid ostium. The sphenoid ostium is usually located in the sphenoethmoid recess, medial to the superior turbinate and lateral to the posterior nasal septum, and about 1.5 cm superior to the posterior choana. Once the ostium is identified, it may be widened inferiorly and medially with a KERRISON punch or BLAKESLEY forceps.

Removal of the Anterior Sphenoid Wall

- ✎ Staying inferomedially, gently infracture the anterior sphenoid wall with the straight BLAKESLEY forceps or an antrum curette. The anterior sphenoid wall can be quite well ossified and difficult to penetrate. Up to 5% of sphenoid sinuses are not pneumatized.

- ✎ Once the anterior wall of the sphenoid is penetrated, gently remove the bony anterior face. This is achieved with a circular cutting STAMMBERGER punch and a selection of KERRISON rongeurs. Complete the removal up to the level of the skull base and out to the medial orbital wall.
- ✎ Once the bilateral sphenoidotomies have been completed and the sphenoid sinus is widely exposed, study the intrasphenoid anatomy using 0°-, 30°-, 45°- and 70°-telescopes.

Intrasphenoid Anatomy

Note the pattern of sphenoid pneumatization, sphenoid dominance and intersinus septi.

Sphenoid Pneumatization

The sphenoid sinus has been classified into three types. These include conchal, presellar and sellar, depending on the extent to which the sphenoid bone is pneumatized.

In the **conchal type**, the area below the sella is a solid block of bone without an air cavity. It is most common in children below the age of 12, at which time the pneumatization begins within the sphenoid sinus.

In the **presellar type**, the sinus cavity does not penetrate beyond a plane perpendicular to the sellar wall.

The **sellar type** is the most common, and in this type, pneumatization extends into the body of the sphenoid below and beyond the sella, and may extend posteriorly as far as the clivus.

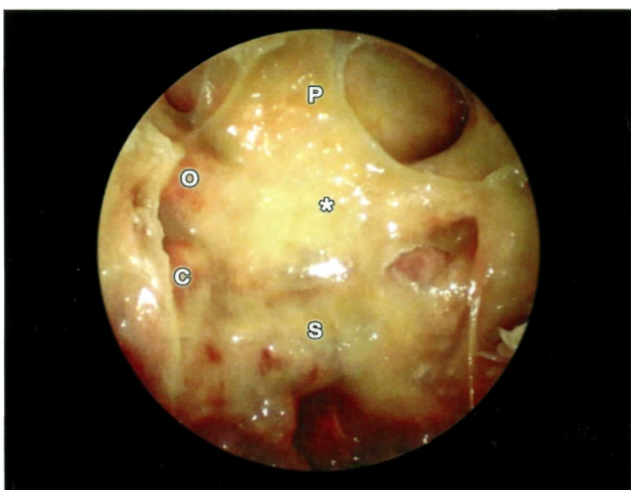


Fig. 31
The intrasphenoid anatomy. Note the planum sphenoidale (P), optic nerve (O), cavernous carotid artery (C), anterior wall of the sella turcica (S), and the tuberculum sella (*).

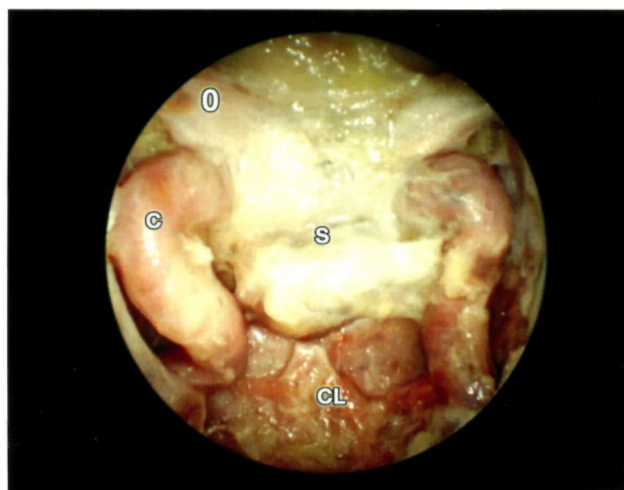


Fig. 32
The bone has been drilled away to expose the soft tissue within the sphenoid sinus. Note the optic nerve (O), cavernous carotid artery (C), sella turcica (S) and clivus (CL).

4 Optic Nerve Decompression

Each optic nerve leaves the chiasm and travels about 15 mm through the intracranial subarachnoid space to enter the optic canal.

The optic canal is bounded medially by the body of the sphenoid and laterally by the optic strut. It is about 5 to 10 mm long and 4.5 mm wide, with an average height of 5 mm. The roof of the canal is 1 to 3 mm thick.

Remove the medial wall of the optic canal to expose the optic nerve from the orbital apex to the optic chiasm.

After leaving the chiasm, each optic nerve travels about 15 mm within the intracranial subarachnoid space. Upon entering the optic canal the nerve is invested with dura mater that forms the dural-periosteal layer. At the anterior end of the canal, the dural splits into two layers. The inner layer forms the dura of the optic nerve and the outer layer becomes the periorbita. The intraorbital course of the optic nerve is approximately 30 mm. The subarachnoid space is maintained throughout the posterior margin of the globe.

Incise the dural sheath, decompressing the nerve from the orbital apex to the optic chiasm.

5 Exposure of the Sella Turcica

Practice the **transseptal approach**. Make a left hemitransfixion incision, and elevate a mucoperichondrial flap on the left side up to the junction of the septal cartilage with the bony nasal septum. Dislocate this attachment and elevate the bilateral mucoperiosteal flaps posteriorly to expose the remnant anterior sphenoid wall in the midline. Remove the sphenoid keel. The transseptal access to the sphenoid sinus is completed. Examine the intrasphenoid anatomy and identify the anterior sellar wall.

The anterior sellar wall is usually fairly thin and can be fractured with the tip of a BLAKESLEY forceps. Remove the anterior sellar wall to expose the dura. Incise the dura with a size 11 blade and examine the intrasellar anatomy with 0° and 30° telescopes. Remove the sellar contents and identify the diaphragma sella.

6 Repair of CSF Fistula

Last, with an upbiting BLAKESLEY forceps or an antrum curette, disrupt the floor of the anterior cranial fossa. Note how thin it is adjacent to the middle turbinate insertion laterally. It becomes thicker in the posterior ethmoid and its more lateral extent adjacent to the orbit. The two most common sites of skull base entry are at the level of the ethmoid dome where the middle turbinate inserts and just anterior to the anterior sphenoid wall.

Attempt to close the created fistula with a free mucosal flap. Practice instrument handling.

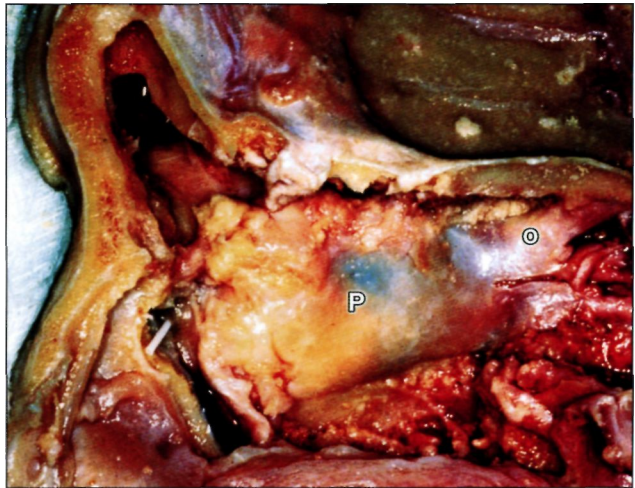


Fig. 33
The lamina papyracea has been removed to expose the periorbita (P). The orbital apex is indicated by (O).

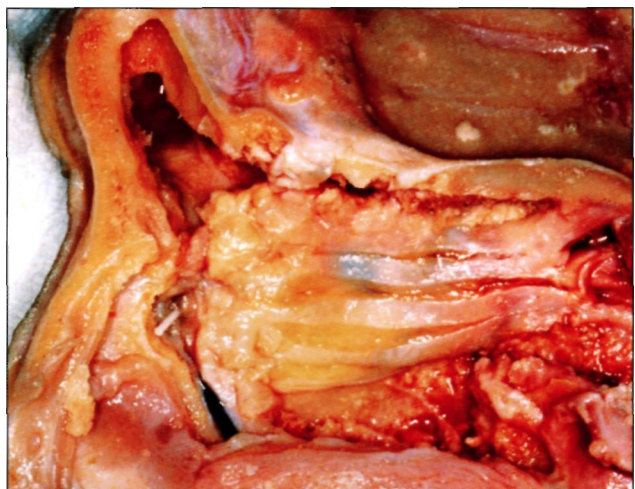


Fig. 34
The periorbita has been incised to expose the periorbital fat.

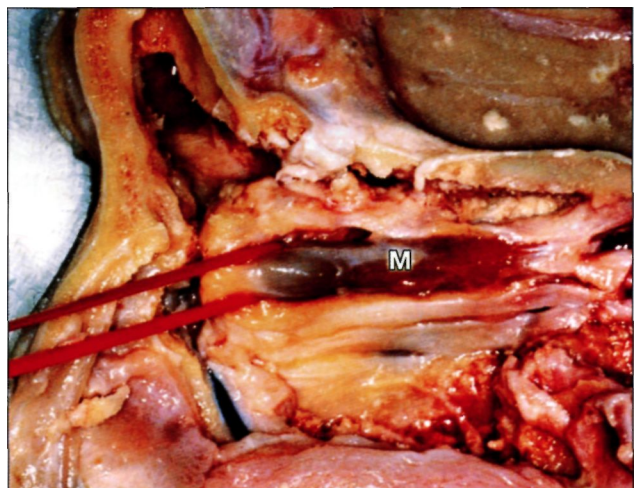


Fig. 35
The medial rectus muscle (M) has been exposed and retracted. Note the close proximity of the medial rectus to the periorbita.

Following the cleft between these two structures will often open up the frontal os.

(To identify the frontal sinus opening, ensure that all residual uncinate process has been resected.)

Removal of the Agger Nasi Cell

Extend the infundibulotomy incision into the agger nasi cells just lateral to the insertion of the middle turbinate on the lateral nasal wall. This maneuver provides improved access to the agger nasi cells and gives more direct access to the frontal opening.

With upbiting BLAKESLEY forceps, carefully remove the anterior wall and any lamellae from the agger nasi cell group that will lie just anterior to the frontal opening.

When the frontal opening is identified, use an upbiting Blakesley forceps or antrum curette to **take down the anterior wall of the ostium**, which is shared in common with the rear wall of the most posterior agger nasi cell. The posterior table of the frontal sinus should be clearly visible.

Study the relationship between the agger nasi and lacrimal cells to the opening of the frontal sinus. These cells are anteriorly and somewhat laterally displaced, and can often be quite extensive in their pneumatization up into the nasal bone and anterior table of the frontal sinus, and can often mimic a frontal sinus.

Advanced Endoscopic Surgical Techniques

Once the sphenoethmoidectomy is complete, additional maneuvers can be performed.

1 Endoscopic Dacrocystorhinostomy

An antrum curette can be used to identify the lacrimal sac and the lacrimal fossa. This structure is most easily located by returning to the previous infundibulotomy and peeling back the mucosa anterior to the site of the uncinate process insertion. The bony lacrimal fossa is often quite dense. If this bone is removed, the lacrimal sac can be identified. Its presence can be confirmed by palpation of the lacrimal sac and endoscopically observing the transmitted pulsations. A sickle knife can be used to incise the lacrimal sac to examine its interior. Identify the opening of the common canaliculus on the lateral wall of the lacrimal sac by passing a probe through the punctum.

2 Orbital Decompression

At this time, an orbital decompression procedure can be practiced. This procedure is performed by removing the medial orbital wall to the orbital apex and leaving the bone covering the optic nerve canal. Resection of the lamina papyracea should be continued along the orbital floor laterally to the level of the inferior orbital nerve. It is important to leave remnants of the lamina papyracea just lateral to the frontal ostium in order to prevent medi-

alizing orbital contents from obstructing the frontal ostium. A sickle knife can be used to incise the periorbital. Begin just medial to the infraorbital nerve, then proceed in an inferior-to-superior direction along the lamina papyracea.

3 Orbital Apex Decompression

The body of the sphenoid sinus forms the medial boundary of the optic canal at the orbital apex. This medial wall can be removed or drilled away to expose the **annulus of Zinn**.

The annulus of Zinn is a fibrous tendinous funnel at the orbital apex that gives rise to five of the six extraocular muscles. The annulus is firmly fused dorsally to the optic nerve. It is divided into two compartments by a dural plane.

The medial compartment contains the optic nerve and ophthalmic artery.

The lateral compartment is also called the oculomotor foramen, which transmits:

- the upper and lower branch of oculomotor nerve
- the VI cranial nerve and the nasociliary nerve (V1)

Incise the annulus of Zinn with a sickle knife to gain access to the medial compartment. Identify the optic nerve.