A DISSECTION COURSE ON ENDOSCOOPIC ENDONASAL SINUS SURGERY

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M. Hajek gives a rhinosurgical demonstration on the occasion of his 70th birthday in 1931 (source: Dr. M. Skopec, curator of the Medical Historical Collection of the Department of Medical History, University of Vienna, Josephinum, Währingerstr.25, A-1090 Vienna, Austria)

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1. Introduction

Since its development in the early 1900s, endonasal sinus surgery has made dramatic progress during the past 30 years owing to the advent of endoscopic and microscopic techniques (review in Hosemann et al. 2000). Since then, it has become the standard method for the operative treatment of chronic sinusitis, and there has been a significant expansion of endonasal surgical procedures for a variety of indications. A great many excellent monographs have been published from various surgical schools, in which a range of techniques are described and often copiously illustrated. A number of these publications are cited in the Bibliography.

What is the purpose of the present manual?

We recognize two major problems in the continuing development and critical appraisal of endonasal endoscopic operating techniques and particularly in the necessary training of the next generation of ENT surgeons:

First, the anatomy of the paranasal sinuses shows a remarkable degree of individual variation, and the surgical-anatomical terminology used in practice-oriented publications is often inconsistent and confusing. As a result, the steps involved in a routine operation for chronic sinusitis are often difficult to describe accurately and unambiguously and cannot be meaningfully classified. Many surgeons, moreover, have little interest in standardizing the details of operating techniques that are individualized for each patient.

ENT surgeons in training must acquire their basic knowledge of anatomy and special surgical principles in specialized dissection courses. This brings us to the second problem: Available anatomical specimens are almost always fixed in formalin, which alters the color, texture, and biomechanics of the tissue. It is more difficult to introduce optical instruments, and the specimens are difficult to clean and have an odd appearance. This often causes students to become disappointed or even disoriented during their training.

The present manual is designed to address these problems:

- It is intended as a companion text for dissection courses based on the use of formalin-fixed paranasal sinus specimens.
- To impart a basic understanding of the principles of sinus surgery, the manual offers step-by-step instructions for the endoscopic dissection and exploration of endonasal anatomy while also providing space for notes and sketches (see pp. 38 ff). Readers can derive the greatest benefit by working through the manual shortly before starting their dissection course.
- The focus of the manual is on instructions for surgical-anatomical endonasal dissection aided by endoscopy. This is similar in many respects but not identical to the operating techniques applied in vivo. The step-by-step instructions are designed to fully exploit the didactic possibilities of dissection in a formalin-fixed specimen. Anatomical descriptions are simplified and organized based on their clinical relevance. Certain overlaps and contradictions in prevalence data are inevitable and are consistent with reports in the literature.
- It is assumed that the reader has a basic knowledge of paranasal sinus anatomy. For self-study purposes, the Bibliography at the back of the manual emphasizes articles published during the past 10 years, as they are easier to find than older publications. It is always profitable, however, to refer back to older and unsurpassed works by such authors as Alyea, Grünwald, Hajek, Halle, Keros, Killian, Ododi, and Zuckerkandl.
2. Preliminary Remarks

We do not know why human beings have paranasal sinuses. Many theories have been advanced – reducing the weight of the skull, improving voice resonance, humidifying the inspired air, absorbing traumatic shocks, providing thermal insulation for the brain – but none have been definitely confirmed.

Anatomically and pathophysiologically, the ethmoid bone is the centerpiece of the paranasal sinuses. The collection of ethmoid cells on one side is shaped like a truncated pyramid with its base directed posteriorly. The system of air cells measures 4–5 cm anteroposteriorly and 1.5–3 cm from top to bottom. Its anterior width is approximately 0.7 cm, its posterior width approximately 1.5 cm. It is 1 cm broader inferiorly than superiorly. There are 2 to 10 anterior ethmoid cells and 2 to 6 posterior cells. The anterior and posterior ethmoid cells are separated from one another by the basal lamella of the middle turbinate (Fig. 1).

In the fetus, the lateral nasal wall bears a series of five or six separate ridges (ethmoturbinals), some of which have a curved shape resembling that of the free edge of the middle turbinate. The fetal ethmoturbinals fuse completely in their posterior portions, while mainly the apexes of the ridges become fused anteriorly. The persistence or partial fusion of the ridges, plus the ingrowth of ethmoid air cells (pneumatization), leads to the adult form of the lateral nasal wall.

The ethmoid labyrinth in the adult still contains four or five, more or less intact remnants of the fetal ethmoturbinals called the basal lamellae (Fig. 1). The most important of these is the basal lamella of the middle turbinate. It separates the anterior and posterior ethmoid cells anatomically (forming a partition) and also functionally (creating separate mucociliary drainage pathways into the middle meatus and superior meatus). The principal structures of the middle meatus are shown schematically in Figs. 7 and 8.

Various classification systems have been proposed for the ethmoid cells (e.g., Terrier et al. 1987, Terrier 1991, Figs. 2–6). From an anatomical standpoint, the location of the ostium (the “starting point” for pneumatization) in relation to the basal lamellae determines the arrangement of each cell. When disease is present, however, the ostia usually cannot be identified and the basal lamellae often cannot be seen, and therefore these classifications have not become widely adopted in routine surgical practice. There is no universally accepted classification for all surgical procedures (an example is shown on pp. 10–11). The Draf scheme has proven useful for classifying surgical approaches to the frontal sinuses (see below).
Fig. 2
Anatomical diagram of a group of anterior cells whose ostium is near the uncinate process ("uncinate cells"). The "bodies" of the some of the cells are in proximity to the ethmoid bulla (compare with Figs. 4 and 8) (from Terrier 1991).

Fig. 3
Anatomical diagram of a group of cells that drain into the anterior part of the middle meatus (frontal recess). With certain positional variants of the uncinate process, this group may even include the frontal sinus (from Terrier 1991).

Fig. 4
Anatomical diagram of a group of anterior ethmoid cells that drain into the retro-/suprabullar recess (formerly known also as the "middle ethmoid cells"). The cells are usually located near the mound of the ethmoid bulla (from Terrier 1991).

Fig. 5
Anatomical diagram of the posterior ethmoid cells, which are posterior to the basal lamella of the middle turbinate. These cells, in turn, may be subdivided into an anterior and posterior group (shown in color) based on their relation to a basal lamella of the superior turbinate (from Terrier 1991).
Fig. 6
Anatomical classification of the ethmoid cells as they appear on axial CT (after Terrier 1987).
1 Anterior ethmoid cells
2 Posterior ethmoid cells
3 Sphenoid sinus
4a First basal lamella
4b Second basal lamella
4c Basal lamella of the middle turbinate (third lamella)
4d Basal lamella of the superior turbinate (fourth lamella)
5 Posterior ethmoid wall
6 Sphenoethmoid recess

Fig. 7
Schematic clinical anatomy of the anterior ethmoid in axial section (from Lusk 1992).
NC Nasal cavity
LD Nasolacrimal duct
VMT Vertical lamella of the middle turbinate
UP Uncinate process
I Ethmoid infundibulum
EB Ethmoid bulla
SL “Sinus lateralis” (supra-/infrabullar recess)
GL Basal lamella of the middle turbinate
HMT Horizontal lamella of the middle turbinate
1 Inferior semilunar hiatus (reddish line)
2 Superior semilunar hiatus (reddish line)

Fig. 8
Schematic anatomy of the middle meatus, viewed from the medial aspect (from Terrier et al. 1987), showing the maxillary ostium (1), the extensions of the uncinate process (s superior, i inferior, p posterior) and the fontanelles (A anterior fontanelle, B/C posterior fontanelle); 2 middle turbinate (fenestrated); 3 ethmoid bulla; 4 inferior semilunar hiatus; 5 superior semilunar hiatus; 6 uncinate process.
Infundibulotomy
Partial removal of the uncinate process to expose the natural ostium of the maxillary sinus. The superior attachment of the uncinate process is left intact, and the drainage zone of the frontal sinus is not altered. The maxillary sinus can be fenestrated in varying degrees (I: posterior extension of the natural ostium = 1 cm; II: posterior inferior extension = 2 cm; III: maximum middle meatal antrostomy, extending from the lacrimal bone to the palatine bone and the insertion of the inferior turbinate).

Partial anterior ethmoidectomy
Infundibulotomy plus partial removal of the anterior ethmoid cells until the basal lamella of the middle turbinate is exposed. Agger nasi cells are opened, but the entrance to the frontal sinus (frontal recess) is not altered further. The maxillary sinus can be fenestrated in varying degrees, as described above.

Sphenoethmoidectomy
This is an extension of the partial anterior ethmoidectomy in which the posterior ethmoid and sphenoid sinus are opened. The maxillary sinus (see above) and sphenoid sinus can be fenestrated in varying degrees (I: simple exposure of the sphenoid ostium; II: removal of the upper half of the anterior wall; III: removal of the entire anterior wall from the floor to the skull base and laterally from the septum to the lateral wall of the sphenoid sinus).
**Frontoethmoidectomy**
This involves opening the drainage zone of the frontal sinus and performing a partial anterior ethmoidectomy. The drainage zone of the frontal sinus is extended, carefully preserving the mucosa in that region. The maxillary sinus can be fenestrated in varying degrees (see above).

**Frontoethmoidectomy with frontal sinus drainage**
Same as above, plus frontal sinus drainage to a variable extent (I: removal of the uncinate process near the skull base or middle turbinate with no other measures; II: extension of the frontal sinus drainage zone; III: extended endonasal opening of the frontal sinus by removing the frontal spine and interfrontal septum to provide midline drainage of the frontal sinus).
3. Review of Basic Anatomical Terms

**Agger nasi**: eminence in the lateral wall of the nose, just in front of the insertion of the middle turbinate (remnant of the first ethmoturbinal or first basal lamella). The agger nasi is generally pneumatized (from the frontal recess), and larger air cells are found in 15% of cases. These cells are formed from the ethmoid infundibulum or frontal recess.

**Ethmoid bulla**: remnant of the second basal lamella. Pneumatization of the ethmoid bulla generally creates the largest and most nonvariant anterior ethmoid cell. If the lamella is not pneumatized, a bony “torus bullaris” remains. The bulla lamella can form the posterior wall of the frontal recess if it extends upward to the skull base.

**Bulla frontalis**: an unusually prominent frontoethmoid cell (see below) that penetrates into the frontal sinus.

**Concha bullosa**: a pneumatized middle turbinate (distinguished from an “interlamellar cell”). The pneumatization of the middle turbinate may originate from structures of the anterior ethmoid (frontal recess, supra- or retrobullar recess, middle meatus). The prevalence of this feature ranges from 15% to 50%, depending on the strictness of the definition. A bulky, unilateral concha bullosa is usually associated with contralateral deviation of the nasal septum.

**Fontanelles**: areas in the medial sphenoid sinus wall above the inferior turbinate, consisting only of two layers of mucosa and a thin fibrous layer with no additional bony support. Fontanelles are sites of predilection for accessory sinus ostia. The anterior fontanelle is located in front of and below the uncinate process. The posterior fontanelle is usually found behind and above the posterior extension of the uncinate process (Fig. 8).

**Frontoethmoid cells**: variable number of ethmoid cells located above the agger nasi (see above). Together with the variable anterior superior attachment of the uncinate process, this collection of cells surrounds and shapes essential portions of the frontal recess (Figs. 26–28). If a cell grows into the interfrontal septum, it creates a special form called an “intersinus septal cell.”

**Basal lamellae**: remnants of five or six ridges that form in the lateral nasal wall during embryogenesis and later undergo partial fusion (ethmoturbinals). The most important is the basal lamella of the middle turbinate (remnant of the third ridge = third basal lamella). It separates the anterior and posterior ethmoid cells and has a complex three-dimensional geometry: its anterior segment has a vertical, sagittal orientation; its middle segment lies in an almost frontal plane; and its posterior segment is almost horizontal. Due to individual differences in pneumatization, large posterior ethmoid cells may cause an anterior bulge in the basal lamella while expansive anterior ethmoid cells may indent the lamella posteriorly (“struggle of the ethmoid”). As a result of this, the “posterior” ethmoid is formed partially by cells of the ethmoid bulla in 10% of cases, while 15% of the posterior cells bulge forward into the ethmoid bulla. The implication is that the surgeon often cannot gain a precise and complete appreciation of the topographic anatomy of the lamellae in any given case. Besides the basal lamella of the middle turbinate, there are other remnants: the first basal lamella – the agger nasi and uncinate process; the second basal lamella – the ethmoid bulla; and the fourth basal lamella – a basal lamella similar to the third lamella but involving the superior turbinate. A supreme turbinate is also present in 15% of cases, adding a fifth basal lamella.

**Haller cell**: an ethmoid cell, usually of the anterior ethmoid, that has grown into the orbital floor. The term “infraorbital ethmoid cell” is preferred. A Haller cell may narrow the natural maxillary sinus ostium or may become a source of infection. Its prevalence is approximately 10%.

**Inferior semilunar hiatus**: a two-dimensional, sagittally oriented, crescent-shaped cleft that represents the shortest distance between the free posterior margin of the uncinate process and the anterior surface of the ethmoid bulla. It provides a passageway for gaining access to the ethmoid infundibulum.

**Superior semilunar hiatus**: a little-used term for a cleft between the posterior ethmoid bulla and the basal lamella of the middle turbinate. The supra- and retrobullar recess (q.v.) can be entered through this space.

**Ethmoid infundibulum**: the space bordered medially by the uncinate process and laterally by the lamina papyracea. It may also be bordered by the frontal process of the maxilla and the lacrimal bone (laterally) and the bulla (posteriorly). The ethmoid infundibulum is entered through the inferior semilunar hiatus.

**Frontal infundibulum**: a funnel-shaped narrowing of the floor of the frontal sinus at its junction with the anterior ethmoid.
Maxillary infundibulum: a funnel-shaped narrowing of the maxillary sinus toward its natural ostium (not always present).

Interlamellar cell: a special form (distinguished from concha bullosa) arising from pneumatization and “splitting” of the vertical lamella of the middle turbinate by a shallow air cell from the superior meatus (Fig. 20).

Middle ethmoid: a misleading term for bulla cells that are pneumatized from the supra-/retrobullar recess. For anatomic and physiologic reasons, only anterior and posterior ethmoid cells should be distinguished based on their separation by the basal lamella of the middle turbinate.

Onodi cell: a posterior ethmoid cell that extends to the optic canal. The term “sphenoethmoid cell” is preferred.

Ostiomeatal unit: a vague term encompassing the anterior middle meatus with its adjacent clefts and passages connecting to the frontal sinus, maxillary sinus, and anterior ethmoid cells (including the ethmoid infundibulum and semilunar hiatus).

Uncinate process: a thin, curved bony plate, resembling a hook, that extends from anterosuperior to posteroinferior along the anterior lateral nasal wall. It is a rudiment of the first ethmoturbinal and, with the agger nasi, forms the remnant of the first basal lamella.

Frontal recess: extension of the anterosuperior middle meatus. The recess is entered in an imaginary plane that extends from anterosuperior to posteroinferior along the anterior lateral nasal wall. It is a rudiment of the first ethmoturbinal and, with the agger nasi, forms the remnant of the first basal lamella.

Prelacral recess: a concavity in the medial, anterosuperior part of the maxillary sinus. It is located in front of the eminence of the lacrimal passages on the medial sinus wall.

Sphenoethmoid recess: a lateral recess in the nasal cavity just in front of the anterior wall of the sphenoid sinus. It is bounded laterally by the superior or supreme turbinate, superiorly by the planum sphenoidale, and medially by the nasal septum.

Supra- and retrobullar recess (also known collectively as the sinus lateralis of Grunwald): Behind the ethmoid bulla, it is extremely common to find an indentation in the lateral nasal wall that is reached through the superior semilunar hiatus. This indentation often leads to two niches that are separated by a tissue bridge between the bulla and basal lamella of the middle turbinate: the supra- and retrobullar recesses. The recess above and behind the bulla extends to the lamina papyracea in 70% of cases. If the ethmoid bulla does not reach the skull base, the suprabullar recess is continuous anteriorly with the frontal recess at that site.

Terminal recess: If the uncinate process inserts anteriorly and superiorly into the lamina papyracea, the ethmoid infundibulum ends blindly to form the terminal recess (Fig. 10).

Sinus lateralis Grunwald: see supra- and retrobullar recess.

Superior nasal spine: a structure with various names and definitions, formed chiefly by the frontal and nasal bones. Essentially it is a clinical descriptive term for a bony process located in the anteromedial floor of the frontal sinus above the nasal cavity and the anterior ethmoid.

Torus lateralis/torus bullaris: nonpneumatized mound of bone and mucosa at the location of the ethmoid bulla (rare). More commonly (5%) the bulla is present but underpneumatized.

Optic nerve tubercle: bulge in the medial part of the bony optic canal in the upper lateral sinus wall at the site of the anterior optic foramen. The bone of the optic canal is relatively thick in this area.
4. General Rules for Dissection

- The paranasal sinuses in the specimen should not be exposed expeditiously as in a routine operation. They should be dissected in an “anatomically oriented” way, taking an ample amount of time and proceeding in steps using optical aids. This is necessary in order to gain a solid understanding of endonasal surgical anatomy.

- There is a tendency for crumbly tissue debris to accumulate in formalin-fixed specimens. Take the time to “clean up” the explored areas so that important structures can be visualized. This is the only way to instill the “engrams” for surgery based on relative anatomical landmarks.

- Hold the endoscope with the thumb and index/middle finger in the left hand and the instruments in the right hand. The endoscope follows the instrument into the nose.

- Take your time in dissecting, probing, and exposing the tissues in layers. In moist specimens, a hidden ostium can often be identified by a mucus bubble that rises into view when the tissue is probed.

- Not infrequently, a large area of mucosa will separate from the underlying bone during the dissection. This is particularly common during a maxillary sinus antrostomy, for example. It is advisable in these cases to sharply divide the mucosa and return the remnants to their original position. Smaller separations may be ignored. A last resort in anatomical specimens is to remove additional areas of mucosa to reestablish an adequate view.

- Please handle the instruments carefully. Of course, slender instruments should never be used to remove thick bony structures or otherwise misused.

5. Preparations

To begin with, the interior of the anatomical specimen should be thoroughly cleaned. The nasal cavity is washed out with a water jet. Loose tissue fragments and other debris are removed with a grasping forceps. Slender forceps can also be used to introduce pieces of surgical sponge through the nasal cavity.

If vision is obscured due to septal deviation, the deviated segments should be removed from the vomer and perpendicular plate through a mucosal incision in the nasal vestibule or through an intranasal incision placed directly in front of the deviation. The inferior turbinate is pushed laterally with the double-ended elevator. If this does not improve the view, the turbinate should be partially resected (conchotomy). Ultimately, the choana should be clearly visible endoscopically as it provides an important landmark.

6. Endoscopy

- Endoscopy of the inferior meatus: identify the choana, the nasopharynx, and the Eustachian tube orifices. Whenever possible, identify the lacrimal excretory duct and the anterior inferior turbinate.

- Endoscopy of the anterior middle meatus: identify the head of the middle turbinate (expanded – possible concha bullosa?), the free edge of the uncinate process, and the ethmoid bulla.

- As you withdraw the endoscope between the inferior turbinate and middle turbinate, it is usually easy to pass it laterally into the posterior middle meatus below the middle turbinate.

- Try to locate the olfactory groove (this can be difficult with a 4 mm-endoscope in a formalin-fixed specimen).
### 7. Standard Instruments Used in Anatomical-Surgical Dissections

<table>
<thead>
<tr>
<th>Item number*</th>
<th>Description</th>
<th>Special notes on application</th>
</tr>
</thead>
<tbody>
<tr>
<td>7230 AA</td>
<td>HOPKINS® Straight-Forward Telescope 0°, enlarged view, O.D. 4 mm, length 18 cm, autoclavable, fiber optic light transmission incorporated, color code: green</td>
<td>Endoscopy of the nasal cavity and ethmoid infundibulum</td>
</tr>
<tr>
<td>7230 BA</td>
<td>HOPKINS® Forward-Oblique telescope 30°, enlarged view, O.D. 4 mm, length 18 cm, autoclavable, fiber optic light transmission incorporated, color code: red</td>
<td>Same as above, also used to inspect the entrance to the maxillary and frontal sinuses</td>
</tr>
<tr>
<td>723772</td>
<td>STAMMBERGER Telescope Handle, round, standard model, length 11 cm, for use with HOPKINS® 30°–120° telescopes with 4 mm O.D. and 18 cm length</td>
<td>Mandatory for telescope handling</td>
</tr>
<tr>
<td>456001 B</td>
<td>BLAKESLEY RHINOFORCE® Nasal Forceps, straight, size 1, working length 13 cm</td>
<td>Tissue removal, tissue palpation &quot;pushing in&quot; cell septa</td>
</tr>
<tr>
<td>456500 B</td>
<td>BLAKESLEY-WILDE RHINOFORCE® Nasal Forceps, 45° upturned, size 0, working length 13 cm</td>
<td>Tissue removal, tissue palpation</td>
</tr>
<tr>
<td>459010</td>
<td>STAMMBERGER RHINOFORCE® Antrum Punch, upward-backward cutting, working length 10 cm</td>
<td>Used mainly to enlarge the natural maxillary ostium</td>
</tr>
<tr>
<td>452002 B</td>
<td>MACKAY-GRÜNWALD RHINOFORCE® Nasal Forceps, through-cutting, straight, extra delicate, tissue-sparing, 11.5 x 3.5 mm, size 2, working length 13 cm</td>
<td>Removal of tissue remnants and stumps, reduction of the middle turbinate</td>
</tr>
<tr>
<td>628002</td>
<td>Sickle Knife, rounded tip, two-way cutting, length 19 cm</td>
<td>Used mainly to resect the uncinate process, incise the periorbita</td>
</tr>
<tr>
<td>479100</td>
<td>COTTLE Elevator, double-ended, graduated, sharp and blunt, length 20 cm</td>
<td>Probing, palpation, prying out small bone pieces (e.g., the lamina papyracea)</td>
</tr>
<tr>
<td>629820</td>
<td>Double-ended Probe, for probing the maxillary sinus ostium, 1.2 mm and 2 mm ball tips, length 19 cm</td>
<td>Used mainly to probe the ethmoid infundibulum and the natural ostium of the maxillary sinus</td>
</tr>
<tr>
<td>628702</td>
<td>Antrum Curette, oblong, small, length 19 cm</td>
<td>Circumscribed removal of hard tissue, probing</td>
</tr>
<tr>
<td>628714</td>
<td>KUHN-BOLGER Frontal Sinus Curette, oval, forward cutting, angled 90°, length 19 cm</td>
<td>Mainly for palpation and circumscribed ablation in the entrance to the frontal sinus</td>
</tr>
<tr>
<td>662123</td>
<td>KERRISON Punch, 40° upbite, forward cutting, size 3 mm, working length 17 cm</td>
<td>Used to enlarge the natural ostium of the maxillary sinus and for bone removal</td>
</tr>
<tr>
<td>529309</td>
<td>FRAZIER Suction Tube, with stylet and cut-off hole, distance markings at 5–9 cm, working length 10 cm, 9 Fr.</td>
<td>Removal of fluids and tissue residues</td>
</tr>
</tbody>
</table>

*) KARL STORZ, Tuttingen, Germany

Additionally required: cotton swabs and/or cleansing cloths, tap water and a syringe, (suction unit, optionally.)
8. Details of Surgical Techniques

8.1 Reduction of the Middle Turbinate

The advantages and disadvantages of middle turbinate reduction have long been debated in the literature. It is known that the head of the turbinate shows varying degrees of anterior extension and that it can restrict access to the middle meatus. The middle turbinate can be completely detached by making a horizontal cut from its anterior insertion on the agger nasi toward the upper extension of the superior meatus, leaving intact approximately half of the medial surface of the ethmoid bone ("conchal lamina"). At the same time, it must be considered that the olfactory mucosa may very well extend onto the anterior superior turbinate, even though this can be demonstrated only for a few olfactory fibers and is not present in every case (Biedlingmaier and Whelan 1996, Leopold et al. 2000).

Considerations of mucosal physiology, surgical tactics, and aerodynamics suggest that it is unwise to resect extensive portions of the middle turbinate.

- The stiffness of formalin-fixed specimens makes it more difficult to carry out endoscopy and other manipulations. Also, the head of the middle turbinate shows varying degrees of anterior projection in different specimens.
- To facilitate further dissection, the head of the middle turbinate should be reduced somewhat from its anterior aspect or should at least be narrowed from the lateral aspect. This is best accomplished with a cutting instrument. The vertical lamella of the middle turbinate should not be broadly resected or forcibly fractured. Applying anteroposterior pressure to the head of the turbinate or uncontrolled spreading of the middle meatus is particularly harmful. After the necessary tissues have been removed, it should be possible to inspect the middle meatus with the endoscope and locate the uncinate process.

<table>
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<th>Fig. 9</th>
<th>Endoscopy in a formalin-fixed specimen (30° telescope):</th>
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<tr>
<td>a</td>
<td>View into the left nasal cavity, showing the head of the middle turbinate (*). Note the uniform color of the formalin-fixed specimen.</td>
</tr>
<tr>
<td>b</td>
<td>The head of the middle turbinate has been reduced, allowing the uncinate process (*) to be identified.</td>
</tr>
<tr>
<td>c</td>
<td>Medialization of the vertical lamella of the middle turbinate affords the first complete view of the middle turbinate and uncinate process.</td>
</tr>
<tr>
<td>d</td>
<td>Pushing the turbinate medially (e.g., with the double-ended elevator) provides a clear view in the direction of the frontal recess.</td>
</tr>
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8.2 Infundibulotomy

Prior to infundibulotomy, it should be determined how the uncinate process is attached superiorly and anteriorly: to the agger nasi or lamina papyracea (54%), to the middle turbinate (34%), or directly to the skull base (7%) (Basak et al. 1998). These anatomical variants of the uncinate insertions dictate the approach to the frontal recess and frontal sinus (Fig. 10).

Endoscopically, the anterior surface of the uncinate process has a “classic” appearance in 85% of cases; in 15% it is medially rotated or stretched over a large bulla (Joe et al. 2000). An incomplete excision of the uncinate process is often done inadvertently due to a lack of knowledge of its anatomy (Owen and Kuhn 1995).

Superiorly, cells of the agger nasi may hamper exploration from the anterior direction. Though always present, agger nasi cells are often of inconsequential size. If they are expansive, they may narrow the frontal recess or restrict visualization from the front. The cells can be opened posteriorly and left in place, or they can be largely removed with a punch from the anterior side (Kuhn et al. 1991).

The middle turbinate is subject to specific variations in approximately one-third of cases. It may be expanded to form a concha bullosa (15%), it may have a sagittal cleft (6%), it may be laterally displaced (4%), it may be “L” shaped in coronal section (3%), it may be bent medially or laterally (3% each), or it may have a transverse cleft (Joe et al. 2000). The craniocaudal length of the anterior vertical lamella (to the cribiform plate) is approximately 26 mm.

The ethmoid bulla, viewed from the anterior aspect, exhibits a typical disc or balloon shape in 45% of cases. It is sausage-shaped in 34% of cases, and it is hypoplastic (flat) in 21% (Joe et al. 2000).

The maxillary sinus ostium is located in the middle or posterior third of the ethmoid infundibulum. The orbital floor slopes away laterally at a 30° angle.
Fig. 12
Endoscopy in a formalin-fixed specimen:

a View into the left middle meatus. The back-biting punch forceps has been passed into the ethmoid infundibulum from the posterior side, and the uncinate process has been incised (★). These manipulations make it easier to dislocate the lower portions of the process and locate the natural ostium of the maxillary sinus (★) (b).

b The uncinate process has been removed, exposing the ethmoid bulla (★).

c View with the 30° telescope upward along the anterior surface of the bulla.

Fig. 13

a The retrobullar recess on the left side is explored with the small curette (30° telescope). The anterosuperior stump of the uncinate process is visible in the upper part of the field.

b The bulla has been opened and its anterior wall removed.

c Superiorly, an additional bulla cell has been exposed and opened from the basal side.

d After removing the bulla cell mentioned above (c), the skull base and the cranial segment of the anterior ethmoidal artery are demonstrated.
Identify the free edge of the uncinate process: probe along the lateral nasal wall from anterior to posterior, beginning at the frontal process of the maxilla. Locate the anterior insertion of the uncinate process by wiggling the process back and forth (palpate the free edge and apply traction to it with the double-ended probe).

Identify the natural ostium of the maxillary sinus, distinguishing it from any accessory ostia.

If you have enough time, you can first strip the mucosal covering from the medial part of the bony uncinate process and remove it to see the precise location and shape of the delicate bone.

Excision of the uncinate process: first probe the anterior surface of the uncinate process and then move its free edge slightly. In that way you can estimate the width of the process based on the mobile tissue areas. The tissue, i.e. the uncinate process, is circumscribed at this width from the front with a sickle knife or scoring knife, working in a cranial-to-caudal direction, and the freed tissue is pushed medially. As an alternative, you can first pass the back-biting forceps into the infundibulum from the posterior side and resect a piece of the process. It will then be easier to dislocate the lower and later the upper portions of the process and selectively remove them. This measure provides a good impression of the overall size of the uncinate process and ethmoid infundibulum.

In most cases, bridges of tissue will remain superiorly and posteroinferiorly after the first incision. If a suitable instrument is available, it can be used to sharply divide the tissue bridges. They can also be removed with relatively little trauma by gripping them with a grasping forceps and applying a twisting motion (note the direction).

During all manipulations in the middle meatus, be careful not to “break” (destabilize) the adjacent vertical lamella of the middle turbinate. A floppy lamella is likely to heal in a laterally displaced condition, predisposing to recurrent sinusitis.

8.3 Opening the Ethmoid Bulla

The ethmoid bulla usually contains one or two cells. Significant underperfusion (see torus bullaris) is found in approximately 5% of cases.

The supra- and retrobullar recess (sinus lateralis) is variable in its development. Most commonly (44%) it extends posterosuperiorly to the skull base but is somewhat narrow in its AP dimension. In 30% of cases it pushes the basal lamella far posteriorly. Another 16% of cases present a hypoplastic sinus with definite separation of the supra- and retrobullar recesses. Reportedly, 10% of cases show extension of the sinus into the posterior ethmoid through a dehiscent basal lamella (Picerno and Bent 1998).

The basal lamella of the middle turbinate naturally contributes to the variability of the ethmoid bulla and particularly to the development of the sinus lateralis. It may be deflected anteriorly or posteriorly or it may be partially fused to the posterior wall of the bulla.

The anterior wall of the bulla can be perforated with the blunt end of the double-ended elevator, for example.

Exploration: Is there a retro- and suprabullar recess? Can you determine how many cells the bulla contains and where its drainage opening is located?

You can remove the bulla piecemeal to expose a circumscribed portion of the lamina papyracea.

Dissecting toward the skull base: the anterior ethmoidal artery is sometimes visible superiorly in relation to the attachment of the anterior bulla lamella.

8.4 Middle Meatal Antrostomy

The posteroinferior portion of the uncinate process has a highly variable morphology. It is typical to find delicate processes extending to the bone of the inferior turbinate, to the bulla, and/or to the palatine bone (Fig. 8); the bone may also flatten out or be absent (Yoon et al. 2000). The first of these processes divides the membranous portions of the medial antral wall into an anterior and posterior fontanelle.
If we subdivide the ethmoid infundibulum into quarters in its course from anterosuperior to posteroinferior, the maxillary ostium is usually located in the next-to-last quarter. The ostium is located an average of 4 mm from the lacrimal passages, but this distance may be as small as 1.5 mm (Lang 1988). Meanwhile, the posteromedial portion of the lacrimal passages adjacent to the middle meatus has only a very thin bony covering less than 1/10 mm thick (Yung and Logan 1999).

The lacrimal duct may be seriously jeopardized by excessive enlargement of the natural maxillary sinus ostium in the anterior direction with the back-biting forceps. This type of injury reportedly occurs in 15% of patients but fortunately causes symptoms in only about 1 case out of 10 (Ünlü et al. 1996). The superior rim of the maxillary ostium is located only 2 mm from the floor of the maxillary sinus. In 10% of cases the orbit bulges slightly above the ostium superomedially, and in 4% of cases the lateral nasal wall is “set beneath the orbit” as a result of maxillary sinus hypoplasia (Myers and Valvassori 1998). This is a potential cause of orbital injury in antrostomies.

The lymphatics of the maxillary sinus drain through the mucosa in the sinus ostium. In 50% of cases lymph also drains transversely through the fontanelles. For these reasons, it is recommended that portions of the natural mucosa – on the anterior maxillary ostium, for example – be left intact (Hosemann et al. 1998).

The orbital floor, viewed through a window in the middle meatus, is an important anatomical landmark for the rest of the operation. Forty percent of the height of the sphenoid sinus lies below a horizontal plane passing through the posteromedial orbital floor at its junction with the medial orbital wall (Casiano 2001).

In the maxillary sinus, sites of bone dehiscence are found along the infraorbital canal or sulcus in 15% of cases (caution: risk of injury from blind manipulations within the sinus cavity!). With ageing, it is increasingly common to find accessory maxillary sinus ostia (up to 30% of cases), which are usually located in the posterior fontanelle. They should not be confused with the natural ostium. If the surgeon enlarges an accessory ostium while ignoring the blocked, adjacent natural ostium, a “missed ostium sequence” can develop leading to persistent or recurrent sinus disease (Parsons et al. 1996).

- After locating and identifying the natural maxillary sinus ostium, remove the posterior fontanelle (with its bony elements including the ethmoid portion of the uncinate process) starting from the posterior rim of the ostium. You can do this in the specimen by passing the movable part of the jaws of the BLAKESLEY forceps, for example, into the medial part of the maxillary sinus.
- Next remove portions of the anterior lamella with the back-biting forceps, taking care not to injure the lacrimal passages. Try to avoid stripping off the maxillary sinus mucosa or creating large tags.
- Try repeatedly to look into the maxillary sinus with the endoscope. Determine what portions of the posterior wall, zygomatic recess, alveolar recess, or anterior wall (prelacral recess) you can see with the endoscope. Even with a maximum middle meatal antrostomy, the interior of the maxillary sinus cannot be completely visualized with standard rigid telescopes (0°, 30°, 45°, 70°) (Hosemann et al. 2003).

![Fig. 14](image)

a The left maxillary sinus is entered with the curette. Remnants of the posterior fontanelles are pushed medially and removed, creating a large window in the middle meatus (inspissated mucus is visible in the sinus) (b).

b The anterior ethmoid is exenterated by removing the cell septa (30° telescope).
8.5 Completing the Anterior Ethmoidectomy
(with Draf Type I Frontal Sinus Drainage)

To complete the anterior ethmoidectomy, it is necessary to demonstrate the third basal lamella (basal lamella of the middle turbinate) and also expose the lamina papyracea and skull base. In approximately 60% of cases the posterior wall of the bulla is fused to the third basal lamella over a variable distance, in which case the superior semilunar hiatus and the supra-/infraorbital recess are absent or partially developed (Kim et al. 2001). In other cases the suprabullar recess may show considerable posterior extension via the sinus lateralis (Picerno and Bent 1998). More commonly (approximately 15% of cases), the basal lamella of the middle turbinate is "pushed" anteriorly by expanding posterior ethmoid air cells, in which case a thorough removal of the ethmoid bulla will necessarily open the posterior ethmoid. These variants are one reason for the difficulty in using the basal lamellae as a basis for classifying surgical procedures.

8.5.1 Removing a Concha bullosa

If a concha bullosa is present and is still intact, it should be split in the sagittal plane and its lateral portion removed (see above).

- The anterior part of the middle turbinate is carefully removed with the sharp nasal forceps placed across the turbinate head, opening the lumen of the concha bullosa. Its lateral lamella is removed piecemeal with the forceps. In the living patient, extreme care is taken at this stage to avoid destabilizing the remaining medial vertical lamella of the middle turbinate, as this would result in undesired postoperative adhesion of the mobile lamella to the lateral nasal wall.

8.5.2 Demonstrating the Skull Base

The ethmoid roof is slightly lower on the right side than on the left in 9% of cases, while the left roof is higher in 1% of cases (Dessi et al. 1994). The lateral wall of the olfactory fossa is very thin and is a site of predilection for injury during ethmoidectomy. The bone is particularly thin at the site of emergence of the anterior ethmoidal artery, and there is a circumscribed absence of bone in 15% of cases. According to Keros, the olfactory fossa is 1–3 mm deep in 12% of cases, 4–7 mm deep in 70%, and 8–16 mm deep in 18% (average depth approximately 5 mm).

The lower the level of the cribriform plate, the greater the height of the nasal cavity measured from the nasal floor to the roof of the ethmoid (ethmoid fovea).

Aside from the variable depth of the olfactory fossa (i.e., a "weak spot" of variable size in the upper medial ethmoid shaft), another pitfall occurs when the lateral lamella of the olfactory fossa does not have a strictly sagittal orientation but slopes obliquely upward. This places it more or less directly in the path of a surgeon dissecting in the anterior-to-posterior direction (no. 3 in Fig. 15).

8.5.3 Demonstrating the Anterior Ethmoidal Artery

The anterior ethmoidal artery runs from lateral to medial and obliquely forward along the skull base. In approximately 40% of cases the artery is up to 2 mm from the skull base, lying free or attached to a "mesentery," and in 60% of cases it courses directly on the skull base (Basak et al. 1998). Laterally, the bone at the level of the lamina papyracea forms a small funnel. If the artery has been injured by intranasal manipulations, it may retract into the orbit at that site and cause a dangerous retrobulbar hematoma. The superior ethmoid in front of the artery almost always extends over the orbit to some small degree; the portion posterior to the artery does so in only rare cases (Chung et al. 2001).

Fig. 15
Important anatomical variants in the anterior ethmoid region (from Hosemann et al. 2000):
1 Infraorbital ethmoid cell
2 Interlamellar ethmoid cell
3 The variable depth of the olfactory fossa can be classified as described by Keros (see above). Particularly important are cases in which the relatively thin lateral wall of the olfactory fossa (end of the reference line at 3) slopes laterally upward, placing a highly vulnerable area directly in the path of surgical instruments dissecting from anterior to posterior along the skull base.
4 Concha bullosa
5 Ethmoid bulla
6 Uncinate process
The vessel can be clearly visualized in 80% of cases. The anterior ethmoidal artery is located by slowly dissecting along the anterior wall of the bulla in the direction of the skull base. Most commonly the artery is located 1–2 mm behind the bulla lamella. Its average distance from the posterior insertion of the middle turbinate is 20 (17–25) mm (Lee et al. 2000). In front of the artery, the skull base first slopes gently upward (15°) and then steepens more anteriorly as it joins with the posterior wall of the frontal sinus. This point is located an average of 9 mm in front of the artery, and a final ethmoid cell is frequently encountered in this area (Hosemann et al. 2001). The medial part of the anterior ethmoidal artery is located behind the globe of the eye in the coronal plane.

As stated, the bone along the medial part of the anterior ethmoidal artery is very thin at the junction with the olfactory fossa and is frequently dehiscent. In more than 40% of cases the arterial canal is not intact, containing sites of bone dehiscence (Kainz and Stammberger 1988).

- Visualize the anterior ethmoidal artery at the skull base with the endoscope. The artery and its accompanying nerves should appear whiter than the surrounding tissues in the formalin-fixed specimen.

### 8.5.4 Demonstrating the Basal Lamella of the Middle Turbinate

The degree of pneumatization may be disproportionately high in the anterior or posterior ethmoid, in which case the basal lamella may be deflected anteriorly or posteriorly by relatively large ethmoid cells. In approximately 14% of cases the basal lamella is displaced anteriorly toward the ethmoid bulla, as described earlier. A fact of practical importance: a thorough excision of the ethmoid bulla in these cases is bound to open the basal lamella, thereby entering the posterior ethmoid.

- Carefully remove the cell septa of the bulla mound as completely as possible and demonstrate the basal lamella through the retro- and suprabullar recess (if present).

### 8.6 Posterior Ethmoidectomy

In the posterior ethmoid, it is very common for the endoscopist to look through the base of a conspicuous, pyramid-like “sphenoid cell.” This cell tends to guide the dissection in a posterior-superior direction. This route should never be taken, however, as it leads toward the optic nerve and may even lead directly to the internal carotid artery! When viewed in horizontal section, the ethmoid bone generally has either a rectangular or a more pyramidal shape. While in the former case the lamina papyracea has an essentially sagittal orientation and provides a valuable extra landmark for dissecting from anterior to posterior, in the latter case the lamina papyracea directs the dissection posteriorly into very hazardous areas!

The posterior ethmoidal artery has a larger caliber than the anterior artery but is usually closer to the skull base than its anterior counterpart. A third ethmoidal artery is present in approximately 30% of cases. Generally a number of “friendly landmarks” are available for use in completing the ethmoidectomy (May et al. 1994):

1. Anteriorly, the posterior end of the lacrimal bone
2. Anterosuperiorly, the insertion of the middle turbinate
3. The antrostomy window with the orbital floor
4. The lamina papyracea
5. The nasal septum
6. The arch of the choana

- The basal lamella is always perforated in its medial and inferior portion.

- If necessary, excise the stump of the middle turbinate (leaving a tissue remnant for later dissection of the sphenopalatine artery).

- Identify the superior meatus, the skull base, and the lamina papyracea. An instrument can be passed posteriorly through the basal lamella and then advanced medially into the superior meatus.

- Exenterate cell septa.
8.6.1 Locating the Posterior (and Third?) Ethmoidal Artery

- You can search posteriorly along the skull base with the endoscope to look for additional arteries as well as small, transverse nerve branches.
- Proceeding in steps, open the posterior ethmoid cells while using the lamina papyracea and skull base as landmarks. Working through the superior meatus, you can palpate the level of the anterior wall of the sphenoid sinus through the ethmoid shaft, and you may even see the choana.

8.7 Fenestration of the Sphenoid Sinus

An old rule published by Mosher (1929) states that the anterior wall of the sphenoid sinus is divided into thirds by the attachment of the superior turbinate: the outer two thirds (“ethmoid part”) lie in continuity with the posterior ethmoid, while the inner third (“nasal part”) leads to the nasal cavity. This rule has limited general validity (Fig. 18), but it can still be helpful as a conceptual model:

The sphenoid sinus can be opened through a transethmoidal and transnasal approach (a transseptal approach is also possible in rare cases). The most important regional landmark is the choana. When the ethmoid surface of the anterior wall of the sphenoid sinus has been positively identified and exposed, and if there is sufficient room available, the sinus can be fenestrated into its inferomedial portion.

You can expose the nasal part of the anterior wall of the sphenoid sinus by pushing the superior turbinate laterally via the nasal cavity, or, working from the ethmoid shaft, you can locate the medial part of the anterior wall through the superior meatus and detach the insertion of the superior turbinate medially from the anterior wall. In both cases you can look through the opened space and see the sphenethmoid recess, and in favorable cases you can obtain a direct view of the natural ostium (Parsons et al. 1994).

The ostium is slitlike in 80% of cases. It has an average diameter of 3 mm (1–9 mm) and is located 7 mm (2–15 mm) above the choana and 4 mm from the midline, placing it in the upper half of the anterior wall of the sphenoid sinus. The ostia on both sides are offset by 2 mm in two-thirds of cases (Elwany et al. 1999).
If the natural ostium can be located, it provides a starting point for opening the anterior sinus wall, initially working in a caudal direction.

If the natural ostium cannot be located, the next step is to perforate the anterior wall. The thickness of the anterior wall increases in the cranial-to-caudal direction, and greater vascularity is encountered in the lower third. A branch of the sphenopalatine artery is particularly important in vivo and may be a source of troublesome bleeding during the sphenoidotomy. Wigand suggested placing the opening approximately 10 mm above the choana in order to avoid the artery and also perforate the bone in a relatively thin area (Fig. 19) (Hosemann et al. 1995).

In 2.5% of cases, there is a marked projection ("overriding") of posterior ethmoid cells over and into the sphenoid sinus (Edelstein et al. 1995). This is a very important finding, as it often leads to errors of orientation. It may be necessary to look for the actual lumen of the sphenoid sinus below those cells.

The sphenoid sinus can pneumatize the greater or lesser sphenoid wing, palatine bone, vomer, pterygoid process, nasal septum, or posterior ethmoid cells in varying degrees. As a result, variable recesses can develop within the lateral sphenoid sinus (e.g., a superior and inferior lateral recess, pterygoid recess, posterior and postero-superior recess). These recesses surround the bony eminences for the optic nerve, the internal carotid artery, and for the maxillary nerve and vidian nerve (pterygoid nerve) in 75% of cases.

The bony lamella over the internal carotid artery is often less than 0.1 mm thick. In 20% of cases it offers no significant mechanical resistance, and in 8% there is even a punctate area devoid of bony coverage (Kainz and Stammberger 1991, Kennedy et al. 1990). The intersphenoid septum is not centered in the majority of cases. With pronounced pneumatization, additional incomplete septa are present and in 1% of cases are attached to the carotid eminence (be careful of the forces transmitted during removal!).

---

**Fig. 19**
If the natural ostium of the sphenoid sinus cannot be located as a starting point for the sphenoidotomy, Wigand notes that it is safe to perforate the anterior wall 10 mm above the choana. Below that site, the anterior wall is thicker and there is greater risk of bleeding from the septal artery (branch of the sphenopalatine artery). Above that site, there is greater risk of injury to the skull base (from Hosemann et al. 2000). A suitable instrument is used to probe the nasopharynx (a) and the choana (b) and then locate the desired point (c).

---

**Fig. 20**
Endoscopy in a formalin-fixed specimen (left side, 30° telescope):

a The left anterior ethmoid has been exenterated, initially leaving the posterior cells intact.

b The posterior cells are progressively removed.

c The nasal part of the anterior wall of the sphenoid sinus (between the vertical lamella of the superior turbinate and the nasal septum) is palpated with a small curette introduced from the choana.

In the case shown, the natural ostium of the sphenoid sinus can be positively identified (*).

d It is considered safe to perforate the anterior wall of the sphenoid sinus 10 mm above the choana (note the intact natural ostium in the specimen shown: (*)).
Transnasal approach to the sphenoid sinus: lateralize the middle turbinate and, if necessary, the superior turbinate. Resect the lower portions of the middle turbinate and the “insertion” of the middle turbinate in the posterolateral nasal cavity. Identify the choana. Try to identify the natural ostium of the sphenoid sinus visually or by carefully palpating the anterior wall of the sphenoid sinus (upward from the choana, using a suction tip or the blunt end of the double-ended elevator). Enlarge the ostium with a punch forceps, first proceeding downward and then laterally and upward. If the natural ostium cannot be identified, perforate the anterior wall 10 mm above the choana at a paramedian site with the suction tip or the blunt end of the double-ended elevator. Enlarge the opening with the punch.

Transethmoidal approach to the sphenoid sinus: after opening the posterior ethmoid, identify the vertical lamella of the superior turbinate medially, the posterior lamina papyracea laterally, and the skull base. Initially proceed only in the inferomedial portion of this “shaft” (the optic nerve and carotid artery are superolateral!), and try to open the sphenoid sinus.

8.8 Endonasal Frontal Sinus Surgery
(Draf Type II a, b; III)
There is controversy as to whether the nasofrontal duct is really a “duct” in the strict sense, or whether the frontal sinus drains through a simple cleftlike extension of the frontal recess between the structures of the anterior ethmoid. Published reports vary widely on the variations in the position of the nasofrontal duct and their relative frequency. In principle, the angle formed by the “duct” with the horizontal plane (110°) is similar to that of the nasolacrimal duct. It terminates less frequently within the ethmoid infundibulum (40%) than outside the infundibulum (60%). Accordingly, the “duct” usually lies just lateral to the vertical lamella of the middle turbinate in the coronal plane, i.e., it is medial to the uncinate process or medial to an infundibular (frontoethmoidal) cell (60%) (Figs. 26 and 27). With few exceptions, the posterior wall of the “duct” is formed by portions of the anterosuperior bulla (Kim et al. 2001, Lee et al. 1997).
This means that probing the superior portion of the ethmoid infundibulum does not lead to the frontal sinus in the majority of cases!

![Diagram of the frontoethmoid cells (types I–IV)](image)

The anterior frontal recess, which gives access to the frontal sinus, is marked by the presence of special ethmoid cells. An Agger nasi cell is almost always present anteriorly (see above). Above that cell is one (type I) or more (type II) “frontoethmoid cells” (Bent et al. 1994, Kuhn 1996, Wormald 2003). These cells may grow very large and invade the frontal sinus as a “bulla frontalis” (type III). Other cells may develop entirely within the frontal sinus (type IV).
The individual approach to the frontal sinus is characterized by the number and size of these two cell types in relation to the uncinate process, with its various patterns of insertion (see above) (Wormald 2003) (Figs. 21–23). When type III cells are present medially in the interfrontal septum, “intersinus septal cells” are formed (after Merrit et al. 1996; prevalence: approximately 30%). These cells require differentiation from a pneumatized crista galli. The intersinus septal cells may be located superiorly in the interfrontal septum (type I), inferiorly in the nasofrontal bone (type III), or between these sites (type II).

In 20% of cases, entrances to supraorbital ethmoid cells are found laterally in front of the anterior ethmoidal artery (Fig. 24). These cells show varying degrees of individual lateral or posterior extension and may even be interpreted as duplications of the frontal sinus. The actual entrance to the frontal sinus in these cases is located medial and anterior. True, complete, anterior bipartitions of the frontal sinuses are relatively rare (1.5%). The relationships described are particularly important in procedures where the goal is to adequately drain all compartments of the frontal sinus from an endonasal approach (carefully analyze the CT image!) (Jovanovic 1961, Kennedy 1992, Owen and Kuhn 1997).

Fig. 22
Range of variation of the complex formed by the frontoethmoid cells and the anterior-superior attachment of the uncinate process, schematic coronal sections on the right side (Wormald 2003).

a Variable insertion of the anterior-superior uncinate process (shown in different colors).

b Basic relationship between the anterior agger nasi cell (beige) and the frontal sinus (red). Both are separated by sectioned extensions of the superior nasal spine and the floor of the frontal sinus.

c Coronal section posterior to b, showing a variant in the relationship between the uncinate process and the agger nasi cell. The frontal sinus is aerated from the medial side, and the ethmoid infundibulum terminates blindly (terminal recess, compare with a).

d Another case: a large agger nasi cell has “pushed” the uncinate process to insert in the area of the middle turbinate.

e A frontoethmoid cell above the agger nasi cell has moved the insertion of the uncinate process to the skull base.

f Frontoethmoid cell above the agger nasi cell, with insertion of the uncinate process on the lamina papyracea.

g Similar to f, but with multiple frontoethmoid cells (Kuhn type II).

h The approach to the frontal sinus (red oval) is displaced laterally and narrowed by multiple frontoethmoid cells.

i Same as h, but with medial displacement of the frontal sinus approach (red oval).
Fig. 23  
Schematic coronal sections illustrating cells of the interfrontal septum (“intersinus septal cells”), **type I** and **type III (red)**.

Fig. 24  
Schematic coronal section (**left**) and axial section (**right**) illustrating a supraorbital ethmoid cell (**red**).

Fig. 25  
Possible narrowing of the anterior frontal recess, and its effect on frontal sinus access, caused by variants of the uncinate process, frontoethmoid cells, ethmoid bulla, or agger nasi (from Stammberger 1999, see also Fig. 22). Remnants of thin bony shells following an incomplete ablation can obstruct access to the frontal sinus. The thin, curved bony lamella lying “on the skull base” at the entrance to the frontal sinus is similar to an egg shell. Anatomically, these cell remnants may be interpreted as a posteriorly expanded agger nasi or frontoethmoid cell, an anteriorly expanded ethmoid bulla, or a superior extension of the terminal recess. A slender instrument, such as a curved curette, can usually be worked between the skull base and shell remnant and can be used to pull the remnant downward and remove it without damaging the mucosa (“uncapping the egg”). Compare with Fig. 10, p. 17.
An important bone forms a portion of the frontal sinus floor and is removed piecemeal in an extended frontal sinus drainage operation: **the nasal spine of the frontal bone.** Note that the vertical dimension of this bone (and thus its volume) cannot be assessed when the bone is viewed from below! The spine is usually 6 mm deep and 10 mm high, with a large range of interindividual variations (Gross et al. 1998) (Figs. 27–29).

Fig. 26
Similar to Fig. 25, viewed from the medial aspect (from Kuhn 1996).

Fig. 27 a, b
Diagram of an anatomical specimen of the ethmoid-frontal sinus junction (compare with Fig. 23). If the frontal sinus is opened with a curette through an endonasal approach by removing narrow cell septa (Draf II a approach), a variable “superior nasal spine” will almost always be left anteromedially. The bony spine may be up to 11 mm in depth and 16 mm in height. The overall depth of the frontal recess floor including the spine is 6–16 mm. The average distance of a neo-ostium of a Draf type II a frontal sinus from the anterior ethmoidal artery is 9 mm (I). The average length of the neo-ostium is 7 mm (3–12 mm) (II), the average width 5 mm (2–9 mm) (III) (from Hosemann et al. 2001).
**Fig. 28 a – c**
A moderately well developed “superior nasal spine” in a right-sided anatomical specimen (parasagittal and axial saw cuts), following ethmoidectomy. The same specimen is shown from the medial (a), inferior oblique (b) and superior aspects (c). The bony “spine” is outlined in red.

**Fig. 29 a, b**
Two different left-sided anatomical specimens (parasagittal saw cut), viewed from medial to lateral. Examples of a disproportionately large (a) and very small (b) superior nasal spine. Compare with Fig. 23, p. 27.
Fig. 30
Drawing of the anterior ethmoid roof following removal of the ethmoid cells. If the frontal sinus drainage pathway is merely demonstrated and not enlarged, the result is a “Draf I” approach as pictured here. A “Draf IIa” procedure consists of circumscribed enlargement of the drainage pathway without altering the vertical lamella of the anterior middle turbinate (long red dashes). Removing the median floor of the frontal sinus from the lamina papyracea to the nasal septum, combined with removal of the anterior vertical lamella of the middle turbinate, results in a “Draf IIb” procedure (short red dashes) (from Hosemann 2000).

Co.m. Middle turbinate
AE Anterior ethmoidal artery
O.fr. Frontal ostium
S. Nasal septum

Fig. 31
Coronal section through the frontal sinuses. In a Draf type III frontal sinus drainage procedure, a bilateral Draf type IIb procedure (shown in orange on the right side) is combined with resection of the upper nasal septum and portions of the interfrontal septum (shown in red) (from Hosemann 2000).

A specific, individualized strategy should be developed for frontal sinus drainage surgery, aided by preoperative CT scans. The surgeon can select among neo-ostia of varying size (Figs. 30 and 31). The anticipated trauma (exposed cartilage areas) should be considered in relation to the predicted width of the neo-ostium, the pathophysiology, and the proficiency of the operator. If the surgeon decides on manipulations that involve the removal of mucosa, the internal diameter of the neo-ostium should be at least 5 mm (Hosemann et al. 1997). A heavily pneumatized agger nasi is anatomically favorable for achieving this goal (Jacobs et al. 2000). A maximum Draf III drainage procedure results in a horseshoe-shaped neo-ostium measuring approximately 8 x 24 mm in favorable cases.

Fig. 32 a – d
Endoscopy in a formalin-fixed specimen (left side, 30° telescope):

a. The skull base is explored in the posterior-to-anterior direction with a curette, starting anterior to the anterior ethmoidal artery.
b. When a frontoethmoid cell is opened, it may initially be mistaken for the frontal sinus.
c. The definitive frontal sinus approach is identified medially and probed (compare with Fig. 25, p.27).
d. Cell septa are pushed aside (and later removed), establishing clear access to the frontal sinus. A small osteoma (★) is noted laterally as an incidental finding.
Up to this point, removal of the anterior ethmoid has exposed the frontal sinus ostium (Draf type I drainage). The ostium can be enlarged by means of the type II a and b and type III drainage procedures (Figs. 30 and 31).

The curved curette is used to enter tissue spaces and for probing (without perforating bony lamellae).

In most cases a “recess” located just lateral to the vertical lamella of the middle turbinate will lead toward the frontal sinus.

Remove cell septa with the curette to the extent that they can be removed without damaging the mucosa. Generally at this stage you will be working in a posterior-to-anterior direction. Simultaneous medial-to-lateral dissection is also performed where necessary.

Mobilized tissue fragments should be carefully and completely removed. This is necessary to maintain an optimum view (with the 30° telescope).

The usual result is a conspicuous neo-ostium through which the posterior wall of the frontal sinus can be seen (also the roof of the frontal sinus in favorable cases).

8.9 Demonstrating the Olfactory Fibers

The olfactory fibers course in the upper part of the bony vertical lamella of the middle turbinate. In 10% of cases they also course in the mucosa lateral to the bony lamella. It is common to find grooves in the lamella for the olfactory nerves, and they can provide useful landmarks (Kennedy 1992, Kim et al. 2003).

Under endoscopic vision, use the curette or other suitable instrument to dissect the lateral surface of the vertical lamella of the anterior middle turbinate. Remove the mucosa and try to demonstrate a whitish nerve that runs vertically in the field. If a nerve is not demonstrable in this area, for practice you can remove the vertical lamella piecemeal from the lateral side and continue to explore it medially.

8.10 Anatomy of the Large Lacrimal Passages: Demonstrating the Lacrimal Sac

The nasolacrimal duct has an anteroposterior diameter of 5 mm (Ünlü et al. 1997). Viewed from the nose, the lacrimal bone encases the posterior 2.5 mm of the duct and is directly in front of the uncinate process. The lacrimal sac extends approximately 9 mm cephalad past the insertion of the middle turbinate (Wormald et al. 2000). The anterior ethmoid and the agger nasi show varying degrees of anterior extension in relation to the lacrimal passages. In almost half of cases, the surgeon cannot avoid opening anterior ethmoid cells when thoroughly exposing the lacrimal sac (Talks and Hopkisson 1996). The lacrimal bone is usually only about 100 μ thick in the area of the lacrimal sac, making it highly vulnerable (Hartikainen et al. 1996), especially during anterior-to-posterior dissection in the middle meatus.

The usual result is a conspicuous neo-ostium through which the posterior wall of the frontal sinus can be seen (also the roof of the frontal sinus in favorable cases).

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First try to demonstrate the lacrimal duct (Hasner valve) below the inferior turbinate using the endoscope.
- Outline a rectangular, vertically oriented mucosal flap over the lacrimal duct (landmark: the agger nasi) and remove the mucosa. The frontal process of the maxilla is exposed anteriorly and portions of the lacrimal bone posteriorly.
- Remove the bone with the punch (a chisel or bur would be used in vivo).
- Try to probe the lacrimal passages from an external approach, and place tension on the lacrimal sac.
- Remove the medial portions of the lacrimal sac.

### 8.11 Sphenopalatine Artery

Measuring 5–8 mm in diameter, the sphenopalatine foramen lies in the superior meatus near the posterior end of the middle turbinate in 90% of cases (Lee et al. 2002). Next to it, the sagittally oriented perpendicular plate of the palatine bone forms an ethmoid crest to which the posterior part of the middle turbinate is attached. This bony prominence can serve as a landmark: in 35% of cases the foramen is directly behind the crest, in 56% the bony ridge is interrupted by the foramen, and in 9% there are two foramina – one in front of and one behind the ethmoid crest, i.e., in the middle and superior meatus (Bolger et al. 1999, Wareing and Padgham 1998) (Fig. 37).

The maxillary artery gives off numerous small branches while still proximal to the foramen, and it becomes
the sphenopalatine artery close to the sphenopalatine ostium (Fig. 38). The latter vessel usually divides into two larger branches 1.5–2 mm in diameter; usually this occurs in front of the ostium and less commonly past it. The smaller medial arterial branch (septal artery) runs under the lower part of the anterior wall of the sphenoid sinus to the posterior nasal septum (caution: source of bleeding during a sphenoidotomy). The larger branch (posterior lateral nasal artery) in turn distributes variable branches to the middle turbinate and posterior fontanelle and passes downward over the perpendicular plate of the palatine bone approximately 1 cm in front of the end of the middle turbinate (usually, but not always, behind the level of the posterior sphenoid sinus wall) (Figs. 39 and 40).

Fig. 38
Diagram showing the distribution of nerve and arterial branches medial and lateral to the sphenopalatine foramen (after Janfaza et al. 2001, Lee et al. 2002, Pearson et al. 1969; Note: sections are placed at different levels laterally and medially). Terminal branches of the maxillary artery, besides the known septal artery and posterior lateral nasal artery, are the posterior superior alveolar artery, the infraorbital artery, the descending palatine artery, and also branches that pass to the foramen rotundum, the pterygoid canal, and the nasopharynx. The latter arteries are located in the pterygopalatine fossa anterior to the nerves (maxillary nerve, nerve of pterygoid canal – greater petrosal nerve, pterygopalatine ganglion, numerous connections).

Key to Fig. 38
1 Maxillary artery
2 Sphenopalatine artery
3 Foramen rotundum
4 Maxillary nerve
5 Inferior alveolar artery and nerve
6 Ostium of sphenoid sinus
7 Pterygopalatine ganglion
8 Mandibular nerve
9 Middle meningeal artery
10 Pharyngeal arterial branch
11 Optic chiasm
12 Inferior turbinate
13 Sphenomandibular ligament
14 Medial pterygoid muscle
15 Parotid gland
16 Oculomotor nerve
17 Pterygoid canal with nerve of pterygoid canal (vidian nerve, from the greater superior petrosal nerve) and artery
18 Posterior septal artery (medial branch of the sphenopalatine artery)
19 Superior and inferior posterolateral branches of the sphenopalatine artery
20 Descending palatine artery
21 Posterior superior alveolar artery
22 Infraorbital artery
* Sections at different levels

Fig. 39 a – d
Arterial supply of the fontanelles in the posterior part of the middle turbinate (the posterior portions of the middle turbinate have been removed in the diagram). Variant a is the most common, and variants b–d are shown in descending order of frequency (from Lee et al. 2002).

st Superior turbinate
mT Middle turbinate
IT Inferior turbinate
Lateral to the sphenopalatine foramen is the highly variable pterygopalatine fossa (Bagatella 1986). The opening of the pterygoid canal with the “vidian nerve” lies posteriorly, 3 mm lateral to the sphenopalatine foramen. The canal and nerve can be demonstrated on the lateral floor of the sphenoid sinus in almost 20% of cases. The foramen rotundum (maxillary nerve) is located higher than the pterygoid canal and 8 mm farther laterally. In approximately 30% of cases this nerve forms a prominence in the lateral wall of the sphenoid sinus (Bagatella 1986, Lang 1988).

- Create a maximum antrostomy window in the middle meatus. This requires complete excision of the posterior fontanelle.
- Make a vertical mucosal incision at the posterior and slightly superior margin of the antrostomy, approximately 8 mm in front of the posterior extension of the middle turbinate. Strip the mucosal covering posteriorly in the subperiosteal plane.
- Free the bony attachment of the ethmoid crest of the palatine bone and the posterior part of the middle turbinate.
- As you continue the mucosal “tunnel,” you will encounter an opening in the bone behind and slightly above the ethmoid crest (extension of the middle turbinate). Arterial branches and nerves (sphenopalatine nerve) can be seen emerging from this opening in a band of tissue.
- When a large middle meatal antrostomy has been created and the bone is weakly developed, a somewhat more tedious method is to remove the posterior wall of the maxillary sinus. The bone becomes thicker in the medial and superior direction (orbital plate of the palatine bone). In other cases this lamella is pneumatized. In cases with relatively scant bone formation, the removals will permit broad exposure of the sphenopalatine foramen.

### 8.12 Inferior Turbinoplasty

- Make a vertical incision in the head of the inferior turbinate. Insert the sharp end of the double-ended elevator into the wound pouch, passing it to the bone, and outline a medial mucosal flap.
- Elevate the mucosal flap by incising the inferior bridges of tissue. Partially resect the anterior and lateral portions of the head of the turbinate.
- Return the mucosa and if necessary outfracture the body of the turbinate with the blunt end of the double-ended elevator.
8.13 Medial Maxillectomy

A medial maxillectomy may be indicated for tumor resections. It involves creating a maximum communication between the nose and maxillary sinus, extending from the nasal floor to the orbital floor and from the anterior wall to the posterior wall of the maxillary sinus.

- Create a maximum antrostomy window in the inferior meatus (preserving the lacrimal passages for the time being).
- Completely excise the inferior turbinate.
- Demonstrate the nasolacrimal duct.
- Resect the nasolacrimal duct and maximize the window.
- Endoscopic inspection: note the broad exposure including the prelacrimal recess of the maxillary sinus.

8.14 Skull Base

- The ethmoid labyrinth has been exenterated. The vertical lamella of the middle turbinate can now be resected. Identify the cribriform plate and the lateral wall of the olfactory fossa, which is usually thin. Explore the site where the anterior ethmoidal artery enters the olfactory fossa (frequent dehiscences, see above).
- For practice, create an “iatrogenic skull base perforation.” Then cover the perforation with a small flap of autologous mucosa.

8.15 Dissection of the Medial Orbit

The lamina papyracea is very thin in places (50 μ) and may be absent at some points.

- Remove the lamina papyracea: an anterior area of the lamina papyracea can be carefully perforated by pressure from the sharp end of the double-ended elevator and then undermined. Proceeding in steps, push or fracture the bone medially and inferiorly like an egg shell and remove the pieces. If possible, the periorbita is elevated from the skull base to the infraorbital nerve and from the lacrimal duct to the entrance to the sphenoid sinus (this cannot always be accomplished with the standard instrument set). Initially it is left intact.
- Now incise the periorbita: first incise the periorbita from posterior to anterior, making several passes with the knife (Fig. 41). The posterior-to-anterior cut is advantageous in vivo for keeping fat from herniating into the visual field. Next the periorbita is elevated by making anterior vertical cuts and is subtotally removed.
- After exposing the orbital fat, perform the ocular pressure test (Fig. 42). In a positive test, applying external pressure to the eye induces movement of the exposed fat (an important test for detecting injuries of the lamina papyracea!). The orbital fat can be loosened somewhat and dissected with the sickle knife.

**Fig. 41**
The periorbita (P) is incised from posterior to anterior after complete exenteration of the right ethmoid. When the posterior-to-anterior incisions are joined by vertical cuts, the periorbita can be removed from the skull base to a point near the infraorbital nerve (from Hosemann 2000).

**Fig. 42**
Ocular pressure test: if there is doubt regarding possible previous injury to the periorbita, it can be resolved by applying external pressure to the eye. Repeated pressure on the globe will induce a secondary movement of the exposed orbital tissue in the nasal cavity, which can be detected with the endoscope.
Demonstrate the medial rectus muscle.
Demonstrate the canal of the vidian nerve. After identifying the sphenopalatine foramen, maximally enlarge the approach to the sphenoid sinus. Demonstrate the canal of the pterygoid nerve (vidian nerve). The foramen rotundum would be located laterally (see above).

8.16 Exploring the Walls of the Sphenoid Sinus

The sphenoid sinus is of variable extent with a volume ranging from 0 to 14 cm³. Its extent can be roughly classified in relation to the pituitary as a **presellar type** (pneumatization extends posteriorly just to the front wall of the pituitary, prevalence 24%) and a **sellar type** (the sphenoid sinus extends well below the pituitary, prevalence 75%). A rudimentary or **conchal type** of sphenoid sinus is very rare.

In two-thirds of cases the carotid artery forms a prominence in the lateral sinus wall (Figs. 43 and 44).

The optic nerve forms a significant prominence in the anterosuperior lateral wall in approximately 20% of cases. In one-third of these cases the optic canal passes more or less freely through a broad sphenoid sinus. The free course of the nerve through the sphenoid sinus is the result of a heavily pneumatized anterior process of the clinoid. In rare cases (3%) the entire canal lies in the lateral wall of a posterior ethmoid cell (DeLano and Zinreich 1996).

8.16.1 Optic Nerve Decompression

The optic canal is approximately 9 mm (5–10 mm) long, and its wall is approximately 0.3–1 mm thick. In 50% of cases the distal opening of the canal is located in a posterior ethmoid cell. It may also lie at the junction of the sphenoid sinus and ethmoid (25%) or in the sphenoid sinus itself (25%). The bone is thinnest in the medial middle portion of the canal. Dehiscences are found in 4% of cases.
If we try to demonstrate the canal by removing the posterior part of the lamina papyracea, the first distal structure that we encounter is the annulus of Zinn (common tendinous ring, insertion of the ocular muscles) followed by the “optic tubercle,” which is the thickened distal part of the optic canal. In 15% of cases the proximal ophthalmic artery runs intradurally in the medial part of the canal, making it susceptible to injury during incision of the nerve sheath. Transnasal decompression of the medial optic nerve can be accomplished over about a 7-mm length of the nerve (Chou et al. 1995, Maniscaldo and Habal 1978).

- Working from anterior to posterior, try to pry away pieces of the bony optic canal in the medial direction using the sharp end of the double-ended elevator.
- Next, incise the exposed optic nerve sheath longitudinally with a sickle knife.

**8.16.2 Demonstrating the Carotid Artery, Demonstrating the Pituitary Prominence, Other Structures of the Sphenoid Sinus Walls**

- Using a similar technique as for the optic nerve, remove the accessible bone over the internal carotid artery and at the midline over the pituitary prominence.
- If the sphenoid sinus is very large, you can also try to identify the maxillary nerve.

**8.17 Endonasal Extension of the Maxillary Sinus Approach, Analogous to the Denker Operation**

The opening between the nasal cavity and maxillary sinus after the medial maxillectomy (see above) can be enlarged further. This is done by starting at the piriform aperture and progressively removing the “medial pillar” of the midface (portions of the medial maxilla and medial anterior wall of the maxillary sinus). First strip the periosteum over the maxilla, starting from the nasal vestibule, and then remove the bone in small pieces. The goal is to enlarge the opening to the maxillary sinus.

**The surgeon’s repertoire should include the following emergency measures for treating complications that may arise during sinus surgery:**

- Control bleeding from the sphenopalatine artery or anterior ethmoidal artery, or at the lower anterior wall of the sphenoid sinus.
- Incise the periorbita to relieve pressure in the orbital cavity.
- Cover a perforation in the skull base.

The anatomical foundations of these measures can be analyzed by completing the dissection exercises described above. One additional emergency measure should be known but is difficult to simulate in a dissection model:

- Decompress the orbit by means of a lateral canthotomy and inferior cantholysis (Fig. 45).

---

**Fig. 45**

With a small scissors, a lateral horizontal cut is made in continuity with the lateral palpebral fissure, cutting through the skin and to the bony orbit. If anterior traction on the lower eyelid shows that the pressure is still not relieved, an inferior cantholysis is added: a downward cut is made from the initial incision (beneath the outer skin), dividing the inferior palpebral ligament. The lower eyelid can now be pulled slightly away from the globe.
Space for Notes and Sketches
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<td>integrated Parfocal Zoom Lens, f = 15–31 mm (2x)</td>
</tr>
<tr>
<td>Min. sensitivity</td>
<td>F 1.4/1.17 Lux</td>
</tr>
<tr>
<td>Grip mechanism</td>
<td>standard eyepiece adaptor</td>
</tr>
<tr>
<td>Cable</td>
<td>non-detachable</td>
</tr>
<tr>
<td>Cable length</td>
<td>300 cm</td>
</tr>
</tbody>
</table>

TH 104

IMAGE1 S H3-ZA Three-Chip FULL HD Camera Head, 50/60 Hz, IMAGE1 S compatible, **autoclavable**, progressive scan, soakable, gas- and plasma-sterilizable, with integrated Parfocal Zoom Lens, focal length f = 15–31 mm (2x), 2 freely programmable camera head buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

Specifications:

<table>
<thead>
<tr>
<th>IMAGE1 FULL HD Camera Heads</th>
<th>IMAGE1 S H3-ZA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product no.</td>
<td>TH 104</td>
</tr>
<tr>
<td>Image sensor</td>
<td>3x ½&quot; CCD chip</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>39 x 49 x 100 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>299 g</td>
</tr>
<tr>
<td>Optical interface</td>
<td>integrated Parfocal Zoom Lens, f = 15–31 mm (2x)</td>
</tr>
<tr>
<td>Min. sensitivity</td>
<td>F 1.4/1.17 Lux</td>
</tr>
<tr>
<td>Grip mechanism</td>
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<tr>
<td>Cable</td>
<td>non-detachable</td>
</tr>
<tr>
<td>Cable length</td>
<td>300 cm</td>
</tr>
</tbody>
</table>
Monitors

9619 NB

19" HD Monitor, color systems PAL/NTSC, max. screen resolution 1280 x 1024, image format 4:3, power supply 100–240 VAC, 50/60 Hz, wall-mounted with VESA 100 adaption, including:
External 24 VDC Power Supply
Mains Cord

9826 NB

26" FULL HD Monitor, wall-mounted with VESA 100 adaption, color systems PAL/NTSC, max. screen resolution 1920 x 1080, image format 16:9, power supply 100–240 VAC, 50/60 Hz including:
External 24 VDC Power Supply
Mains Cord
## Monitors

<table>
<thead>
<tr>
<th>KARL STORZ HD and FULL HD Monitors</th>
<th>19&quot;</th>
<th>26&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted with VESA 100 adaption</td>
<td>9619 NB</td>
<td>9826 NB</td>
</tr>
</tbody>
</table>

### Inputs:
- DVI-D
- Fibre Optic
- 3G-SDI
- RGBS (VGA)
- S-Video
- Composite/FBAS

### Outputs:
- DVI-D
- S-Video
- Composite/FBAS
- RGBS (VGA)
- 3G-SDI

### Signal Format Display:
- 4:3
- 5:4
- 16:9
- Picture-in-Picture
- PAL/NTSC compatible

### Optional accessories:
- 9826 SF **Pedestal**, for monitor 9826 NB
- 9626 SF **Pedestal**, for monitor 9619 NB

### Specifications:

<table>
<thead>
<tr>
<th>KARL STORZ HD and FULL HD Monitors</th>
<th>19&quot;</th>
<th>26&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop with pedestal</td>
<td>optional</td>
<td>optional</td>
</tr>
<tr>
<td>Product no.</td>
<td>9619 NB</td>
<td>9826 NB</td>
</tr>
<tr>
<td>Brightness</td>
<td>200 cd/m² (typ)</td>
<td>500 cd/m² (typ)</td>
</tr>
<tr>
<td>Max. viewing angle</td>
<td>178° vertical</td>
<td>178° vertical</td>
</tr>
<tr>
<td>Pixel distance</td>
<td>0.29 mm</td>
<td>0.3 mm</td>
</tr>
<tr>
<td>Reaction time</td>
<td>5 ms</td>
<td>8 ms</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>700:1</td>
<td>1400:1</td>
</tr>
<tr>
<td>Mount</td>
<td>100 mm VESA</td>
<td>100 mm VESA</td>
</tr>
<tr>
<td>Weight</td>
<td>7.6 kg</td>
<td>7.7 kg</td>
</tr>
<tr>
<td>Rated power</td>
<td>28 W</td>
<td>72 W</td>
</tr>
<tr>
<td>Operating conditions</td>
<td>0–40°C</td>
<td>5–35°C</td>
</tr>
<tr>
<td>Storage</td>
<td>-20–60°C</td>
<td>-20–60°C</td>
</tr>
<tr>
<td>Rel. humidity</td>
<td>max. 85%</td>
<td>max. 85%</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>469.5 x 416 x 75.5 mm</td>
<td>643 x 396 x 87 mm</td>
</tr>
<tr>
<td>Power supply</td>
<td>100–240 VAC</td>
<td>100–240 VAC</td>
</tr>
<tr>
<td>Certified to</td>
<td>EN 60601-1, protection class IPX0</td>
<td>EN 60601-1, UL 60601-1, MDD93/42/EEC, protection class IPX2</td>
</tr>
</tbody>
</table>
Data Management and Documentation
KARL STORZ AIDA® – Exceptional documentation

The name AIDA stands for the comprehensive implementation of all documentation requirements arising in surgical procedures: A tailored solution that flexibly adapts to the needs of every specialty and thereby allows for the greatest degree of customization.

This customization is achieved in accordance with existing clinical standards to guarantee a reliable and safe solution. Proven functionalities merge with the latest trends and developments in medicine to create a fully new documentation experience – AIDA.

AIDA seamlessly integrates into existing infrastructures and exchanges data with other systems using common standard interfaces.

WD 200-XX* AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, power supply 100-240 VAC, 50/60 Hz including:
- USB Silicone Keyboard, with touchpad
- ACC Connecting Cable
- DVI Connecting Cable, length 200 cm
- HDMI-DVI Cable, length 200 cm
- Mains Cord, length 300 cm

WD 250-XX* AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, including SMARTSCREEN® (touch screen), power supply 100-240 VAC, 50/60 Hz including:
- USB Silicone Keyboard, with touchpad
- ACC Connecting Cable
- DVI Connecting Cable, length 200 cm
- HDMI-DVI Cable, length 200 cm
- Mains Cord, length 300 cm

*XX Please indicate the relevant country code (DE, EN, ES, FR, IT, PT, RU) when placing your order.
Workflow-oriented use

Patient
Entering patient data has never been this easy. AIDA seamlessly integrates into the existing infrastructure such as HIS and PACS. Data can be entered manually or via a DICOM worklist. All important patient information is just a click away.

Checklist
Central administration and documentation of time-out. The checklist simplifies the documentation of all critical steps in accordance with clinical standards. All checklists can be adapted to individual needs for sustainably increasing patient safety.

Record
High-quality documentation, with still images and videos being recorded in FULL HD and 3D. The Dual Capture function allows for the parallel (synchronous or independent) recording of two sources. All recorded media can be marked for further processing with just one click.

Edit
With the Edit module, simple adjustments to recorded still images and videos can be very rapidly completed. Recordings can be quickly optimized and then directly placed in the report. In addition, freeze frames can be cut out of videos and edited and saved. Existing markings from the Record module can be used for quick selection.

Complete
Completing a procedure has never been easier. AIDA offers a large selection of storage locations. The data exported to each storage location can be defined. The Intelligent Export Manager (IEM) then carries out the export in the background. To prevent data loss, the system keeps the data until they have been successfully exported.

Reference
All important patient information is always available and easy to access. Completed procedures including all information, still images, videos, and the checklist report can be easily retrieved from the Reference module.
Fiber Optic Light Cables for Cold Light Fountains

Fiber Optic Light Cable, with straight connector, extremely heat-resistant, diameter 4.8 mm, length 250 cm

Cold Light Fountain XENON 300 SCB

Cold Light Fountain XENON 300 SCB with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB power supply: 100–125 VAC/220–240 VAC, 50/60 Hz including:

Mains Cord
SCB Connecting Cable, length 100 cm

Spare Lamp Module XENON with heat sink, 300 watt, 15 volt

XENON Spare Lamp, only, 300 watt, 15 volt

Cold Light Fountain XENON NOVA® 175

Cold Light Fountain XENON NOVA® 175, power supply: 100–125 VAC/220–240 VAC, 50/60 Hz including:

Mains Cord

XENON Spare Lamp, 175 watt, 15 volt
Equipment Cart

Equipment Cart
- wide, high, rides on 4 antistatic dual wheels equipped with locking brakes
- 3 shelves, mains switch on top cover
- central beam with integrated electrical subdistributors with 12 sockets, holder for power supplies, potential earth connectors and cable winding on the outside

Dimensions:
- Equipment cart: 830 x 1474 x 730 mm (w x h x d)
- shelf: 630 x 510 mm (w x d)
- caster diameter: 150 mm

Including:
- Base module equipment cart, wide
- Cover equipment, equipment cart wide
- Beam package equipment, equipment cart high
- 3x Shelf, wide
- Drawer unit with lock, wide
- 2x Equipment rail, long
- Camera holder

Monitor Swivel Arm,
- height and side adjustable
- can be turned to the left or the right side
- swivel range 180°, overhang 780 mm
- overhang from centre 1170 mm
- load capacity max. 15 kg
- with monitor fixation VESA 5/100
- for usage with equipment carts UG xxx
Recommended Accessories for Equipment Cart

**Isolation Transformer,**
200 V – 240 V; 2000 VA with 3 special mains socket, expulsion fuses, 3 grounding plugs, dimensions: 330 x 90 x 495 mm (w x h x d), for usage with equipment carts UG xxx

**Earth Leakage Monitor,**
200 V – 240 V, for mounting at equipment cart, control panel dimensions: 44 x 80 x 29 mm (w x h x d), for usage with isolation transformer UG 310

**Monitor Holding Arm,**
height adjustable, inclinable, mountable on left or right, turning radius approx. 320°, overhang 530 mm, load capacity max. 15 kg, monitor fixation VESA 75/100, for usage with equipment carts UG xxx