Hands-On Dissection Guide on
ENDOSCOPIC ENDONASAL
SINUS SURGERY

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1.1 Introduction

Endonasal endoscopic sinus surgery has become established as the standard procedure for treating sinonasal disorders, particularly of those associated with sinusitis. Generally, the major objectives of surgery are related to improving ventilation and drainage of the affected sinuses in conjunction with the removal of diseased tissue as determined by the type and extent of disease.

Sinus surgery aiming to optimize ventilation and drainage as well as to preserve healthy mucosa and anatomic structures that are free of disease is known as ‘Functional Endoscopic Sinus Surgery’ (FESS). Based on the concept of tissue-sparing, function-oriented FESS, ‘Extended Endoscopic Sinus Surgery’ (EESS) has been evolved, enabling a targeted resection of anatomic structures in the area of nasal / paranasal sinuses – or even in adjoining areas, e.g., skull base, medial orbit – to treat tumors or sinonasal diseases that are associated with severe inflammatory processes.

Performing FESS or EESS not only requires a good control of endoscopic surgical techniques. Just as important to the outcome of a chosen procedure is the technical equipment, which should include an HD video camera system with widescreen monitor, HOPKINS® rod-lens endoscopes, dedicated microinstruments and powered (optional) devices, such as a shaver unit, navigation system, and additional components.

This manual has been designed to systematically present the spectrum of modern endoscopic sinus surgery in a step-by-step manner. In the first instance, we will deal with what is typically considered the primary surgical step – resection of the uncinate process. In the subsequent chapters, the authors give detailed descriptions which finally address the comprehensive surgical treatment of all sinonasal compartments (pansinus surgery, ‘full-house’ FESS) including extended surgical approaches. Surgical procedures are described using anatomic specimens, graphic diagrams, and endoscopic findings. The didactic concept gives due consideration to all relevant aspects of the topographic anatomy, current findings in physiology and pathophysiology, and the technological state of the art.

Accordingly, sinus surgery is divided into modules that can be implemented either exclusively or can be combined for a gradually extended procedure. Both the operation and dissection are conducted with specific reference to predefined anatomic landmarks to ensure that procedures are performed correctly, safely, and completely, according to the principles of good surgical practice.

The first section of this booklet is devoted to the general rules of dissection, followed by a detailed description of practical steps which are supplemented by surgical-anatomic aspects of the most common sinonasal approach, mainly encompassing the middle meatus and involving uncinectomy, identification of the maxillary sinus ostium with creation of a wide middle meatal antrostomy, and partial anterior ethmoidectomy.
2 Basics of Surgical-Anatomic Dissection

2.1 General Rules

- It is strongly recommended that you take your time to thoroughly dissect the provided specimens step-by-step in order to gain the best possible understanding of ‘endonasal surgical anatomy’.
- Initially, the endoscopic image should be optimized as follows:
  - Make sure that a sharp view of the anatomical site is obtained by rotating the front adjustment ring at the camera head to focus the center of the field of view.
  - At the beginning of dissection / surgery, a panoramic view with a high depth of field is particularly helpful. The rear adjustment ring is used to zoom in until the magnified circular image is only slightly cropped, while most of the image content is taken up by the rectangular video screen. When focusing on details, you may zoom in until the area of interest is shown with the highest possible definition.
  - The current orientation of the scope may be locked in position by minimal counterclockwise rotation of the adapter at the camera.
  - If necessary, the video camera system must be white-balanced beforehand.
- There are various options for holding the scope and the camera. Posture and manual control of the scope depend on whether the surgeon prefers standing or sitting and whether the arm rests on a table to guide the scope. Special sleeves are available for the endoscope sheath to facilitate holding the scope while connected to a light cable. Many surgeons hold the scope like a pencil, between the thumb and index/middle finger of the non-dominant hand, while instruments are held in the dominant hand (in the case of a right-handed person, standing or sitting on the right side of the patient).
- Beginners should first insert the instrument in the nasal vestibule and elevate the nostril a little to increase the available space. In the next step, while inserting the scope, care must be taken to always keep the distal end of the instrument under visual control in order to prevent inadvertent injury to the mucosa. While changing instruments, the scope must stay in a resting position inside the nose. Note, that there is an inadvertent tendency of the inexperienced surgeon to let the scope move further into the nose while changing instruments. Due care should be taken to avoid this.
- The scope is typically supported in the nasal dome. Aside from a few notable exceptions, the surgical instrument is guided underneath the shaft of the scope. This configuration has proven useful in that it allows the opening provided by the nostril to be enlarged, thereby increasing the space offered for instrument insertion.
- The image on the video screen should always be in standard upright orientation, even when looking sideways with a scope that offers a direction of view other than 0°. This is required to maintain a consistent and reliable anatomical orientation. In cases where the scope’s central view and the operative route do not match with the regular vertical plane, the orientation of the camera must be realigned.

In all scopes offering a direction of view other than 0°, the image on the video screen is shown in upright orientation whenever the cable – connected to the camera (not the light cable that is connected to the scope!) – points toward the patient’s feet. The home position should be realigned exclusively by rotation of the camera head. Otherwise, loss of orientation can result from the incorrect home position of the reference system.

- While practicing on a cadaver specimen, the actual route of dissection should be repeatedly checked with the naked eye. This particularly applies to situations where it is difficult to maintain anatomic orientation. As a matter of principle, the scope’s position and its spatial alignment in relation to the patient’s head are appreciated and checked against the endoscopic image. In general, there is a tendency to inadvertently work in a lateral direction – which may result in injury to the orbit and, farther posteriorly, to the optic nerve.

The following rigid standard scopes are available on the market:
- Straight-forward scopes are wide-angle scopes with a fixed direction of view of 0°. ‘Angled’ scopes belong to the same category, but offer a fixed direction of central view other than 0° – e.g., 30°, 45°, and 70°. The latter subtype should not be confused with advanced multiangled rigid scopes* which have a movable mirror-prism at the distal end.
- All scopes with a shaft diameter of 4 mm come with a wide-angle rod-lens system which offers a field of view nearly twice as large as that of the normal human eye. Therefore, it is possible to perform procedures on the lateral nasal wall even with a 0°-scope (in ‘straight forward view’). The intrinsic field of view of a 30°-scope is oriented such as to still allow for a straight-forward view. In the 45°-scope, an exact straight-forward view is missed by 5°. ‘Angled’ scopes allow viewing ‘around the corner’ into hidden recesses of sinuses or the surgical field.

The scope is chosen on the basis of the surgeon’s individual habits and preferences, as well as the technical equipment available on site, etc. In general, working with a 0° straight-forward scope is easier, but the 30°-scope, and in many cases the 45°-scope, may be used as well. If the need arises in a surgical procedure to ‘work around a corner’, the use of ‘angled’ scopes is very helpful and, occasionally, imperative.

*) e.g., ENDOCAMELEON®, KARL STORZ Tuttingen, Germany.
In the course of intranasal anatomic dissection, the overlying mucosa often detaches from the bony support, particularly when there is a need for creating a maxillary antrostomy. Minor detachment should be ignored. In case of major detachment, the mucosa should be cut with a sharp instrument, and the remnants should be repositioned to restore a regular aspect of the surgical field. When practicing on an anatomic specimen, the last resort is to remove a large area of mucosa to ensure a good overview.

In moist specimens, an obscured ostium often becomes apparent through an air bubble that emanates from the depth after probing the tissue.

2.2 Practical Points and Preparatory Work

Instruments are checked for completeness, integrity and proper function. This also applies to the scopes and videendoscopic imaging chain. Pertinent adjustments should be made to optimize the endoscopic image (see above).

Prepare and set up your workplace in such a way, that optimized ergonomics and safety issues are given adequate consideration.

Unfixed specimens often still need to be cleaned. Take your time to obtain a good view of key anatomic structures:
- Flush out the nasal cavity with a water syringe.
- Aspirate detritus and any remaining ice. Remove any fragments of tissue or detritus with grasping forceps. With the aid of a slim forceps, swabs can be pulled through the main nasal cavity for cleansing purposes.

Please handle the offered instruments with care: sharp instruments of slender design are not suited to cut and remove dense bony tissue.

All recommendations related to dissection technique in cadaver dissections, in most aspects analogously apply to intraoperative in vivo conditions. However, intraoperative bleeding is a phenomenon to be always reckoned with in a live patient. Suitable measures for reducing intraoperative bleeding are described in detail in the literature.

In cases where vision is obscured by a deviated septum, all parts of cartilage, vomer, or perpendicular plate that are found to contribute to the deviation should be removed via a mucosal incision made in the nasal orifice or via an intranasal incision placed immediately in front of the deviated segment.

The inferior turbinate is gently lateralized using a double-ended elevator. As an important landmark, the choana should be readily visible through the scope. In some cases, turbinoplasty with removal of the turbinate bone protruding far into the nasal lumen is required (if necessary, the adjacent frontal process of the maxilla is included in resection).
Step 1a: Nasal Endoscopy and Preparatory Surgical Steps

3.1 Objectives
A systematic approach to nasal endoscopy covers the main nasal cavity, the inferior, middle, and superior meatuses, and the anterior wall of the sphenoid sinus with sphenoethmoidal recess, choana, and nasopharynx.

Step 1a is aimed at building an understanding of the individual sinonasal anatomy and its surgically relevant landmarks as well as giving an impression of the breadth of space accessible for surgical inspection and treatment. Preparatory surgical steps are defined (e.g., septoplasty, lateralization of the inferior turbinate, specific surgical maneuvers on the inferior and/or middle turbinate, or turbinoplasty of the inferior / middle turbinate).

3.2 Regional Anatomy
- The lateral nasal wall derives its specific anatomical structure from the inferior, middle, and superior turbinates – composed of an osseous body wrapped in a mucosal lining – which are attached laterally or cranially.
- The nasal turbinates define the corresponding inferior, middle, and superior meatus and part of the sphenoethmoidal recess.
- In anterosuperior position to the anterior attachment of the middle turbinate (axilla) lies the agger nasi, from which the vertical ‘maxillary line’, a prominent ridge, is seen to course toward the head of the inferior turbinate.
- The olfactory cleft is located between the middle / superior turbinates and the nasal septum.
- Dorsally, the choana forms the boundary of the main nasal cavity and marks the transition to the nasopharynx with the pharyngeal opening of the auditory tube.

3.3 Anatomical Landmarks *
- Nasal septum revealing individual types of variation in shape.
- Size and shape of the inferior, middle and superior turbinates.
- Width of the inferior meatus and location of the nasolacrimal duct orifice.
- Width of the middle meatus with attachment, shape and extension of the uncinate process.
- Axilla of the middle turbinate.
- Agger nasi.
- ‘Maxillary line’.
- Accessory maxillary sinus ostia, if present.
- Anterior wall and undersurface of the ethmoid bulla.
- Width of the superior meatus.
- Sphenoethmoidal recess.
- Position and shape of the sphenoid sinus ostium.
- Olfactory cleft.
- Choana.
- Nasopharynx.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.
3.4 Details of Dissection / Surgical Technique

3.4.1 Clinical Notes
An initial overview is gained when advancing the scope (in an anteroposterior direction). A detailed inspection is often conducted when retracting the scope.

- Endoscopy of the inferior meatus.
  - Identify the choana, nasopharynx, and Eustachian tube orifices.
  - Whenever possible, identify the nasolacrimal duct beneath the anterior aspect of the inferior turbinate.
- Endoscopy of the middle meatus.
  - Identify the head of the middle turbinate (expanded – possible concha bullosa? Paradoxical shape? Lateral flexion?).
  - Identify the free edge of the uncinate process.
  - Identify the ethmoid bulla and possible accessory maxillary sinus ostia.

- Endoscopy of the superior meatus.
  - Identify the superior turbinate.
  - Identify the entrance into the posterior ethmoid.
- Endoscopy of the sphenoid recess and anterior sphenoid wall, with exposure of the sphenoid sinus ostium.
  - Try to locate the olfactory cleft (this can be difficult). Lateral displacement of the middle turbinate should be carefully avoided in a living patient.

4

Step 1b: Surgery of the Middle Turbinate (Optional Step)
Resection of the Lateral Lamella of a Concha Bullosa

4.1 Objectives
Reduction of a broad anterior middle turbinate or other types of resection performed on the middle turbinate in cases where access to the middle meatus is blocked considerably (concha media bullosa, pronounced paradoxical curvature or lateralization, distinctly enlarged turbinate head).

Step 1b is intended to create a sufficiently wide access to the middle meatus that allows proceeding with the subsequent operative steps, while preserving integrity of a stable middle turbinate to the greatest degree feasible. Once the required tissue removal has been accomplished, the middle meatus should be readily visible through the scope, and permits the uncinate process to be identified.

4.2 Regional Anatomy
The middle turbinate demarcates the middle meatus, which communicates with the maxillary sinus, the anterior ethmoid cells, and the frontal sinus. Its attachment zone starts anteriorly in the area of the ‘axilla’ at the agger nasi, courses in an anterosuperior direction along the skull base and ends posterocaudally at the lateral nasal wall. The basal lamella – as the main osseous membrane of the middle turbinate that merges with neighbouring bony structures via distinct attachment zones – separates the anterior from the posterior ethmoid and is characterized by a complex three-dimensional structure. Anteriorly, it is oriented sagitovertically, in the middle region nearly frontally, and assumes a rather horizontal orientation dorsally, with an attachment in the area of the ethmoidal crest of the palatine bone, adjacent to the sphenopalatine foramen. Its vertical portion extends superiorly where it is continuous with the lateral wall of the olfactory cleft. 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 the frontal section (3%),
- it may be bent medially (3%) or
- laterally (3%), or
- it may exhibit a transverse cleft.*

4.3 Anatomical Landmarks *

- Middle turbinate (note, there is considerable variation in shape and size).
- Middle meatus (note, there is considerable variation in terms of width, site of attachment, shape and extension of the uncinate process).
- Axilla of the middle turbinate.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.
Step 1b: Surgery of the Middle Turbinate (Optional Step)

4.4 Details of Dissection / Surgical Technique

- In the presence of a concha bullosa, the head of the middle turbinate may be distinctly enlarged (pneumatized) and/or may reach far anteriorly:
  - Make an anterior incision (using micro scissors) along an imaginary line extending from the medial axilla of the middle turbinate to the lateral caudal edge of the turbinate, taking into account the anticipated / required anteroposterior reduction in length.
  - Proceed with continued transection of tissue in the area of the lateral lamella that belongs to the opened body of the turbinate, traverse dorsally in a parasagittal direction and, in the caudal area, take a slightly lateral direction toward the attachment site at the lateral nasal wall.
  - Remove lateral portions of the concha bullosa with a through-cutting nasal forceps. If necessary, resect protruding tissue using a Kerrison punch. In a live scenario, intraoperative coagulation is applied to the dorsal inferolateral excision margin and, if necessary, to exposed (mostly minor) bleeding vessels.
- In case of paradoxical curvature or pronounced lateral deviation: Remove excess tissue of the middle turbinate in the middle meatus using, e.g., the Kerrison punch from laterally.

4.4.1 Clinical Notes

- Surgical manipulations performed at the head of the middle turbinate should be done sparingly and with foresight.
- If possible, avoid medialization of the (often fragile) vertical lamella or widening of the middle meatus with a speculum – this can lead to (typically unnoticed) fracture and, in the postoperative period, to scarring and lateralization with sequelae related to insufficient ventilation and drainage of dependant sinus compartments. The same holds true when undue pressure is applied to the head of the turbinate in an anteroposterior direction (‘anteroposterior incision of a concha bullosa’).
- The benefits and drawbacks associated with a regular partial removal of the middle turbinate are intensively discussed in the literature. Preservation of mucosal and respiratory aerodynamic physiology had been stated as an argument against an ample resection of the middle turbinate. Conversely, no evidence of long-term side effects has been provided in study cohorts that were investigated after (anteroinferior) partial resection of the middle turbinate with preservation of its landmark function. In some cases of pronounced disease, there are even reports on reduced postoperative scarring and improved outcome after partial turbinectomy.
- It is important to keep in mind that the olfactory mucosa may well extend to the anterosuperior aspect of the middle turbinate – although this could not be demonstrated in every case and was only shown for a few olfactory sensory neurons.\(^3, 10\)
- An “interlamellar cell” of the middle turbinate is frequently found to be of no pathological significance – and is also a finding that is frequently missed.

Fig. 4.1 Vertical splitting of a concha bullosa with removal of the lateral lamella.

a. Anterior view of a left-sided concha bullosa.
b. The anterior part of the middle turbinate is carefully incised and its lumen is opened minimally. The turbinate is split in the sagittal plane in a step-by-step fashion using the axilla above – which needs to be spared as much as possible – as a landmark for orientation. Care must be taken to avoid applying undue anteroposterior force to the medial vertical lamella of the turbinate.
c. Endoscopic view of the middle meatus following removal of the lateral lamella.
Nasal septum (1); middle turbinate (2); middle turbinate (medial lamella of concha bullosa) (3); middle turbinate (lateral lamella of concha bullosa) (4); axilla (5); uncinate process (6); ‘maxillary line’ (broken line) (7); agger nasi (8).
Step 2: Surgery of the Middle Meatus
Infundibulotomy (Uncinectomy), Identification of the Maxillary Sinus Ostium, Types I–III Middle Meatal Antrostomy

5.1 Objectives
Resection of the uncinate process, identification of the maxillary sinus ostium, and step-by-step enlargement of the orifice of the maxillary sinus (= maxillary sinus antrostomy).

Step 2 is intended to expose and, if necessary, adequately enlarge the drainage and ventilation pathways of the maxillary sinus as well as those of the anterior ethmoid cells and frontal recess.

5.2 Regional Anatomy
In procedures on the anterior ethmoid cells, a central role is played by the uncinate process, a thin osseous lamella at the entrance to the middle meatus that may be tilted at various angles and extends in a cranial direction between the inferior turbinate and the attachment of the middle turbinate. It limits access to the anterior ethmoid cells. In the trough-shaped space, located in front of the ethmoid bulla, it forms the ethmoidal infundibulum, which drains into the middle meatus through the inferior semilunar hiatus.

In its anteromedial aspect, the uncinate process overlaps the maxillary sinus ostium, which is located between the maxillary frontal process, the lacrimal bone, maxillary sinus roof, and superior margin of the inferior turbinate.

The anterior ethmoid complex consists of multiple smaller cells that are categorized into cell groups as determined by topographic location and how they relate to the drainage pathway of the frontal sinus. There is a series of terms that are used synonymously by several classification systems:

- The cells abutting on the frontal process of maxilla in its anterior and lateral aspects (agger nasi cell, supra agger cells, supra agger frontal cell). Their clinical and surgical relevance lies in the fact that they displace the drainage pathway of the frontal sinus dorsally or dorsomedially.

- The bulla cells abutting dorsally on the basal lamella of the middle turbinate. They account for anterior displacement of the drainage pathway. The most anteroinferior cell is termed ethmoid bulla. In a cranial direction, various supra bulla cells or a ‘supra bulla frontal cell’ may be found.

- Dorsolaterally, a ‘supraorbital ethmoid cell’ may pneumatize the orbital roof and part of the posterior wall of the inferior frontal sinus. The frontal sinus drainage pathway is displaced anteriorly and medially.

- The cells located medially in the nasal and frontal sinus septum (‘frontal septal cells’) laterally displace the frontal sinus drainage pathway.

- An infraorbital cell pneumatizes the roof of the maxillary sinus and may narrow the ostium of the maxillary sinus from dorsally.

In ‘minor’ sinonasal surgery, only the agger nasi cell, the ethmoid bulla, and any infraorbital cell, if present, are of clinical relevance to the surgical strategy planning.

The maxillary sinus pneumatizes the maxilla and is shaped like a three-sided pyramid composed of anterolateral, posterior, and medial walls and the orbital floor. The pyramid tip points to the zygomatic process of the maxilla. The infraorbital nerve, as the terminal branch of the maxillary nerve, traverses the maxillary sinus roof. The floor of the maxillary sinus is formed by the alveolar recess anteriorly and the palatine recess medially. The nasolacrimal duct, from which a prelacrimal recess may emanate, runs medioanteriorly.

The natural drainage pathway of the maxillary sinus is located near the roof of the maxillary sinus, directly behind the nasolacrimal duct, where the slightly oval and somewhat oblique maxillary ostium opens into the ethmoidal infundibulum.

5.3 Anatomical Landmarks *

- Uncinate process. Note, there is considerable variation in terms of site of attachment, shape and extension.
- Agger nasi.
- ‘Maxillary line’.
- Anterior wall and undersurface of the ethmoid bulla.
- Ethmoidal infundibulum.
- Maxillary sinus.
- Maxillary sinus ostium.
- Accessory maxillary sinus ostium.
- Roof of the maxillary sinus.
- Infraorbital ethmoid cells.
- Frontal process of the maxilla.
- Inferior turbinate.
- Lacrimal duct.
- Infraorbital nerve.
- Roots of teeth.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.
5.4 Details of Dissection / Surgical Technique

Resection of the uncinate process (termed ‘uncinectomy’, ‘infundibulotomy’) is the central and first stage of virtually any surgical procedure performed on the ethmoid and maxillary sinus.

Uncinectomy is a reliable method for exposure of the ostium of the maxillary sinus and exposure of the ethmoidal infundibulum constituting the natural communication and drainage pathway of the anterior ethmoid and frontal sinus.

- First, identify the attachment zone and the free margin of the uncinate process.
- Palpate the lateral nasal wall.
- Mobilize the uncinate process in an anteroposterior direction and vice versa.
- If adequate time is available, the medial mucosal lining may first be separated from the bony uncinate process and removed to clearly show the position and shape of the fragile bone.
Uncinectomy / infundibulotomy can be performed in an anteroposterior direction or vice versa:

- **Anteroposterior approach (Fig. 5.3):** The incision is made in an anterosuperior-to-posteroinferior direction starting behind the attachment zone at the frontal maxillary process. The detached tissue is simultaneously mobilized in a medial direction, which opens and exposes the ethmoidal infundibulum and offers a first glance of the maxillary sinus ostium. Once the initial incision has been completed, a tissue bridge often remains in a cranial, and also in a dorso-caudal direction. Both attachments are severed with a sharp instrument or detached cautiously with a twisting motion of the instrument, while preserving the mucosal lining to the greatest possible extent. The horizontal remnant of the uncinate process can be released from its mucosal pocket and excised, followed by removal of residual mucosa. Next, the ostium of the maxillary sinus is freed completely and can be assessed as to its size and the potential presence of mucosal swelling. The rounded opening of the maxillary sinus ostium should be appreciated. Integrity of the mucosal lining of the maxillary sinus ostium is still fully preserved.

- **Posteroanterior approach (Fig. 5.4):** Using the mobile jaw of a backward-biting punch, the ethmoidal infundibulum is entered dorsally passing along the free edge of the uncinate process, which is incised or punched proceeding in an anterior or anterosuperior direction toward the maxillary sinus ostium. The curved probe is used to locate the maxillary ostium, which in turn is gently medialized at its caudal lip. This makes it easier to remove remnants of the uncinate process. The rest of the procedure follows the same steps as described for the anteroposterior approach.

- Using the ‘swing-door’ technique, the normal course of uncinectomy is preceded by cutting and removing the midsection of the uncinate process. A ball-end probe is slid under the remnants of the uncinate process and used to mobilize (‘swing’) them in a medial direction.

- Complete uncinectomy – with removal of the cranial portion – commonly opens up the view onto or even into an agger nasi cell. For this purpose, the cranial portion of the uncinate process is mobilized and removed at its lateral point of attachment, e.g. by using a Kerrison punch.

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| a. | Endoscopic view of the middle meatus. Note the proposed line of incision (anterior grey outline) for removal of the uncinate process. |
| b. | Incision made to the uncinate process using a sickle knife. |
| c. | Medial displacement of the uncinate process with exposure of the ethmoidal infundibulum and maxillary sinus ostium. |
| d. | Exposure of the maxillary sinus ostium while preserving its integrity (type I maxillary antrostomy). |
| e. | Close-up view of the maxillary sinus ostium. |
| f. | Enlarged maxillary sinus ostium (corresponding to a type II maxillary antrostomy). |

Nasal septum ①; middle turbinate ②; ethmoid bulla ③; uncinate process ④; see also the grey outline in (a); inferior turbinate ⑤; maxillary sinus ostium ⑥; lamina papyracea ⑦; roof of the maxillary sinus (plane) ⑧; infraorbital nerve ⑨. View through the exposed ethmoidal infundibulum onto the anterior wall of the ethmoid bulla ⑩.
Once the ostium of the maxilla has been identified, a preliminary partial inspection of the maxillary sinus is undertaken. At this point, and in the course of any enlargement of the maxillary sinus ostium, the surgeon should repeatedly check which parts of the posterior maxillary sinus wall, zygomatic recess, alveolar recess, palatine recess, anterior maxillary wall, and prelacrimal recess are accessible and/or need to be inspected. In cases where a maximal antrostomy has already been created in the middle meatus, one should bear in mind that even with the use of standard rigid HOPKINS® scopes, complete inspection of the maxillary sinus may not be accomplished on a regular basis.

The maxillary sinus ostium can be enlarged in a step-by-step fashion. Leaving the natural shape of the ostium untouched is classified as type I antrostomy. Type II denotes a moderate enlargement (about 1–1.5 cm in an anteroposterior direction). Type III corresponds to the maximum opening extending from the roof of the maxillary sinus to the attachment of the inferior turbinate and from the nasolacrimal duct to the level of the posterior wall of the maxillary sinus. Creation of a maximal antrostomy frequently makes it necessary to also remove parts of the ethmoid bulla.

The ostium is usually enlarged starting from its dorsal margin by removing the posterior fontanelle.

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Fig. 5.4 Postero-anterior left uncincetomy / infundibulotomy.

- a. Endoscopic view of the middle meatus. Maxillary sinus ostium is obscured by the inferior uncinate process.
- b. Deeper inspection into the middle meatus reveals an accessory maxillary ostium in the posterior fontanelle and also a secondary ostium anteroinferior to the uncinate process.
- c. The uncinate process is probed with a curved Freer elevator.
- d. A backbiting through-cutting punch forceps is passed behind the free edge of the uncinate process.
- e. Once the mobile jaw of the backbiting forceps has been introduced into the ethmoid infundibulum via the hiatus semilunaris inferior, the uncinate process is cut in a step-by-step fashion.
- f. Next, the ethmoidal infundibulum comes into view, revealing the accessory ostium and the maxillary sinus ostium.
- g. Close-up view of the maxillary sinus ostium, posterior accessory ostium, and the exposed anterior secondary ostium.
- h. The remaining bridge of tissue between the maxillary ostium and the posterior / anterior accessory ostia is cut through and removed, thus merging the apertures with each other.
- i. The final view shows the enlarged maxillary sinus ostium, which corresponds to a type II maxillary antrostomy. Anterosuperior remnants of a protruding uncinate process should finally be removed.

Nasal septum ①; middle turbinate ②; uncinate process (hatched area) ③; ‘maxillary line’ (broken line) ④; inferior turbinate ⑤; maxillary sinus ostium ⑥; maxillary sinus accessory ostium ⑦; opening / accessory ostium in the anterior fontanelle ⑧; backbiting punch forceps (⑨).
This step may include resection of embedded ethmoidal and/or palatine projections of the uncinate process. For this purpose, the mobile jaw of the instrument is always advanced toward the maxillary sinus cavity.

- Due consideration is given to the presence of infraorbital ethmoid cells, which should be removed, if required. In some cases, this can be accomplished using a posterior translacral access.
- Residual portions of the anterior parts can be removed using the backbiting punch.
- Special care should be taken not to remove the mucosal lining of the maxillary sinus like a ‘wallpaper’. The surgeon should also be alerted to the risk of inadvertently creating large flaps, e.g., when using conventional nasal forceps. In order to prevent such a mishap from occurring, through-cutting instruments should be preferred.

5.4.1 Clinical Notes

- In an anteroposterior approach, during incision of the uncinate process, there is a potential risk of iatrogenic orbital injury, particularly if the angle between the uncinate process and lamina papryacea is small. Starting the incision at the level of the maxillary sinus ostium and further enlarging it in an anterocranial and posterocaudal direction is considered a safe option in this regard.
- The maxillary sinus ostium should be enlarged as determined by the patient’s individual anatomy and by the type and extent of disease. The optimum dimension of the maxillary antrostomy should be tailored to the patient's individual anatomy and cannot be defined by scientific rules. A general recommendation is to leave the maxillary sinus ostium untouched, provided its size is seemingly sufficient. However, on the other hand, it may also be sensible to match the anticipated size to the severity of disease and to the potential need for advanced operative steps performed in the maxillary sinus (necessary range of action of the instruments, visual control). According to general physiology, a maxillary sinus orifice should have 4–5 mm in diameter. Surgeons must bear in mind, that any surgically enlarged maxillary sinus ostium is susceptible to a scar-related reduction in the size of the neo-ostium by 50% in the postoperative period.
- With ageing, it is increasingly common to find accessory maxillary sinus ostia, which are usually located in the posterior fontanelle. They must 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.
- Accessory ostia should be joined to the natural ostium to prevent the onset of recirculatory mucociliary flow patterns. Infraorbital cells are prone to narrowing the natural ostium, predisposed to recurrent acute sinusitis, and should therefore be removed.
- 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 – should be left intact.
- The lacrimal duct may be seriously jeopardized by excessive enlargement of the maxillary sinus ostium in the anterior direction with the backbiting forceps. This type of injury reportedly occurs in 15% of patients, but fortunately causes symptoms in only about 1 case out of 10.
- Blind manipulation inside the maxillary sinus places the infraorbital nerve at risk of injury, particularly in cases where the nerve is not covered by bone.
- If the neo-ostium is enlarged to the level of the posterior wall of the maxillary sinus, bleeding from smaller branches of the sphenopalatine artery often occurs and should be controlled in a systematic manner.
Step 3: Anterior Ethmoidectomy

6.1 Objectives
Opening and removal of the ethmoid bulla and, if required, of a suprabullar cell proceeding as far as the basal lamella of the middle turbinate.

Dissection is aimed at improving drainage and facilitating access for targeted therapy. Opening of the ethmoid bulla is sometimes necessary to achieve a maximal maxillary sinus antrostomy – therefore, anterior ethmoidectomy and middle meatal antrostomy are overlapping modular elements that are sometimes used in combination.

6.2 Regional Anatomy
See Step 2, page 12.

6.3 Anatomical Landmarks *
- Anterior wall and undersurface of the ethmoid bulla.
- Anterior ethmoid cells: ethmoid bulla and suprabullar cell.
- Basal lamella of the middle turbinate.
- Roof of the maxillary sinus.
- Skull base – roof of the ethmoid sinus.
- Anterior ethmoidal artery.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.

6.4 Details of Dissection / Surgical Technique
To begin with anterior ethmoidectomy, the anterior wall of the ethmoid bulla is removed. Prior to initiating the procedure, a probe may be used to explore whether there is a retrobullar recess. Given the absence of a retrobullar recess, the basal lamella of the middle turbinate lies in a proximate dorsal position to the mound of the ethmoid bulla.

It is considered safest to open the ethmoid bulla inferomedially by cautiously perforating the anterior wall or by fenestrating the bulla from a caudal direction. Subsequently, removal of the anterior wall is performed in a step-by-step fashion proceeding in a cranial direction and extending toward its margins.

Given the absence of a suprabullar cell or recess, the cranial margin is formed by the skull base, which is the area where the anterior ethmoidal artery can be identified. If the presence of a suprabullar cell is confirmed, the latter is opened inferomedially and then removed. The dorsal margin of anterior ethmoidectomy is the basal lamella of the middle turbinate.

6.4.1 Clinical Notes
- Opening and resection of anterior ethmoid cells anterior to the ethmoid bulla (e.g., agger nasi cell and supra agger cells) pertains to frontal recess surgery and is hence part of a direct approach to the frontal sinus.
- Using the roof of the maxillary sinus as a landmark adds significantly to the safety of the procedure. Note, that the skull base is always above the level of the maxillary sinus roof.
- If a shaver is used, the blade is passed along the vulnerable lamina papyracea which requires the surgeon to proceed with utmost care. Inadvertent fracture of the lamina papyracea and periorbita places part of the adjacent medial rectus muscle at risk of being sucked in and injured. The surgeon must make sure that the shaver blade is meticulously monitored at all times while the device is activated.

Fig. 6.1 Opening and removal of the ethmoid bulla on the left side (after completion of maxillary antrostomy).

a. Fenestration is done with a punch forceps directed inferomedially into the ethmoid bulla at the level of the maxillary sinus roof.

b. Once the ethmoid bulla has been opened, stepwise removal of its anterior wall is carried as far as the lamina papyracea (c) until the roof of the bulla (d) is exposed.

a b c d

Ethmoid bulla (1); middle turbinate (2); middle meatal antrostomy (3); plane of the maxillary sinus roof (broken line) (4); lamina papyracea (5), posterior wall of ethmoid bulla (6).
Step 4: Dissection of the Frontal Recess
Draf Types I and Ia Frontal Sinus Drainage Procedures

7.1 Objectives
Surgery may involve the resection of cellular septa in the lower frontal recess to augment natural drainage from the lower portion of the frontal sinus (Draf type I frontal sinus drainage procedure) or the removal of all anterior ethmoid cells that obstruct frontal sinus drainage to establish maximum natural drainage (Draf type Ia frontal sinus drainage procedure).

7.2 Regional Anatomy
The frontal sinus is the pneumatized space of the frontal bone, which develops from the anterior ethmoid. Depending on the highly variable degree of pneumatization, the frontal sinus extends to a variable degree dorsally and laterally beyond the orbit, into the frontal bone cranially and the temporal bone laterocranially. It often assumes an asymmetric shape. Aplasia is present in 5–12% of patients.

Among the major parameters relevant to frontal sinus surgery are the anteroposterior diameter of the inferior medial frontal sinus, the width of the anterior ethmoid, the cell configuration of the anterior ethmoid, and the shape of the frontal beak. These parameters define the size and position of the frontal sinus drainage pathway.

Based on the most recent consensus update on anatomy, the junction of the anterior ethmoid and frontal sinus is no longer considered the ‘proper’ frontal sinus ostium but rather a continuous drainage pathway between the frontal sinus and anterior ethmoid.

Nevertheless, for practical reasons, the ‘ostium’ is often defined as the bottleneck of the passage of the frontal recess and the frontal sinus, which is formed anteriorly by the nasal spine and posteriorly by the skull base (posterior wall of frontal sinus). This is best appreciated on a parasagittal CT scan, in which the frontal sinus opening is seen as the narrowest point of an hourglass (Fig. 7.1). The lateral border is formed by the lamina papyracea and the medial border by the cranial extension of the vertical lamella of the middle turbinate or the lateral wall of the olfactory fossa.

The frontal beak (synonyms: spina nasalis ossis frontalis, nasal spine of frontal bone) is an osseous projection of the frontal bone that protrudes posteriorly as the lowest aspect of the medial portion of the anterior frontal sinus wall. It is clearly noticeable in a parasagittal CT scan.
The frontal beak has a mean depth of 6 mm (maximum 11 mm) and a mean height of 10 mm (maximum 16 mm) (Fig. 7.2). The anteroposterior diameter of the frontal sinus including the frontal beak is on average 12–14 mm, but it is subject to considerable variation. The distance between the posterior wall of frontal sinus and the anterior ethmoidal artery is 0–19 mm (on average 9 mm). The distance between the posterior frontal sinus wall and the first olfactory fibre is approximately 4–12 mm, occasionally 0 mm.

A major challenge in frontal sinus surgery is the complex anatomy of the intervening anterior ethmoid cells. The anatomy of these cells can vary greatly from one patient to the next. The system for naming the ethmoid cells in this publication follows the classification system of Wormald et al., which is compared below with the traditional systems of Kuhn and Lund et al. (Tab. 7.1):

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<tr>
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</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Agger nasi cell</td>
<td>Agger nasi cell</td>
<td>Agger nasi cell</td>
</tr>
<tr>
<td>Frontal cell type 1, 2</td>
<td>Anterior ethmoid cells</td>
<td>Supra agger cell</td>
<td></td>
</tr>
<tr>
<td>Frontal cell type 3</td>
<td>Anterior frontoethmoid cells</td>
<td>Supra agger frontal cell</td>
<td></td>
</tr>
<tr>
<td>Frontal cell type 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>Bulla ethmoidalis</td>
<td>Bulla ethmoidalis</td>
<td>Bulla ethmoidalis</td>
</tr>
<tr>
<td></td>
<td>Supra bulla cell</td>
<td></td>
<td>Supra bulla cell</td>
</tr>
<tr>
<td></td>
<td>Bulla frontalis</td>
<td>Posterior frontoethmoid cells</td>
<td>Supra bulla frontal cell</td>
</tr>
<tr>
<td></td>
<td>Supraorbital cell</td>
<td>Supraorbital recess</td>
<td>Supraorbital ethmoid cell</td>
</tr>
<tr>
<td>Medial</td>
<td>Interfrontal sinus septal cell</td>
<td>Intersinus septal cell</td>
<td>Frontal septal cell</td>
</tr>
</tbody>
</table>

The pathway for frontal sinus drainage is formed by the cells of the anterior ethmoid, which direct and constrict the pathway. The precise arrangement of these cells is subject to considerable individual variation (Fig. 7.3, 7.4).

- **Anteriorly:** the agger nasi cell (ANC, the first cell of the anterior ethmoid, best depicted by frontal CT) and, above it, the supra-agger cell (SAC) and supra-agger frontal cell (SAFC).
- **Posteriorly:** the ethmoid bulla (bulla ethmoidalis, BE), the overlying suprabulla cell (SBC) and suprabulla frontal cell (SBFC), and the posterolateral supraorbital ethmoid cell (SOEC).
- **Medially:** the cells in the nasal septum and frontal sinus septum (frontal septal cell, FSC).

The frontal recess is a drainage space located below the nominal location of the frontal sinus ostium. The recess is bounded posteriorly by the ethmoid bulla, anteroinferiorly by the agger nasi, laterally by the lamina papyracea, and inferiorly by the terminal recess of the ethmoid infundibulum (or it may open into the ethmoid infundibulum if the uncinate process inserts on or medial to the skull base). The frontal recess is best demonstrated as a fan-shaped area in a parasagittal CT scan (Fig. 7.1). With few exceptions, the posterior wall of the ‘drainage tract’ is formed by the anterior wall of the ethmoid bulla or supra bulla cell.
7.3 Anatomical Landmarks *

- Frontal sinus.
- Spina nasalis ossis frontalis (frontal beak).
- Frontal process of maxilla.
- Middle turbinate.
- Anterior ethmoidal artery.
- Frontal recess and anterior ethmoidal cells.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.

7.4 Details of Dissection / Surgical Technique

A detailed preoperative analysis of frontal sinus anatomy and drainage based on CT scans in three planes will greatly facilitate the operation. Navigation is very helpful in this regard. With modern navigation systems, the surgical route can be preplanned and overlaid on the endoscopic image for precise intraoperative guidance (Fig. 7.5).

The best technique is to dissect toward the frontal sinus in a stepwise fashion with targeted cell-by-cell removal, following the clefts and drainage spaces that are visualized. The (usually) last shell between the frontal recess and the actual frontal sinus is removed (‘scooped out’) in a technique that has been described as ‘uncapping the egg’.

The classification of frontal sinus drainage procedures into Draf types I, IIa, IIb and III is used throughout the world, despite the fact that it does not fully take into account the anatomical diversity of the anterior ethmoid or the frontal sinus itself. Newer classifications have endeavored to address these weaknesses (Tab. 7.2).

![Fig. 7.5 Based on the data acquired during preoperative planning, modern surgical navigation systems not only facilitate anatomical orientation, but also enable real-time intraoperative control. The screenshot was captured during an endoscopic frontal sinus procedure. Panels 1 to 3 are preoperative CT images taken in sagittal, coronal and axial planes. The surgical pathway determined during preoperative planning is shown in green on panels 1 to 3. The endoscopic view is highlighted by a funnel-shaped line drawing. The overlaid tubular structure (green), which appears foreshortened in perspective on panel 4, may be used as a guide to the left frontal sinus. In this case, preoperative surgical planning was conducted with the NAV1® SinusTracker™ software. The system’s inherent inaccuracy, or potential deviation from the main axis of the calculated pathway, is indicated by a light blue circle shown in 4. A close-up view of the pathway is best appreciated on the coronal CT scan 5.]

<table>
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<tr>
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<tbody>
<tr>
<td><strong>Type I</strong> Opening of the frontal recess. Uncinctomy, and – as an optional step – partial removal of the medial lamella of the agger nasi cell and anterior wall of the ethmoid bulla.</td>
<td><strong>Type 0</strong> Balloon dilatation.</td>
<td><strong>Type 1a</strong> Complete removal of uncinate process and – as required – removal of the inferior medial part of agger nasi cell or part of the ethmoid bulla. No other manipulation in the frontal recess.</td>
<td><strong>Grade 0</strong> Balloon dilatation.</td>
</tr>
<tr>
<td><strong>Type 1b</strong> Type 1a with removal of anterior ethmoid cells below the level of the frontal sinus ‘ostium’. No manipulations inside the frontal sinus.</td>
<td><strong>Grade 1</strong> Cells removed below the frontal sinus ostium.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type IIa</strong> Removal of all cells of the anterior ethmoid narrowing the frontal drainage pathway.</td>
<td><strong>Type 2a</strong> Removal of all cells of the anterior ethmoid narrowing the frontal drainage pathway, including those protruding into the frontal sinus cavity.</td>
<td><strong>Grade 2</strong> Cells removed within the frontal sinus ostium.</td>
<td></td>
</tr>
<tr>
<td><strong>Type IIb</strong> Adjunctive resection of the frontal sinus floor is carried from the lamina papyracea as far as the nasal septum and in an anterior direction.</td>
<td><strong>Type 2b</strong> Adjunctive resection of the frontal sinus floor is carried from the lamina papyracea as far as the nasal septum and anteriorly, including that part of the middle turbinate which is anterior to the posterior frontal sinus wall.</td>
<td><strong>Type IIb</strong> Draf IIb</td>
<td></td>
</tr>
<tr>
<td><strong>Type IIb</strong> Draf IIb</td>
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Frontal sinus ostium enlarged by removing bone from the nasofrontal beak.
Step 4: Dissection of the Frontal Recess

Fig. 7.6 Anatomical variants related to the attachment of the uncinate process.

a. Uncinate process attaching medially to the middle turbinate. After removal of the uncinate process, the outflow tract toward the frontal sinus is of ample size (broken line). Uncinate process ①; middle turbinate ②.

b. Uncinate process attaching laterally to the agger nasi cell. As a result, a blind sac – called the ‘terminal recess’ (recessus terminalis) – is formed toward the superior ethmoid infundibulum. Uncinate process ①; middle turbinate ②; agger nasi cell ③; terminal recess ④; ethmoid bulla ⑤; outflow tract of frontal sinus (red broken line).

The Draf type I drainage procedure is not precisely defined as to the scope of the manipulations or its results. The operation starts at the entrance to the frontal recess, which is opened. The procedure includes a complete resection of the uncinate process and, if necessary, portions of the medial lamella of the agger nasi cell and the anterior wall of the ethmoid bulla. To prevent scarring, care should be taken to avoid any manipulations in the upper frontal recess and frontal sinus opening. The size and configuration of the resulting drainage tracts will vary, depending on the attachment site of the uncinate process and the number and arrangement of the anterior ethmoid cells (Fig. 7.6a, b).

Table 7.2 Comparative survey of current endoscopic frontal sinus drainage procedures, adapted from the Draf classification.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Grade</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type IIc</td>
<td>Draf Iib with resection of the superior nasal septum.</td>
<td>5</td>
<td>Unilateral frontal drillout.</td>
</tr>
<tr>
<td>Type IId</td>
<td>Bilateral Draf Iib with resection of the frontal sinus septum.</td>
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<tr>
<td>Type IIe</td>
<td>Bilateral Draf Iib with resection of the superior nasal septum and of the frontal sinus septum, preserving integrity of the frontal recess.</td>
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<tr>
<td>Type III</td>
<td>Central bilateral resection of the frontal sinus floor, with resection of both the nasal septum and the frontal sinus septum, preserving integrity of both frontal recesses.</td>
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</tr>
<tr>
<td>Type 3a</td>
<td>Type 2b with resection of the superior part of the nasal septum, enabling bilateral endoscopic visualization and surgery.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3b</td>
<td>Type 3a with resection of the frontal sinus septum and – as required – of the frontal sinus floor as far as the contralateral middle turbinate. Integrity of the contralateral frontal sinus outflow tract is preserved.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type III</td>
<td>Type Iib on both sides and resection of the frontal sinus septum including the superior nasal septum (creation of a maximum possible opening of the frontal sinus).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3c</td>
<td>Type 2b on both sides and resection of the frontal sinus septum including the superior nasal septum (creation of a maximum possible opening of the frontal sinus).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type III</td>
<td>Draf type III.</td>
<td>6</td>
<td>Draf type III.</td>
</tr>
</tbody>
</table>

Table 7.2 Comparative survey of current endoscopic frontal sinus drainage procedures, adapted from the Draf classification.
The Draf type IIa procedure requires the removal of all anterior ethmoid cells that obstruct frontal sinus drainage. This creates a maximum clear corridor between the vertical lamella of the anterior middle turbinate and the lamina papyracea. The term ‘frontal sinusotomy’, while often used, is not clearly defined and corresponds most closely to a Draf type IIa procedure. Any incidental ridges in the frontal sinus floor are taken down with a frontal sinus punch.

Remnants of the anterior superior uncinate process should be removed. They can be mobilized with an angled curette, for example, and extracted with a small, angled punch forceps (Figs. 7.7a–d, 7.8a–h). At this point, the (opened) ethmoid bulla is visible posteriorly and the opened agger nasi cell superiorly. The agger nasi cell is a key landmark, whose medial lamella is often conspicuous (‘vertical bar’) and forms the lateral boundary of the drainage pathway to the frontal sinus.

The dissection proceeds along the preformed spaces between the anterior ethmoid cells, following their natural contours and configurations:

- The free and accessible walls of an agger nasi cell are perforated, mobilized forward and downward, and removed. A similar technique is used in the presence of a supra agger (frontal) cell (SAFC).
- The anterior wall and roof of the ethmoid bulla are removed, dissecting from the posterior and inferior sides as in an anterior ethmoidectomy (see Step 3) and exposing the basal lamella of the middle turbinate.
- In the prebullar approach to the frontal sinus, the ethmoid bulla is left intact.

Finally, all protruding cellular septa are removed to establish a natural frontal sinus drainage tract of maximal size.

Cellular walls and septa can be mobilized with instruments such as angled curettes, small hooks, suction curettes, or thin angled suction tips. Removal should be done with through-cutting instruments, special punches, or a shaver to avoid the unintended removal of mucosa. The narrower the frontal recess, the more slender the instruments should be.

7.4.1 Clinical Notes

- Special care should be taken during surgery to preserve as many intact mucosal surfaces in the frontal recess as possible and to spare the ‘ostial region’ in order to prevent stenosis of frontal sinus outflow due to scarring or new bone formation.
- Many authors follow an ‘all or nothing’ rule and advocate the removal of all cellular septa on the scale of a type IIa or type I drainage procedure. Irregular manipulations of the small clefts and compartments of the anterior ethmoid cells without removing them can predispose to scarring and osteoneogenesis. As a result, the operation may fail to achieve its goal and the postoperative status may be even worse than before surgery.
- Surgical access to the frontal sinus can be improved by removing the attachment of the middle turbinate on the lateral nasal wall (the ‘axilla’) with a punch forceps. This site corresponds to the anterior wall of the agger nasi cell (if present).
Step 4: Dissection of the Frontal Recess

Fig. 7.8 Type I–Ila frontal sinus drainage procedures on the left side.

a, b The uncinate process ① has been mobilized and resected, exposing a large agger nasi cell ② superiorly. The ethmoid bulla ③ is visible posteriorly. The proposed drainage pathway toward the frontal sinus (green arrows, hidden aspects = broken line) is located between the agger nasi cell and ethmoid bulla.

b. Intraoperative view of a type I frontal sinus drainage procedure.

c, d Following resection of the ethmoid bulla, a supra bulla cell ① is seen proximally, extending as far as the skull base. The desired drainage pathway (green arrows) between the supra bulla cell and agger nasi cell ② is progressively exposed by mobilizing the adjoining cells.

Vertical bar ③; basal lamella of the middle turbinate ④; posterior ethmoid ⑤.

e, f Type Ila frontal sinus drainage procedure on the left side. Removal of cell septa is best achieved with through-cutting instruments such as 45°-upturned nasal forceps ①. A through-cutting frontal sinus forceps ② can be used farther superiorly. The use of a sinus shaver may be considered as an alternative option.

g, h Type Ila frontal sinus drainage procedure on the left side. Cell septa near the frontal sinus ‘ostium’ or inside the frontal sinus can also be resected using a Hosemann frontal sinus punch. After removal of all anterior ethmoid cells obstructing adequate drainage, the final outcome should correspond to a type Ila frontal sinus drainage procedure, offering an unimpeded view into the frontal sinus. In the case shown, vision is obscured to a minor degree by a protruding frontal beak ③. Lamina papyracea ④; anterior ethmoidal artery ⑤; vertical portion of the middle turbinate ⑥.
It has been reported that raising a local, medially based mucosal flap approximately 8–10 x 8–10 mm in size from the anterior surface of the axilla of the middle turbinate (called an ‘axillary flap’) and replacing it on the middle turbinate at the end of the operation can more clearly expose the entrance to the frontal sinus while promoting controlled scar formation. The better the exposure, the better the opportunity to use a 0°-scope or a 30°/45°-scope, which is easier to use than a 70°-scope and less susceptible to technical errors.

If a larger opening is needed for frontal sinus drainage, the tract can be enlarged by resecting the frontal sinus floor in the medial and anterior directions as in a type IIb frontal sinus drainage procedure. The goal is to establish maximum, unilateral frontal sinus drainage from the nasal septum to the anterior nasal sidewall, which is freed of cellular septa, and from the anterior wall of the frontal sinus to the anterior ethmoid roof. For this purpose, the attachment of the middle turbinate must be resected anterior to the plane of the posterior frontal sinus wall, and drilling is usually required.

The key landmarks for frontal sinus revision surgery are the frontal process of the maxilla anteriorly, the lamina papyracea laterally, the ethmoid roof posteriorly, and if necessary, the healthy opposite side (see also Hands-on Dissection Guide on Advanced Endoscopic Endonasal Sinus Surgery: Type III Frontal Sinus Drainage).

8 Step 5: Posterior Ethmoidectomy

8.1 Objectives
The goals are to resect the basal lamella of the middle turbinate and remove all posterior ethmoid cells to create a uniform ethmoid cavity extending to the anterior wall of the sphenoid sinus posteriorly and between the lamina papyracea laterally, the middle and superior turbinates medially, and the skull base (ethmoid roof) above. The cavity is continuous inferiorly with the nasal cavity through the middle and superior meatus.

8.2 Regional Anatomy
See also: Hands-on Dissection Guide on Advanced Endoscopic Endonasal Sinus Surgery. Step 2, Regional Anatomy.

The posterior ethmoid bone extends anteroposteriorly from the basal lamella of the middle turbinate to the anterior wall of the sphenoid sinus (‘sphenoid face’). It extends mediolaterally from the superior (or occasionally the supreme) turbinate to the lamina papyracea and craniocaudally from the skull base to the horizontal portion of the basal lamella of the middle turbinate or the superior meatus. It consists of few cells, only two of which have specific names and require special surgical attention:

The posterior sphenoethmoidal cell (formerly called the Onodi cell). The optic nerve is in direct or near contact to this cell, hence forming a bulge of variable degree. Its bony shell may show sites of dehiscence. Sphenoethmoidal cells extend over the sphenoid sinus – which is located inferiorly and extends posteriorly – at least to some degree (Fig. 8.1a–c).

The other major cell is the posterior infraorbital or retromaxillary ethmoid cell, which is interposed between the lamina papyracea and orbital floor (Fig. 8.2a–b).

The posterior ethmoidal artery runs through the roof of the posterior ethmoid bone in a lateral-to-medial direction, passing just anterior to the sphenoid face. It is smaller than the anterior ethmoidal artery and is usually recessed into the bone.

Fig. 8.1a–c Anatomical close-up views (CT scans) of the posterior ethmoid.

a. Bilateral sphenoethmoidal cell 2 extends posteriorly over the sphenoid sinus. The optic nerve protrudes slightly into the lumen. Note the presence of dehiscences in the bony canal on the right side. Optic nerve 3; sphenoethmoidal cell 2; sphenoid sinus 1.

b. Same condition as (a), shown on an axial CT scan. Sphenoethmoidal cell 1; pneumatized anterior clinoid process (pneumatization from the opticocarotid recess) 2; optic nerve 3.

c. Same condition as (a), with a unilateral sphenoethmoidal cell shown on a sagittal CT scan. Sphenoethmoidal cell 1; sphenoid sinus 2; optic nerve 3; internal carotid artery 9.
8.3 Anatomical Landmarks *

- Ethmoid.
- Middle turbinate and its basal lamella.
- Superior turbinate and its basal lamella.
- Anterior wall of sphenoid.
- Ethmoid roof.
- Optic nerve.
- Ethmoidal arteries.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.

8.4 Details of Dissection / Surgical Technique

The posterior ethmoidectomy starts by perforating the basal lamella of the middle turbinate (Fig. 8.3a–b). It should be perforated at an inferomedial site just above the horizontal portion of the basal lamella.

The superior turbinate and superior meatus can be identified medially. This area marks the entrance to the transethmoidal-transnasal approach for a sphenoid sinusotomy (Fig. 8.3d, see also Step 5).

Starting at the initial opening, the frontal portion of the basal lamella is completely removed by a piecemeal technique. The horizontal portion is preserved as much as possible, because resecting too much tissue will destabilize the middle turbinate. Attention should be given to a posterior infraorbital cell, which extends beneath the orbital floor posterior to the basal lamella (Fig. 8.2).

Next, the few cells of the posterior ethmoid are removed. The surgeon should watch for the possible presence of a sphenoethmoidal cell or a prominent optic nerve.

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Fig. 8.2 CT images of the posterior ethmoid with an infraorbital cell on the right side, presented in coronal (a) and axial (b) sections.

- a. Maxillary sinus (1); roof of the maxillary sinus/orbital floor (2); posterior infraorbital ethmoid cell (3); posterior ethmoid sinus (4); middle turbinate (horizontal portion of the basal lamella) (5).
- b. Maxillary sinus (1); posterior infraorbital ethmoid cell (2); middle turbinate (posterolateral attachment) (3).

Fig. 8.3 Posterior ethmoidectomy on the left side (0°-scope).

- a. The opening is made at an inferomedial site, just above the horizontal portion of the basal lamella of the middle turbinate. Vertical sagittal portion of the middle turbinate (1); anterior ethmoid artery (2); entrance into the frontal sinus after a type IIa frontal sinus drainage procedure (3); lamina papyracea (4); basal lamella of the middle turbinate (vertical frontal portion) (5); maxillary sinus (6); horizontal portion of the basal lamella of the middle turbinate (7); level of the posteromedial maxillary sinus roof (= broken red line).
- b. The basal lamella is resected with a Kerrison punch. Vertical sagittal portion of the middle turbinate (1); lamina papyracea (2); basal lamella of the middle turbinate (vertical frontal portion) (3); maxillary sinus (4); level of the posteromedial maxillary sinus roof (= broken red line).
- c. The superior nasal turbinate and meatus are clearly visible, along with the opened posterior ethmoid sinus. Vertical (1) and horizontal (2) portions of the middle turbinate; superior meatus (3); vertical (3) and horizontal (6) portion of the superior turbinate (4); sphenoid sinus roof (4); lamina papyracea (5).
- d. At this point, the superior nasal turbinate and meatus are clearly visible, along with the opened posterior ethmoid sinus. Vertical (1) and horizontal (2) portions of the middle turbinate; superior meatus (3); vertical (3) and horizontal (6) portion of the superior turbinate (4); sphenoid sinus roof (4); lamina papyracea (5).
When the posterior ethmoidectomy has been completed, the surgical cavity may resemble the interior of a box (or pyramid), depending on individual anatomy. This is illustrated by a comparison with an upright matchbox (Fig. 8.4, 8.5). The top of the box is formed by the ethmoid roof, traversed by the posterior ethmoidal artery just anterior to the sphenoid face. It is continuous medially with the vertical lamella of the superior turbinate, forming a variable curve, and is connected laterally to the lamina papyracea. The anterior wall of the sphenoid sinus, or the body of the sphenoid bone, forms the posterior wall of the box. The floor is formed by the horizontal lamella of the middle turbinate. Inferomedially is the superior meatus, through which the natural sphenoid sinus ostium can be approached by a transnasal-transethmoidal route.

8.4.1 Clinical Notes

Endoscopic dissection and other surgery will tend to proceed in a laterally upward direction toward the optic nerve, especially for a right-handed surgeon working on the left side. Thus, proper anatomic orientation should be regularly checked by reference to the landmarks noted above.

The roof of the maxillary sinus is another helpful landmark for maintaining a safe surgical approach. By keeping below a horizontal plane at the level of the posteromedial maxillary sinus roof, the surgeon can avoid injury to the ethmoid roof above that plane.

Dissection and other surgical procedures performed on the posterior ethmoid sinus and the posterior portions of the nasal cavity and paranasal sinuses usually require the use of a 0° or 30°-scope. The 45° endoscope is reserved for intermittent use in selected cases.
Step 6: Sphenoidotomy
Transnasal, Transethmoidal, Transethmoidal-Transnasal Approach

9.1 Objectives
The sphenoid sinus is opened through the natural ostium or the posterior ethmoid with removal of the sphenoid face.

9.2 Regional Anatomy
The specific anatomy of the sphenoid sinus varies in different individuals. The sinus may pneumatize the body of the sphenoid bone, the greater or lesser sphenoid wing, the palatine bone, the vomer, the pterygoid process, the nasal septum, or the posterior ethmoid cells. Variable recesses may be present within the lateral portion of the sphenoid sinus, depending on its extent. The sphenoid sinus is closely related to the following structures (Fig. 9.1).\(^1,2\)

- **Superior**: pituitary and middle cranial fossa.
- **Lateral**: the cavernous sinus and contained structures.
- **Dorsal**: posterior cranial fossa, clivus, brainstem, and basilar part of the occipital bone.
- **Inferior**: nasopharynx.
- **Superolateral**: optic nerve.
- **Posterolateral**: internal carotid artery.
- **Inferior**: maxillary nerve and the nerve of the pterygoid canal.

Anatomical and CT studies have yielded varying data on the incidence of dehiscences in the lateral wall of the sphenoid sinus and on protrusions of important anatomic structures.\(^1,19,31,62\) To considerably simplify matters, we may assume that protrusions of the internal carotid artery, optic nerve, maxillary nerve, and the nerve of the pterygoid canal (Vidian nerve) are encountered in approximately 30% of cases, while up to 10% of cases show dehiscences in the bony wall. The internal carotid artery is often covered by a bony shell less than 0.1 mm thick, and therefore tissue resistance to probing is markedly decreased in more than 20% of patients.\(^19\)

The natural ostium of the sphenoid sinus is almost always located medial to the attachment of the superior nasal turbinate.\(^5,12,13,16,21,43,55\) In approximately half of cases it is found halfway up the sphenoid face. In cases with less sphenoid sinus pneumatization, the ostium is located closer to the skull base (Fig. 9.2).\(^17,21\)

The sphenoid sinus ostium is slitlike in 80% of cases and is round or punctate in 20%.\(^21\) It is usually located approximately 7 mm (2–15 mm) above the choana and a few millimeters lateral to the nasal septum. It is usually less than 10 mm from the inferior border of the posterior end of the superior turbinate.\(^16,21\)

Depending on the degree of sphenoid sinus pneumatization, the sphenoid face has a variable area of contact with the nasal cavity or sphenoethmoidal recess on the one hand (nasal face of the anterior sphenoid wall) and with the posterior ethmoid bone on the other (ethmoid face of the anterior sphenoid wall) (Fig. 9.3). These contact areas are of major importance in a sphenoid sinusotomy.

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**Fig. 9.1** Anatomy of the lateral sphenoid sinus wall (adapted from Lang 1988).\(^21\) Genu of the internal carotid artery ①; horizontal segment of the internal carotid artery ②; paracaval segment of the internal carotid artery ③; prominence of the pterygoid canal ④; maxillary nerve ⑤; abducens nerve ⑥; prominence of the optic nerve canal ⑦; optico-carotid recess ⑧; roof of the nasopharynx ⑨; sellar floor ⑩; clivus ⑧.

**Fig. 9.2** Endoscopic view of the right anterior sphenoid wall (45°-scope). The slitlike natural sphenoid ostium ① is commonly located 8–10 mm above the postero-inferior attachment of the superior turbinate ②. Note the absence of a sphenoethmoidal recess. The green arrows with broken lines are placed at sites where the sphenoethmoidal recess is often found. Middle turbinate ③; nasal septum ④.
The sphenethmoidal recess, present in approximately 50% of cases, is a laterally directed blind pocket in the nasal cavity, approximately 5 mm deep located just anterior to the anterior sphenoid wall and behind the superior (or occasionally the supreme) nasal turbinate. Its roof is formed by the planum sphenoidale (Fig. 9.2, 9.3).32

The following approaches are available for performing a safe sphenoid sinusotomy. Specific options should be tailored for individual anatomic variants (Fig. 9.4):

- **Transnasal**: the natural sinus ostium is identified and enlarged.
- **Transnasal**: the sinus is opened at the level of the inferior border of the intact superior turbinate.21
- **Transnasal**: the sinus wall is probed and penetrated with a blunt instrument 10—12 mm above the choana,21 at a paraseptal site medial to the attachment of the superior turbinate.

**Transethmoidal**: Imagine a box whose vertical lines are formed by the lamina papyracea laterally and the vertical lamella of the superior turbinate medially; its horizontal lines are formed by the skull base superiorly and the horizontal lamella of the superior turbinate inferiorly. The sphenoid sinus can be safely opened in the inferomedial quadrant.5,47

**Transethmoidal**: if the posterior nasal artery can be identified on the anterior sphenoid wall, the sinus can be opened at a medial site just above the horizontal portion of the artery.

**Transethmoidal-transnasal**: the free border of the superior turbinate is identified after a posterior ethmoidectomy. The ethmoid cavity and superior meatus provide a route through which the natural sphenoid sinus ostium can be identified and approached.

**Transseptal**: the sphenoid sinus is opened by removing those portions of the nasal septum located directly in front of the sinus (vomer, rostrum of the sphenoid sinus). If necessary, this may be aided by first identifying the natural ostium.

**Transpterygoid**.

The level of the posteromedial roof of the maxillary sinus provides an additional guide to identifying the natural ostium of the sphenoid sinus. The roof of the maxillary sinus always occupies a lower level than the roof of the sphenoid sinus (Fig. 9.5).5,18 An imaginary plane that runs parallel to the nasal floor and is placed at the level of the posteromedial maxillary sinus roof, is located +/- 2.8 mm below the sphenoid sinus ostium and 12 +/- 3 mm below the roof of the sphenoid sinus.36

![Fig. 9.3](image1) **Anterior sphenoid wall with one part facing the nasal cavity (green) and the other facing the posterior ethmoid cells (red)**. As shown in panel (a), the transethmoidal corridor to the sphenoid is considerably broader than the transnasal one. Note the absence of a sphenoethmoidal recess in (a). As shown in panel (b), the nasal face of the anterior sphenoid wall is significantly wider when a sphenoethmoidal recess 1 is present.

![Fig. 9.4](image2) **Axial CT scans demonstrate the transnasal (1), transethmoidal (2), transethmoidal-transnasal (3), transseptal (4) and transpterygoid (5) approaches to the sphenoid sinus.**

![Fig. 9.5](image3) **The coronal CT scan confirms that the roof of the maxillary sinus (green) and the sphenoid sinus roof (red) are at different levels. Note that the posterior medial aspect of the maxillary sinus roof is always at a lower level relative to the sphenoid sinus roof, which is why the roof of the maxillary sinus is a useful anatomical landmark for orientation!**
9.3 Anatomical Landmarks *

- Basal lamella of middle and superior turbinate.
- Superior nasal meatus, attachment of the superior turbinate.
- Natural ostium of sphenoid sinus, sphenoethmoidal recess.
- Roof of maxillary sinus.
- Choana.
- Sphenopalatine artery, posterior nasal artery.
- Transethmoidal approach: via the so-called 'rhomboid': skull base / horizontal part of basal lamella of superior turbinate – lamina papyracea / vertical part of basal lamella of superior turbinate. Enter the sphenoid sinus medially and caudally.

9.4 Details of Dissection / Surgical Technique

The sphenoid sinus can be approached strictly through a transethmoidal, transethmoidal-transnasal, transnasal, transseptal, or transpterygoid route (Fig. 9.4). The most favorable approach for any given case is determined mainly by individual anatomy and by the nature and severity of the disease.

- The transethmoidal approach is favorable in cases where there is a broad contact area between the sphenoid sinus and posterior ethmoid sinus and a simultaneous ethmoidectomy is planned (Figs. 9.6–9.9).

Fig. 9.6 Transethmoidal approach for a left sphenoid sinusotomy. Endoscopic view of the superior turbinate, meatus, and opened posterior sphenoid. Vertical portion of the middle turbinate (1); superior meatus (2); vertical portion of the superior turbinate (3); roof of the posterior ethmoid (4); lamina papyracea (5); horizontal portion of the superior turbinate (6); horizontal portion of the middle turbinate (7).

Fig. 9.7 Transethmoidal approach for a left sphenoid sinusotomy. Panel (a): Imagine a box with horizontal sides formed by the skull base superiorly, and the horizontal portion of the superior turbinate inferiorly. Its vertical sides are formed medially by the vertical portion of the superior turbinate, and laterally by the lamina papyracea. The resulting virtual plane is divided into four quadrants. The safest zone for entering the sphenoid sinus covers the medial and inferior quadrants.

Note: The virtual plane formed by the roof of the maxillary sinus (red broken line) may also be projected onto this safe access zone for a transethmoidal sphenoid sinusotomy. Panels (b, c): Same approach as in (a). The ethmoid face of the anterior sphenoid wall has been removed.

Fig. 9.8 Key to (a, c): Superior meatus (1); vertical portion of the superior turbinate (2); roof of the posterior ethmoid (3); lamina papyracea (4); anterior wall of the sphenoid (5); horizontal portion of the middle turbinate (6); maxillary sinus (7); vertical portion of the middle turbinate (8); optic nerve (9); posterior sphenoid wall (10); horizontal portion of the superior turbinate (11); internal carotid artery (12).

In the transethmoidal-transnasal approach, the initial steps consist of transethmoidal perforation of the basal lamella of the middle turbinate and a posterior ethmoidectomy. The anterior sphenoid wall is then exposed and approached transnasally through the superior meatus (Figs. 9.10–9.11). Inferior portions of the superior turbinate can often be preserved by making an L-shaped opening in the anterior sinus wall on the left side and a mirror-image L-shaped sphenoidotomy on the right side, so that the opening skirts the superior

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.
The middle turbinate is not lateralized and destabilized in this approach.

- In the transnasal approach, the middle turbinate and if necessary, the superior turbinate must be lateralized (Fig. 9.12). The sphenoidotomy can be performed by exposing and enlarging the natural ostium, or the sinus can be opened at the level of the inferior border of the intact superior turbinate or 10 mm above the choana.

The transnasal approach is often preferred for revisions in which the middle and superior turbinates are absent. An intact middle turbinate is usually fractured, and thus destabilized, in the transnasal approach. The strictly transnasal approach may be very difficult or impossible to use in noses where access to the posterior nasal cavity is greatly restricted.
The *transseptal* approach is particularly suitable for patients with isolated sphenoid sinus disease and/or patients with limited transnasal access who may also be having septal surgery. These cases may allow for additional removal of the posterior portion of the septum in order to establish a broad transnasal access to the sphenoid sinus, as experience has shown that this region can be quite difficult in terms of postoperative care.

The *transpterygoid* sphenoidotomy is generally done as an adjunct to a previous sphenoidotomy, as in patients with dural lesions or meningoceles in the lateral recess of a well-pneumatized sphenoid sinus. In this procedure, the posterior wall of the maxillary sinus is removed and the pterygopalatine fossa is exposed. Once the medial branches of the sphenopalatine artery have been secured, the soft tissue of the fossa is retracted laterally along with its periorbita, and the bony anterior wall of the lateral recess or inferolateral recess of the sphenoid sinus is exposed. This recess is then broadly opened by

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**Fig. 9.11** Transethmoidal-transnasal approach to the left sphenoid sinus. 
*a, b* First, the inferior attachment of the superior turbinate—covering the natural sphenoid sinus ostium—is resected. The middle turbinate is preserved medially and remains in situ, which is essential for maintaining structural stability. 
*c, d* The sphenoid sinus ostium is progressively enlarged (e.g., with an olive-tipped *Hosemann* sphenoid punch) until the anterior sphenoid wall has been completely removed.

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**Fig. 9.12** Transnasal approach for a left sphenoid sinusotomy (*a, b*) in a patient with severe chronic rhinosinusitis and nasal polyposis (*0°*-scope). 
*Transnasal enlargement of the natural sphenoid ostium* (*c, d*). 
*a, b* Edematous mucosa obstructs the sphenoid sinus ostium (*1*). The ostium is located by referring to the posteroinferior attachment of the superior turbinate (*2*), approximately 6–8 mm above. Lateralization of the middle turbinate (*3*) is shown. The present topographic configuration confirms that the site of the sphenoid sinus ostium is below a virtual plane running through the posteroomedial aspect of the maxillary sinus roof (broken red line, *b*), which in this case is at a very high level. The maxillary sinus (*4*) extends well posteriorly.

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**Fig. 9.12** Maximal fenestration of the sphenoid is accomplished by transnasal and transethmoidal removal of the anterior sphenoid wall (*transethmoidal view, 0°*-scope).
bone removal, while particular attention is given to the pterygoid nerve canal and foramen rotundum.

9.4.1 Clinical Notes
- Many authors resect a few millimeters from the inferior third of the superior turbinate, or remove it altogether, and state that this can be done without complications, despite a theoretical risk of a slight loss of olfactory ability. In the only study published to date, resection of the inferior portion (inferior one-third or one-fourth) of the superior turbinate was not associated with loss of olfactory sensation even though olfactory tissue was found in one-sixth of the surgical specimens. Interestingly, none of the patients with significant postoperative loss of olfactory ability were found to have olfactory tissue in their superior turbinate specimens.
- Analogous to operations on the maxillary and frontal sinuses, authors have described a sphenoid drill-out procedure with complete removal of the anterior sphenoid wall and septum, and the adjacent nasal septum in patients with chronic, therapy-resistant sphenoid sinusitis.
- Widening the sphenoid sinus ostium inferiorly is consistently associated with bleeding from the transverse branch(es) of the posterior nasal artery, which must be coagulated (Fig. 9.13).

10 Step 7: Posterior Translacrimal (Postlacrimal) Approach to the Maxillary Sinus

10.1 Objectives
Extending the endoscopic approach to the maxillary sinus by resecting the bony canal around the nasolacrimal duct and mobilizing the duct anteriorly.

10.2 Regional Anatomy
See Step 2, page 12.

10.3 Anatomical Landmarks *
- Frontal maxillary process.
- Lacrimal ostium, nasolacrimal canal.
- Maxillary sinus.
- Natural maxillary sinus ostium.
- Inferior turbinate.
- Nasolacrimal duct.

10.4 Details of Dissection / Surgical Technique
- After performing a standard type III middle meatal antrostomy (see Step 2), a horizontal incision is made in the mucosa covering the frontal process of the maxilla and the lacrimal bone halfway between the attachment of the inferior turbinate and the plane of the maxillary roof (Fig. 10.1a–h). The mucosa is gently pushed inferiorly and superiorly, exposing the bone. Subsequently, the medial parts of the frontal process of the maxilla are trimmed off tangentially with a chisel, exposing the soft tissues of the nasolacrimal duct. Using a curved Freer elevator, the posterior and lateral parts of the frontal process and also the lacrimal bone are mobilized and removed. The superior extent of bone removal is the level of the roof of the maxilla.
- The inferior extent of dissection is the level of the attachment of the inferior turbinate. In doing so, the bony attachment of the inferior turbinate which directly connects to the frontal process is removed (Fig. 10.2a–c). Following removal of its entire bony circumference, the membranous but intact nasolacrimal duct can be mobilized temporarily in an anterior direction, permitting improved access to the maxillary sinus. This approach improves visualization of the anterior wall of the maxillary sinus, the alveolar recess, the palatine recess, and portions of the prelacrimal recess.

* See Section 11, Review of Relevant Sinonasal Landmarks and Related Anatomical Variations.
**Step 7: Posterior Translacrimal (Postlacral) Approach to the Maxillary Sinus**

**Fig. 10.1** Posterior translacrimal approach to the left maxillary sinus.

a. Incision. The virtual plane of the medial maxillary roof is highlighted by a red broken line.

b. The mucosa is mobilized superiorly and inferiorly.

c. The protruding frontal process of the maxilla is cut away with a sharp chisel.

d. The nasolacrimal duct is mobilized and released from its bony canal with a curved elevator.

Frontal process of maxilla; nasolacrimal duct.

**Fig. 10.2** Translacrimal posterior approach to the left maxillary sinus (45°-scope).

a. The bone at the junction of the nasolacrimal duct and inferior turbinate is cut in a posterior direction. A Freer elevator is best suited for this purpose.

b. At this point, the nasolacrimal duct is easily mobilized in an anterior direction (green arrows). The inferior meatus can now be pushed downward (orange arrows) to obtain a good view into the maxillary sinus.

c. Endoscopic view of the maxillary sinus.

**Fig. 10.3** Improved endoscopic visualization of the maxillary sinus in a posterior translacrimal approach (cadaver specimen).

a. Endoscopic view of the left maxillary sinus (45°-scope) after type III middle meatal antrostomy (maximal fenestration).

b. Improved endoscopic view (45°-scope) of the left maxillary sinus in the posterior translacrimal approach.

Lateral / posterior wall of the maxillary sinus; zygomatic recess; anterior wall of the maxillary sinus; infraorbital nerve; alveolar recess.

**10.4.1 Clinical Notes**

This approach can be an appropriate option, e.g., in selected patients with a fungal ball in the maxillary sinus, significant *chronic rhinosinusitis with nasal polyposis* (CRSwNP), choanal polyps, or symptomatic cysts.
Review of Relevant Sinonasal Landmarks and Related Anatomical Variations

Agger nasi

The agger nasi is a protuberance in the lateral nasal wall just anterior and superior to the attachment of the middle turbinate (remnant of the first ethmoturbinal or the first ‘basal lamella’). Pneumatization of the agger nasi (agger nasi cell) is common (70–90%) and larger cells are found in 15% of cases. Formation of these cells derives from the ethmoidal infundibulum or frontal recess. An agger nasi cell is considered a key anatomical reference since it is the first cell that is seen in an anterior-posterior series of frontal CT scans.

Axilla

In clinical usage, the axilla is the ‘armpit-shaped’ anterior attachment zone of the middle turbinate at the lateral nasal wall (agger nasi).

Basal (or ground) lamellae

Basal lamellae are remnants of five or six ridges that form in the lateral nasal wall during embryogenesis and later undergo partial fusion (ethmoturbinals).

- First basal lamella = agger nasi and uncinate process.
- Second basal lamella = bulge of the ethmoid bulla.
- Third basal lamella = attachment of the middle turbinate. 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.
- Fourth basal lamella = attachment zone of the superior nasal turbinate.
- Fifth basal lamella (present in 15% of cases) = attachment zone of the supreme nasal turbinate.

Bulla ethmoidalis

The ethmoid bulla is a remnant of the second ‘basal lamella’. Pneumatization of the ethmoid bulla generally creates the largest and most nonvariant anterior (caudal) ethmoid cell. This ‘bulla ethmoidalis’ is either composed of a single cell or of two anterior ethmoid cells, which frequently drain into the retrobullar recess along with the superior semilunar hiatus. If the anterior wall of the ethmoid bulla cranially reaches the skull base (in the absence of a suprabullar recess), the bulla lamella forms the posterior boundary of the frontal recess.

In rare instances, if the lamella is not pneumatized, a bulge of bone and mucosa, termed ‘torus bullaris’, remains.

Concha bullosa

A concha bullosa is a well-pneumatized anterior middle turbinate (to be distinguished from a shallow ‘interlamellar cell’). The pneumatization of the middle turbinate mostly originates 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. The extent of pneumatization of the middle turbinate can be restricted to the inferior, bulky part of the turbinate or can be limited to the vertical lamella, or otherwise, may involve both parts.

Concha inferior

The inferior turbinate (concha inferior) is anchored into the lateral nasal wall and composed of a lamella, which in the course of fetal development evolves from a separate bony core, the so-called ‘os turbinale’. The bone is attached to the frontal process of the maxilla and articulates with the medial maxillary wall. The inferior meatus is bounded by the inferior turbinate and receives drainage from the nasolacrimal duct in its lateral anterior portion. The distal opening is continuous with the course of the frontal process of the maxilla.

Concha media

In its anterior portion, the middle turbinate (concha media) attaches cranially to the skull base; the posterior portion attaches laterally through the frontally and horizontally oriented basal lamella. It is frequently pneumatized and if so, forms a ‘concha bullosa’; it also can be paradoxically bent or doubled. The middle turbinate forms the middle meatus, receiving drainage from the maxillary sinus, anterior ethmoid cells, and the frontal sinus.
Concha superior

The superior turbinate (concha superior) inserts cranially at the skull base, dorsally at the anterior wall of the sphenoid sinus, and with its horizontal lamella, it is attached to the orbit. It forms the superior meatus, which receives drainage from the posterior ethmoid cells. The superior turbinate borders the sphenoethmoidal recess into which the natural sphenoid sinus ostium typically drains. Depending on where the superior turbinate attaches to the anterior wall of the sphenoid sinus, either a transethmoidal sphenoidotomy (Types A, B = attachment in the medial or middle third) or transnasal sphenoidotomy (Types C, D = attachment in the lateral third or at the orbit) is recommended.

Ethmoidal arteries

Anterior ethmoidal artery (AEA): the anterior ethmoidal artery is a branch of the ophthalmic artery measuring approximately 1.2 mm in diameter. It emerges between the medial rectus and superior oblique muscles and runs toward the anterior ethmoidal foramen in a lateral-to-medial course.

The canal with the artery, ethmoidal nerve, and a small vein runs obliquely along the skull base in a posterolateral-to-anteromedial course. Bony dehiscences of the canal are observed in up to 40% of cases. Its distance from the frontal sinus entrance is approximately 9 (0–19) mm. Viewed in a frontal sectional image, the AEA lies in the plane of the posterior ocular globe.\(^{34,39}\)

From the orbital cavity, the AEA traverses the anterior skull base and takes an endocranial course (olfactory fossa) at the upper attachment of the middle turbinate. At the ethmoid roof, it is typically interposed between the attachments of the 2nd and 3rd basal lamella. The artery can be 'suspended' up to 2 mm from the skull base in a mesentery, exposing it to an elevated risk of iatrogenic injury. A small, funnel-shaped projection of the medial orbital wall accompanies the artery in the lateral ethmoid sinus. If the AEA is injured here, it may retract into the orbital cavity and result in orbital hematoma, which is considered a severe complication.

Middle ethmoidal artery (accessory ethmoidal artery): according to the literature, a third ethmoidal artery is found at the skull base in approximately 30% of patients.\(^{7,34,39,67}\) This vessel has a smaller caliber than the AEA and occupies a canal with relatively thicker bony walls. For these reasons the middle ethmoidal artery is rarely exposed during routine surgery. It is most commonly encountered in the third quarter of the distance from the AEA to the posterior ethmoidal artery, running a straight lateral-to-medial course.

Posterior ethmoidal artery: approximately 0.5 mm in diameter, this artery runs a mostly horizontal course close to the anterior wall of the sphenoid sinus. It is almost consistently embedded in the bony skull base. In approximately 25–50% of cases, CT in the coronal plane shows a small protuberance in the superomedial orbital wall marking the proximal portion of the canal.\(^{34,39}\) The distance from the posterior ethmoidal artery to the optic nerve or distal optic canal is 4–7 mm.\(^{7,50}\)

Fontanelles

Fontanelles are areas in the medial maxillary sinus wall located above the level of the inferior turbinate, consisting only of two layers of mucosa and a thin fibrous layer with no additional bony support. The anterior fontanelle is located anteroinferiorly to the uncinate process. The posterior fontanelle is found behind and above the posterior extension of the uncinate process. Fontanelles are sites of predilection for accessory sinus ostia, that are present in 5% of cases.\(^{39}\) With ageing, these become more common and are typically located in the posterior fontanelle.\(^{33}\)

Hiatus semilunaris inferior

The inferior semilunar hiatus (hiatus semilunaris inferior) is an essentially 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 ethmoidal infundibulum.

Hiatus semilunaris superior

The superior semilunar hiatus is a cleft located between the posterior ethmoid bulla and the basal lamella of the middle turbinate. The supra- and retrobullar recess can be entered through this space.

Haller cell

See infraorbital ethmoid cell.

Infraorbital ethmoid cell

The infraorbital ethmoid cell (formerly known as ‘Haller cell’) is an ethmoid cell, usually of the anterior ethmoid, that has grown into the orbital floor. An infraorbital ethmoid
cell may narrow the maxillary sinus ostium or may become a source of infection. Its prevalence is approximately 10%.

Infundibulum ethmoidale

The *infundibulum ethmoidale* (ethmoidal infundibulum) is a space bordered anteromedially 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 ethmoidal infundibulum is entered through the inferior semilunar hiatus. The maxillary sinus drains into the ethmoidal infundibulum via the maxillary ostium.

Interlamellar cell

An *interlamellar cell* may be understood as a rudimentary pneumatization of the upper parts of the middle turbinate (most commonly originating from the superior meatus) causing the vertical lamella to split up and form a shallow air space in between.

Maxillary sinus

The *maxillary sinus* has a volume of about 5–22 ml and exhibits a pyramidal shape. Its tip is formed by the zygomatic recess. Anatomical substructures that may also be distinguished are the prelacrimal recess, alveolar recess, and often the palatine recess.

- The *prelacrimal recess* is the anteromediosuperior projection of the maxillary sinus, typically located laterally and anteriorly to the nasolacrimal duct in the medial wall of the maxillary sinus. In close-up view, a medial and a lateral recess can be distinguished. Prevalence of a prelacrimal recess is reported to be about 30%. A prelacrimal recess is a significant finding because it can neither be fully visualized by endoscopy nor may it be managed with surgical instruments, even in the presence of a maximal middle meatal antrostomy. Special consideration is given to this anatomical structure when planning a prelacrimal access to the maxillary sinus.

- Dental roots may protrude to a varying depth into the *alveolar recess*.

- The *palatine recess* may exhibit pneumatization medially below the nasal floor.

- The *roof of the maxillary sinus* or the *orbital floor*, viewed through a middle meatal antrostomy, is a major anatomic landmark for subsequent surgical steps. 40% of the height of the sphenoid sinus is located below a horizontal plane that passes through the posterior medial orbital floor at the transition to the medial orbital wall.

- In about 40% of cases, a vertical bulge is found cranially at the posterior wall of the maxillary sinus; it corresponds to the dorsal part of the *infraorbital canal* or *infraorbital sulcus*. When following the course of the infraorbital canal or sulcus at the roof of the maxillary sinus, bony dehiscences are found in 15% of cases. Note, that the thickness of the bony roof of the maxillary sinus is often as low as 0.5 mm.

- Nearly 50% of patients present with *maxillary sinus septa* – most commonly, there is only one, sized about 10 mm. On the floor of the maxillary sinus, they are observed in 25% of cases, with a height of 2–11 mm.

- The *maxillary ostium* measures about 5 mm in diameter. From a lateral perspective (that is, from the maxillary sinus), it is located about halfway between the anterior and posterior wall of the maxillary sinus, often near a mucosal fold. Viewed from medially (from the ethmoidal infundibulum or uncinate process), the maxillary sinus ostium is typically located in the third quarter of a line that is drawn in an anterosuperior-to-posteroinferior direction through the ethmoidal infundibulum or the uncinate process. The maxillary ostium exhibits a mean anterior distance from the lacrimal duct of 4 mm. However, in some cases, the distance may only be 1.5 mm. Also of note is that the posteromedial part of the lacrimal duct, in close proximity to the middle meatus, only exhibits a very thin bone layer of less than 0.1 mm. The ostium is not exactly in the sagittal plane, but is oriented in a slightly posterior direction and, usually, cannot be appreciated using a 0°-standard scope with straight-forward direction of view.

- Cranially, the maxillary sinus ostium is in immediate vicinity of the roof of the maxillary sinus / orbital floor, which slopes downward laterally at an angle of 30°. The upper edge of the maxillary ostium is only 2 mm away from the roof of the maxillary sinus.
Review of Relevant Sinonasal Landmarks and Related Anatomical Variations

Maxillary line

The maxillary line is an anatomical reference that is used in procedures on the maxillary sinus or the anterior ethmoid (particularly, uncinectomy) and in lacrimal duct surgery. It is the vertex of a vertically oriented, semicircular ridge in the lateral nasal wall located superior to the inferior turbinate and anterior to the attachment of the middle turbinate. In 90% of cases, the line is located directly above the nasolacrimal duct and in 2/3 of cases, it is located above the maxillolacrimal suture. The maxillary line is often used as a landmark for identification of the maxillolacrimal suture.46

Processus uncinatus

The processus uncinatus (uncinate process) is a thin ‘hook-shaped’ outgrowth that emanates from the anterior ethmoid bone in the area of the anterior lateral nasal wall and takes a sickle-shaped course from anterosuperiorly to posteroinferiorly. This rudiment of the first ethmoturbinal, together with the agger nasi, forms the remnant of the first basal lamella. Cranially, the uncinate process is attached to the agger nasi or the lamina papyracea (54%), to the vertical lamella of the middle turbinate (34%), or directly to the skull base (7%). In nearly 60% of cases, the uncinate process has more than one attachment zone anteriorly and cranially (lamina papyracea and cranial base; lamina papyracea and middle turbinate).81 Provided the anterior and superior part of the uncinate process is attached to the lamina papyracea, the ethmoidal infundibulum ends blindly and forms the terminal recess.

Anteriorly, the uncinate process attaches to the lacrimal bone or to the medial surface of the lacrimal fossa. At the level of the common lacrimal duct, this fossa is overlapped to a highly variable degree (literature reports of 0–100 %) by the uncinate process – as rule of thumb, a one-quarter overlap is found in 17% of cases.58 The posteroinferior projection of the uncinate process is highly variable in shape. Delicate processes toward the bone of the inferior turbinate, bulla and/or to the palate are typical. The bone can also assume a flat appearance or it is completely absent in the posterior portion.25,79 The former variant (of flat shape) divides the membranous portions of the medial maxillary sinus wall into an anterior and posterior fontanelle.

On endoscopy, the anterior surface of the uncinate process presents with the ‘classic’ shape in 85% of cases. In the remaining 15%, it is twisted medially or tented over a large bulla.30,41 If the free margin is inverted anteriorly, it occasionally assumes the shape of a ‘doubled middle turbinate’. Rarely, the uncinate process is pneumatized or it may also be everted (medially oriented margin).39 If a patient’s individual and delicate anatomy of the uncinate process is not duly respected, incomplete removal may result.
References


Telescopes, Instrument Sets and Videoendoscopic Equipment for Endonasal Endoscopic Sinus Surgery
**HOPKINS® Telescopes**

**Diameter 4 mm, length 18 cm**

- **HOPKINS® Straight Forward Telescope 0°**, enlarged view, diameter 4 mm, length 18 cm, **autoclavable**, fiber optic light transmission incorporated, color code: green

- **HOPKINS® Forward-Oblique Telescope 30°**, enlarged view, diameter 4 mm, length 18 cm, **autoclavable**, fiber optic light transmission incorporated, color code: red

- **HOPKINS® Forward-Oblique Telescope 45°**, enlarged view, diameter 4 mm, length 18 cm, **autoclavable**, fiber optic light transmission incorporated, color code: black

- **HOPKINS® Lateral Telescope 70°**, enlarged view, diameter 4 mm, length 18 cm, **autoclavable**, Fiber optic light transmission incorporated, Color code: yellow

It is recommended to check the suitability of the product for the intended procedure prior to use. Not all products listed in this document are certified according to Directive 93/42/EEC or Regulation 2017/745/EU on medical devices. For this reason, some products that require certification according to this directive/regulation may not be available in these countries.
Accessories

STAMMBERGER Telescope Handle, flat, standard model, length 11 cm, for use with HOPKINS® straight forward telescopes 0° with diameter 4 mm and length 18 cm

STAMMBERGER Telescope Handle, round, standard model, length 11 cm, for use with HOPKINS® telescopes 30°–120° with diameter 4 mm and length 18 cm

Instruments

FREER Elevator, double-ended, semisharp and blunt, length 20 cm

FREER-WEBER Elevator, double-ended, one side slightly curved, other side strongly curved, sharp, length 19 cm

COTTLE Elevator, double-ended, semisharp and blunt, graduated, length 20 cm

Sickle Knife, pointed, length 19 cm

Antrum Curette, oblong, small, length 19 cm

KUHN-BOLGER Frontal Sinus Curette, 55° curved, oval, forward cutting, length 19 cm

Probe, double-ended, maxillary sinus ostium seeker, ball-shaped ends diameter 1.2 and 2 mm, length 19 cm

CASTELNUOVO Frontal Sinus Probe, double-ended, curved, length 22 cm
Instruments

586026  v. EICKEN Antrum Cannula, Luer-Lock, with cut-off hole, long curve, outer diameter 2.5 mm, length 12.5 cm

586030  v. EICKEN Antrum Cannula, Luer-Lock, long curved, outer diameter 3 mm, length 12.5 cm

529309  FRAZIER Suction Tube, with mandrel and cut-off hole, with distance marking at 5– cm, 9 Fr., working length 10 cm

213314  WULLSTEIN Scissors, curved, sharp/sharp, length 14 cm

174200  COTTLE Metal Mallet, length 18 cm

484004  COTTLE Chisel, flat, graduated, straight, width 4 mm, length 18.5 cm
Nasal Forceps

451000B  GRÜNWALD-HENKE RHINOFORCE® II Nasal Cutting Forceps, straight, through-cutting, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

451500B  GRÜNWALD-HENKE RHINOFORCE® II Nasal Cutting Forceps, 45° upturned, through-cutting, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

456001B  BLAKESLEY RHINOFORCE® II Nasal Forceps, straight, size 1, with cleaning connector, working length 13 cm
Nasal Forceps

**456501B BLAKESLEY-WILDE RHINOFORCE® II Nasal Forceps**, 45° upturned, size 1, with cleaning connector, working length 13 cm

**634824 STRÜMPEL Forceps**, with oval, fenestrated, cupped jaws, straight, width 2.5 mm, working length 12.5 cm

**651010 STAMMBERGER RHINOFORCE® II Double Spoon Forceps**, vertical opening, 65° upturned, spoon diameter 3 mm, with cleaning connector, working length 12 cm
Nasal Scissors

663300

Scissors,
straight, working length 18 cm

663307

Scissors,
45° curved upwards, extra delicate,
working length 18 cm

*) Not all products listed in this document are certified according to Regulation 2017/745/EU. For this reason, some products may not be available in countries requiring certification under this Regulation.
Punches

459010  STAMMBERGER RHINOFORCE® II Antrum Punch, upside backward cutting, with cleaning connector, working length 10 cm

459040  PARSONS RHINOFORCE® II Punch, for resection of the uncinate process, upward backward cutting, movable jaw with round tip, diameter 2.5 mm, with cleaning connector, working length 10 cm

651065  STAMMBERGER Punch, circular cutting, 65° upturned, for frontal sinuses recess, diameter 4.5 mm, with cleaning connector, working length 17 cm, including Cleaning Tool 651050R
HOSEMANN Frontal Sinus/Recess Punches and Sphenoid Punch
with integrated irrigation channel

HOSEMANN Frontal Sinus/Recess Punch, 70° upturned, slender model, punch head diameter 3.5 mm, not through-cutting, upper part of punch fixed, lower part of punch movable, sheath diameter 2.5 mm, central irrigation channel with concealed LUER-Lock irrigation adaptor, working length 13 cm

HOSEMANN Sphenoid Punch, straight, slender model, punch head diameter 3.5 mm, not through-cutting, front part of punch fixed, rear part of punch movable, sheath diameter 2.5 mm, central irrigation channel with concealed LUER-Lock irrigation adaptor, working length 13 cm

HOSEMANN Frontal Sinus/Recess Punch, 70° upturned, robust model, punch head diameter 5.5 mm, not through-cutting, upper part of punch fixed, lower part of punch movable, sheath diameter 3.5 mm, central irrigation channel with concealed LUER-Lock irrigation adaptor, working length 13 cm
STAMMBERGER Antrum Punches

459051

STAMMBERGER Antrum Punch,
right side downward and forward cutting,
with cleaning connector, working length 10 cm

459052

STAMMBERGER Antrum Punch,
left side downward and forward cutting,
with cleaning connector, working length 10 cm
KERRISON Bone Punches

662122  KERRISON Bone Punch, detachable, rigid, upbiting 40° forward, size 2 mm, working length 17 cm

662123  KERRISON Bone Punch, detachable, rigid, upbiting 40° forward, size 3 mm, working length 17 cm
UNIDRIVE® S III ENT SCB

UNIDRIVE® S III ECO

40701620-1

UNIDRIVE® S III ENT SCB, motor control unit with color display, touch screen, two motor outputs, integrated irrigation pump and SCB module, power supply 100–240 VAC, 50/60 Hz including:
- Mains Cord
- Irrigator Rod
- Two-Pedal Footswitch, two-stage, with proportional function
- Clip Set, for use with silicone tubing set
- SCB Connecting Cable, length 100 cm
- Single Use Tubing Set, sterile, package of 3

40701420

UNIDRIVE® S III ECO, motor control unit with two motor outputs and integrated irrigation pump, power supply 100–240 VAC, 50/60 Hz including:
- Mains Cord
- Two-Pedal Footswitch, two-stage, with proportional function
- Clip Set, for use with silicone tubing set
- Single Use Tubing Set, sterile, package of 3

Specifications:

<table>
<thead>
<tr>
<th>Feature</th>
<th>UNIDRIVE® S III ENT SCB</th>
<th>UNIDRIVE® S III ECO</th>
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<tr>
<td>Touch Screen</td>
<td>UNIDRIVE® S III ENT SCB: 6.4*/300 cd/m²</td>
<td>Dimensions w x h x d: 300 x 165 x 265 mm</td>
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<tr>
<td>Flow</td>
<td>9 steps</td>
<td>Weight: 5.2 kg</td>
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<tr>
<td>Power supply</td>
<td>100–240 VAC, 50/60 Hz</td>
<td>Certified to: EC 601-1, CE acc. to MDD</td>
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</table>

*9 steps for Flow
DrillCut-X® II Shaver Handpiece and
DrillCut-X® II N Shaver Handpiece

Special Features:
- Oscillation mode for shaver blades, max. 10,000 rpm
- Rotation mode for sinus burrs, max. 12,000 rpm
- Straight suction channel and integrated irrigation
- Suitable for use in washer and autoclavable at 134°C
- Quick coupling mechanism facilitates exchange of work inserts

40712050 DrillCut-X® II Shaver Handpiece, for use with UNIDRIVE® S III ECO/ENT/NEURO/OMFS
40712055 DrillCut-X® II N Shaver Handpiece, adaptable to shavertracker 40800122, for use with UNIDRIVE® S III ECO/ENT/NEURO

40712090 Handle, adjustable, for use with DrillCut-X® II and DrillCut-X® II N

Optional Accessories:

41250RA Cleaning Adaptor, Luer-Lock, for cleaning DrillCut-X®/DrillCut-X® II shaver handpieces
Shaver Blades, straight
for Nasal Sinuses and Skull Base Surgery

For use with all DrillCut-X® II and DrillCut-X® II-35 Handpieces

<table>
<thead>
<tr>
<th>Detail</th>
<th>Shaver Blade for use with handpieces</th>
<th>Shaver Blade length 12 cm</th>
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<tbody>
<tr>
<td></td>
<td>40712050 DrillCut-X® II, 40712055 DrillCut-X® II N, 40712035 DrillCut-X® II-35 and 40712535 DrillCut-X® II-35 N</td>
<td>Serrated cutting edge, diameter 4 mm, color code: blue-red</td>
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<tr>
<td></td>
<td>41201KN</td>
<td>Double serrated cutting edge, diameter 4 mm, color code: blue-yellow</td>
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<tr>
<td></td>
<td>41201KK</td>
<td>Serrated cutting edge, diameter 3 mm, color code: blue-yellow</td>
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<tr>
<td></td>
<td>41201KSA</td>
<td>Double serrated cutting edge, diameter 3 mm, color code: blue-red</td>
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<td></td>
<td>41201KKSA</td>
<td>Double serrated cutting edge, diameter 3 mm, color code: blue-yellow</td>
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</table>

Shaver Blades, curved
for Nasal Sinuses and Skull Base Surgery

For use with all DrillCut-X® II and DrillCut-X® II-35 Handpieces

<table>
<thead>
<tr>
<th>Detail</th>
<th>Shaver Blade for use with handpieces</th>
<th>Shaver Blade length 12 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40712050 DrillCut-X® II, 40712055 DrillCut-X® II N, 40712035 DrillCut-X® II-35 and 40712535 DrillCut-X® II-35 N</td>
<td>Curved 40°, cutting edge serrated backwards, double serrated, diameter 3 mm, color code: blue-yellow</td>
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<tr>
<td></td>
<td>41204KKB</td>
<td>Cleaning Adaptor, Luer-Lock, for cleaning the inner and outer blades of reusable Shaver Blades 412xx</td>
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<tr>
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<td>41204KKBA</td>
<td>Optional Accessory:</td>
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</table>

Optional Accessory:

41200RA

Cleaning Adaptor, Luer-Lock, for cleaning the inner and outer blades of reusable Shaver Blades 412xx
Shaver Blades, curved
for Nasal Sinuses and Skull Base Surgery

For use with all DrillCut-X® II and DrillCut-X® II-35 Handpieces

![Shaver Blade Image]

41203KKF

Shaver Blades, curved 65°, sterilizable

<table>
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<td>length 12 cm</td>
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<td></td>
<td>41203KKBA</td>
<td>curved 65°, cutting edge serrated backwards, double serrated, diameter 3 mm, color code: blue-yellow</td>
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</table>

Optional Accessory:

41200RA Cleaning Adaptor, Luer-Lock, for cleaning the inner and outer blades of reusable Shaver Blades 412xx

Sinus Burrs, curved
for Nasal Sinuses and Skull Base Surgery

For use with DrillCut-X® II and DrillCut-X® II N

![Sinus Burr Image]

41305RN

Sinus Burrs, curved 70°/15°, for single use, sterile, package of 5

<table>
<thead>
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<th>Sinus Burr</th>
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<td>40712050 DrillCut-X® II Handpiece, 40712055 DrillCut-X® II N Handpiece</td>
<td>length 12 cm</td>
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<td></td>
<td>41305DN</td>
<td>curved 15°, diamond head, drill diameter 3 mm, shaft diameter 4 mm, color code: red-yellow</td>
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<tr>
<td></td>
<td>41303DT</td>
<td>curved 70°, diamond head, drill diameter 3.6 mm, shaft diameter 4 mm, color code: red-yellow</td>
</tr>
</tbody>
</table>

Additional blades or burrs can be found in the UNIDRIVE® catalog excerpt as well as in the ENT catalog.
DrillCut-X® II-35 Handpiece with 35k Sinus Burrs
Power meets precision

- Handpiece
  Compatible for use with sinus burrs up to 35,000 rotations per minute, and the already existing portfolio of shaver blades
- 35k Burr inserts
  Five different models available

+ Compatibility
  Handpiece and burr inserts can be used with the existing UNIDRIVE® S III ENT motor system
+ EM navigation
  Can be expanded with the shaver blade tracker for electromagnetic navigation of sinus burrs and shaver attachments

40712035  
DrillCut-X® II-35 Shaver Handpiece,  
for use with UNIDRIVE® S III ENT/NEURO

40712535  
DrillCut-X® II-35 N, shaver handpiece,  
adaptable to Optical Shaver Tracker 40800122,  
for use with UNIDRIVE® S III ENT/NEURO and NAV1® pico or NAV1® optical

40712090  
Handle, adjustable,  
for use with DrillCut-X® II N shaver handpiece

Optional Accessory:

41250RA  
Cleaning Adaptor, Luer-Lock,  
for cleaning DrillCut-X®/DrillCut-X® II shaver handpieces
### 35k Sinus Burrs
for Nasal Sinuses and Skull Base Surgery

For use with DrillCut-X® II-35 Shaver Handpiece 40712035 and DrillCut-X® II-35 N Shaver Handpiece 40712535

<table>
<thead>
<tr>
<th>Detail</th>
<th>35k Sinus Burrs, with integrated irrigation, length 12 cm, sterile, for single use, package of 5, color code: red</th>
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<tr>
<td><img src="image1.png" alt="Image" /> 41335W</td>
<td>curved 40°, cylindrical, burr diameter 3 mm, shaft diameter 4 mm</td>
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<tr>
<td><img src="image2.png" alt="Image" /> 41335RN</td>
<td>curved 15°, bud drill, burr diameter 4 mm, shaft diameter 4 mm</td>
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<tr>
<td><img src="image3.png" alt="Image" /> 41335DW</td>
<td>curved 40°, diamond head, burr diameter 5 mm, shaft diameter 4 mm</td>
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<tr>
<td><img src="image4.png" alt="Image" /> 41335DT</td>
<td>curved 70°, diamond head, burr diameter 3.6 mm, shaft diameter 4 mm</td>
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<tr>
<td><img src="image5.png" alt="Image" /> 41335DS</td>
<td>curved 40°, diamond-shaped cutting, burr diameter 4 mm, shaft diameter 4 mm</td>
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</tbody>
</table>
The IMAGE1 S™ camera platform offers surgeons a single system for all applications. As a modular camera platform, IMAGE1 S™ combines various technologies (e.g. rigid, flexible, 3D and 4K endoscopy) in one system and is therefore adaptable to individual customer needs.

- Universal, high-resolution camera system
- Versatile visualization options for diagnosis and therapy
- S-Technologies (CLARA, CHROMA, SPECTRA A*, SPECTRA B**) for tissue differentiation
- Natural color rendition
- Automatic light source control

Furthermore, the camera platform offers expanded compatibility and connectivity for ICG-enhanced near-infrared (NIR) fluorescence imaging, the integration of operating microscopes and the use of the VITOM® 3D exoscope.

**CLARA + CHROMA:**
Homogeneous illumination + contrast enhancement

- Standard Image
- CLARA + CHROMA

**CLARA:** Homogeneous illumination

- Standard Image
- CLARA

**CHROMA:** Contrast enhancement

- Standard Image
- CHROMA

**SPECTRA A:** Color hue shift and exchange (filtering reds)

- Standard Image
- SPECTRA A

**SPECTRA B:** Spectral color shift (intensification of greens and blues)

- Standard Image
- SPECTRA B

* SPECTRA A: Not for sale in the U.S.
** SPECTRA B: Not for sale in the U.S.
Monitors

**TM220**

**27" FULL HD Monitor**, screen resolution 1920 x 1080, image format 16:9, video inputs: DVI, 3G-SDI, VGA, S-Video, Composite, video outputs: DVI, 3G-SDI, Composite, power supply 100–240 VAC, 50/60 Hz, 5 V DC output (1 A), wall mount with VESA 100 adaptation

including:
- 1x External 24 VDC Power Supply
- 1x Mains Cord
- 1x Cable Cover
- 4x Mounting Screws M4

**TM342**

**31" 4K Monitor**, screen resolution 3840 x 2160, image format 16:9, video inputs: DP 1.2a, 2x DVI-D, 12G-SDI, 3G-SDI, USB Type-B, RS-232C, GPI, video outputs: DVI-D, 12G-SDI, 3G-SDI, power supply 100–240 VAC, 50/60 Hz, with VESA 100 and VESA 200 adaptation

including:
- External 48 VDC Power Supply
- 1x Mains Cord
- 1x Cable Cover
- 2x Screws for cable cover
- 4x Mounting Screws M4
- 4x Mounting Screws M6
- 1x Instruction Manual
## Monitors

### Technical Specifications of 31" 4K Monitor and 27" FULL HD Monitor

<table>
<thead>
<tr>
<th>Specification</th>
<th>TM342</th>
<th>TM220</th>
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<tbody>
<tr>
<td><strong>Screen size</strong></td>
<td>31.1&quot;</td>
<td>27&quot;</td>
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<tr>
<td><strong>Resolution</strong></td>
<td>3840 x 2160 pixels</td>
<td>1920 x 1080 pixels</td>
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<tr>
<td><strong>Signal format display</strong></td>
<td>16:9</td>
<td>16:9</td>
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<tr>
<td><strong>Contrast ratio</strong></td>
<td>1500:1</td>
<td>1000:1</td>
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<tr>
<td><strong>Brightness</strong></td>
<td>350 cd/m²</td>
<td>500 cd/m²</td>
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<tr>
<td><strong>Max. viewing angle</strong></td>
<td>178° vertical/horizontal</td>
<td>178° vertical</td>
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<tr>
<td><strong>Video inputs</strong></td>
<td>2x DVI-D, 1x 12G-SDI, 1x 3G-SDI, 1x Display Port</td>
<td>2x DVI-D, 1x 3G-SDI, 1x RGBS (VGA), 1x S-Video, 1x Composite</td>
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<tr>
<td><strong>Video outputs</strong></td>
<td>1x DVI-D, 1x 12G-SDI, 1x 3G-SDI</td>
<td>1x DVI-D, 1x 3G-SDI, 1x S-Video, 1x Composite</td>
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<tr>
<td><strong>RS-232C serial port</strong></td>
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<td><strong>5V phone connector</strong></td>
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<td>—</td>
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<tr>
<td><strong>USB socket</strong></td>
<td>5V/1A</td>
<td>5V/1A</td>
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<tr>
<td><strong>Mount</strong></td>
<td>100/200 mm VESA</td>
<td>100 mm VESA</td>
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<tr>
<td><strong>Power supply pack</strong></td>
<td>external, DC 48V</td>
<td>external</td>
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<tr>
<td><strong>Technical features</strong></td>
<td>picture-in-picture function</td>
<td>picture-in-picture function</td>
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<tr>
<td><strong>Rated power</strong></td>
<td>139.2 W</td>
<td>72 W</td>
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<td><strong>Power supply, frequency</strong></td>
<td>100–240 VAC, 50/60 Hz</td>
<td>100–240 VAC, 50/60 Hz</td>
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<td><strong>Dimensions (w x h x d)</strong></td>
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<td>660 x 400 x 87 mm</td>
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<td><strong>Hygienic Reprocessing</strong></td>
<td>wipe disinfection</td>
<td>wipe disinfection</td>
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<tr>
<td><strong>Degree of protection against ingress of humidity</strong></td>
<td>IP45 front</td>
<td>IP32</td>
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<tr>
<td><strong>Pedestal</strong></td>
<td>9832SFH, 9826SF</td>
<td>9826SF</td>
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</table>
Documentation

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 completely new documentation experience – AIDA®. AIDA® seamlessly integrates into existing infrastructures and exchanges data with other systems using common standard interfaces.

WD300-EN*  AIDA®, Documentation System Set, for recording still images and videos, dual channel up to FULL HD, 4K, 2D/3D, power supply 100-240 VAC, 50/60 Hz

including:

AIDA®
USB Silicone Keyboard, with US English character set, with touchpad

WD350-EN*  AIDA® with SMARTSCREEN®, Documentation System Set, for recording still images and videos, dual channel up to 4K, 2D/3D, power supply 100-240 VAC, 50/60 Hz

including:

AIDA®
OR1™ SMARTSCREEN®
USB Silicone Keyboard, with US English character set, with touchpad

* Please specify the language code when placing your order.

Available in English (EN), German (DE), Spanish (ES), French (FR), Italian (IT), Portuguese (PT) and Russian (RU).
Workflow-oriented use

**Patient**
The procedure data input can be performed manually or via a DICOM worklist.

**Checklist**
You have the option of digitizing a wide range of OR safety checklists.

**Record**
Still images and video sequences can be recorded in FULL HD, 4K and 3D quality.

**Edit**
Simple adjustments to recorded still images and videos can be very rapidly completed with the Edit module.

**Complete**
A procedure can be completed with just one click. The Intelligent Export Manager (IEM) allows the automatic transmission of all data to configured storage locations in the background.

**Reference**
Allows you direct and easy access to previously recorded data at all times.
Fiber Optic Light Cable

**Fiber Optic Light Cable**, with straight connector, extremely heat-resistant, with safety lock, increased light transmission, diameter 3.5 mm, length 230 cm, can be used for NIR/ICG fluorescence imaging.

Cold Light Fountain Power LED 300

**Cold Light Fountain Power LED 300**, with integrated KARL STORZ-SCB, high-performance LED module and one KARL STORZ light outlet, power supply 100–240 VAC, 50/60 Hz including:
- **Mains Cord**

Cold Light Fountain Power LED Rubina®

**Cold Light Fountain Power LED Rubina®**, for NIR/ICG fluorescence imaging and standard endoscopic diagnosis, with 2 LEDs and KARL STORZ light cable connection, with integrated KS HIVE® connection, power supply: 100–125/220–240VAC, 50/60 Hz, including:
- **Mains Cord**
- **Patch Cable**
- **Sync Connecting Cable**
**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

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

**Dimensions**

<table>
<thead>
<tr>
<th>Equipment cart w x h x d</th>
<th>830 x 1474 x 730 mm</th>
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<tbody>
<tr>
<td>Shelf w x d</td>
<td>630 x 510 mm</td>
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<tr>
<td>Caster diameter</td>
<td>150 mm</td>
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**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 use with equipment carts UG xxx
**Isolation Transformer**, 200–240 VAC; 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 UGxxx

**Earth Leakage Monitor**, 200–240 VAC, for mounting at equipment cart, control panel dimensions: 44 x 80 x 29 mm (w x h x d), for usage with isolation transformer UG310

**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 UGxxx
Notes
with the compliments of
KARL STORZ — ENDOSKOPE