Endoscopic Anatomy of the Nose and Paranasal Sinuses

From this point a flat groove can be followed as it runs upward and medially to form the boundary between the posterior wall and roof of the antral cavity. The junction between the roof and anterior wall is usually smooth. The surgeon learns to recognize the typical contours, usually bilaterally symmetric, in order to preserve the thin wall of the orbit during sharp dissection. The anterior wall of the antral cavity slopes outward, and tapers inferi orly (Fig. 2.42 c).

The bony canal of the infraorbital nerve may form a sagittal bulge running anteriorly in the roof of the antral cavity, providing a valuable landmark (Fig. 2.42 b). It must not be confused with mucosal bands that often run from the medial to the lateral walls of the antral cavity under its roof (Fig. 2.43).
Fig. 2.42a  Endoscopic view of the left posterior wall of the antral cavity through an inferior meatal antrostomy. The zygomatic recess lies on the right side (+) (70° telescope). b Left antral roof with prominent canal of the infraorbital nerve (+). View with a 70° telescope through an inferior meatal antrostomy. c The left anterior antral wall shown in yellow, bordering onto the roof shown in pink, and the posterior wall in blue. The zygomatic recess lies at the point of intersection of the three different colored regions. View with a 70° telescope through an inferior meatal antrostomy. d Alveolar recess of a left antral cavity with the root of a molar tooth (+). The posterior wall of the antrum is marked in blue, the anterior wall in yellow. View with a 70° telescope through an inferior meatal antrostomy.

Fig. 2.43  Mucosal fold (+) in a left antral cavity. View with a 70° telescope through an inferior meatal antrostomy.

Fig. 2.44  Abnormal extension of the ethmoids into the maxillary sinus with protruding giant cells (coronal CT).
Endoscopic Anatomy of the Nose and Paranasal Sinuses

**Fig. 2.49 a, b** Intranasal middle meatal antrostomy.  
*a* First step: application of a pointed 45° upward-cutting ethmoid forceps immediately above the center of the inferior turbinate.  
*b* The punch is pushed in a strictly horizontal direction with the jaws slightly open. A small window is created by closing the forceps and removing fragments that are grasped.

**Fig. 2.50** The left lateral nasal wall of an anatomical dissection with a small middle meatal antrostomy (+) at the typical site above the center of the inferior turbinate, immediately above its upper edge, directly under the posterior end of the uncinate process. The window may be considerably widened above, anteriorly, and posteriorly from this point.

**Fig. 2.51** A small middle meatal antrostomy (+) seen through a straight telescope from in front. The middle turbinate has been pushed slightly medially and upward. The uncinate process and the ethmoid bulla are visible.

**Fig. 2.52** A large middle meatal antrostomy as seen through a 70° telescope, and the posterior wall of the antrum beyond it. The overhanging middle turbinate conceals the uncinate process and the bulla.
Fig. 2.53  Topography of the supraturbinate part of the lateral nasal wall in the plane of a proper fenestration, in a frontal section of a dissected specimen. The antral opening of the maxillary ostium lies very close to the floor of the orbit above a fold. If the nasal wall is always perforated in a strictly horizontal direction above the dorsum of the turbinate bone, the orbit is always out of reach of the instrument.

Fig. 2.54 a–c  Transoral fenestration of the maxillary cavity.
\( a \) The sublabial skin incision in the upper oral vestibule.
\( b \) Exposure of the translucent bone in the canine fossa.
\( c \) Limited bone resection with a chisel has preserved the anterior mucosa. A small bony frame protects the infraorbital nerve (arrow).

Fig. 2.55 a, b  Transcanine endoscopy of the maxillary cavity.
\( a \) Direct inspection (0° telescope) of the posterior wall bending down from the floor of the orbit with the primary ostium on its left side.
\( b \) Cranial view of the inferior orbital wall.
The second principle is complete opening of the cells to guarantee healing of the chronic polypoid mucosal inflammation. Remaining cells are often the point of origin of persistent disease. These two aspects therefore led us to develop complete ethmoidectomy, in which an entirely visible ethmoid compartment is created with no remaining narrow areas and no remaining cells. The resulting wide upper nose was a new and surprising experience, which did not lead to drying of the regenerating mucosa or to the development of ozena.

Operations on the Frontal Sinus

Indications

- Recurrent empyema of the frontal sinus
- Chronic frontal sinusitis
- Auxiliary drainage of osteitic complications
- Auxiliary endonasal aproach together with external operations for frontal trauma or foreign bodies
- Biopsy and removal of small tumors, and tumorlike lesions

Principles

The goal of the endoscopic operation from below is the restoration of ventilation and drainage. For this purpose, a recanalization of the frontal sinus infundibulum is often sufficient, and provides mucosal recovery also in remote recesses. Preservation of mucosa and thus of mucociliary transport are preconditions, especially in the frontoethmoidal transition as a bottleneck. Limited pathological changes can be removed endoscopically. For more difficult intracavitary manipulations, combined external–endonasal approaches are recommended (Gross et al. 1995; Seiden and Stankiewicz 1998; Lowry and Brennon 2002). Every defect in the anterior bony wall, however, implies the danger of ingrowing subcutaneous soft tissues. The following approaches are available:

- Endoscopic, limited opening of the frontal sinus from below (widening of the frontoethmoidal junction zone).
- Limited intracavitary manipulations controlled by angled- or fiber-optics, laser surgery.
- Combined external–endonasal approaches utilizing the endoscope as monitor of remote manipulations in minimal-access surgery for trauma and tumor growth.
- A limited external frontal sinus procedure using the endoscope and plastic repair of the small defect in the anterior wall of the frontal sinus, with preservation of the bony framework. If necessary, a mucocele is marsupialized and tumors are reduced in size within the cavity before removal. Treatment of inflammatory complications by such conservative surgery is still developing, and demands intensive postoperative care.

Operative Technique

Preliminary Observations

The restricted access to the often extensive and recessed frontal sinus limits transnasal frontal sinus surgery. Whereas the view into all recesses may be satisfactory for diagnostic purposes, many therapeutic manipulations are ill-advised because the necessary instruments cannot be monitored endoscopically. However, much can be achieved, contrary to what might be expected, including the generous transnasal fenestration of the floor of the frontal sinus, which suffices for the treatment of most cases of sinusitis when combined with circumscribed dissection of the frontal infundibulum. Many other problems such as stenosis, foreign bodies, and occasionally mucopyoceles can be tackled if this procedure is combined with a small transfrontal portal to allow the introduction of an endoscope or instruments. When choosing between a transfacial or intranasal procedure, the safety of the patient is more important than avoiding a facial scar. Recent developments of combined instruments for fiber-optic monitoring and laser delivery have opened new options.

Exposure of the Frontal Infundibulum

The prerequisite for endoscopic exposure of the frontal sinus from the nose is removal of the anterior part of the ethmoid area as far as the base of the skull. If the most anterior ethmoid cells have been opened intranasally during an anterior ethmoidectomy, the blunt probe usually glides smoothly into the frontal infundibulum. The...
use of force and of pointed bougies is dangerous. An endoscope with an angled telescope should be used to expose the anterior ethmoid.

Bony overhangs, coarse mucosal tags, and polyps interfering with the view into the frontal duct should be removed under vision (see Fig. 6.43). The curved Bolger spoon curette (see Fig. 4.8) is a useful and safe pathfinder for this purpose. These obstacles are often not present, so that removal of the most anterior cells leads directly into the frontal sinus. In those cases with a well-developed cell system, the frontal duct can easily be widened to a diameter of 4–5 mm by removing small remaining septa with the punch, curette, or rasp. This step improves the prospects of healing of chronic sinusitis and prevents obstruction by scar tissue.

If a curved suction tube 4 mm in diameter passes without resistance, the frontal duct will usually be found to be wide enough. The resulting opening suffices for suction of thickened secretions and for the removal of polyps or cysts with the curved forceps. Further procedures are unnecessary, even if the mucosa is thickened and humped, because of the excellent recuperative capacity of the frontal sinus mucosa.

Care must be exercised when tearing off mucosal tags because resulting reparative granulation tissue can lead to the formation of cicatricial stenosis and formation of new bone. On no account must the mucosa around the entire circumference be damaged, as this leads to a ring of scar tissue.

If the endoscope does not expose the nasofrontal duct and the anterior ethmoid cells apparently end blindly, or if only a narrow nasofrontal duct is visible, broad fenestration of the floor of the frontal sinus may be indicated (Weber et al. 2001), but the author usually omits this extension of the procedure if the ethmoiditis is not extensive and radiography has shown good aeration of the frontal sinus with no mucosal swelling. On the other hand, when there is no view into the frontal sinus, external sinusotomy might be carried out for massive intracavity polyposis indicating a severe disorder of drainage and aeration of the sinus. It is likewise indicated for the removal of frontal mucoceles, foreign bodies, and tumors (see below).

Transnasal Frontal Sinusotomy

Three concepts are important:

1. If the nasofrontal duct has a visible diameter of only 1–2 mm and appears incapable of ensuring satisfactory drainage for extensive polyposis of the frontal sinus, it should be widened to form a broad duct extending as far as the frontal infundibulum. This procedure corresponds to the concept of isthmus surgery. Although the surgeon is now aware of the direction of dissection, widening of the duct is often more difficult than perforation of the cells by the above-described method because the cells are usually small and few in number.

2. Sometimes the search for the frontal duct with the endoscope proves fruitless. However, if radiographs have shown the presence of a developed frontal sinus, a careful endoscopic examination should be carried out. This maneuver is particularly delicate and demanding because inadvertent perforation of the anterior skull base is life-threatening. The surgeon should orientate himself by the transverse bar formed by the anterior ethmoid artery, and proceed forward from there. At the same time the
roof of the maxillary sinus below, high up to the angle between ethmoid and frontobasis. In fact, such complete uncovering is only appropriate for major approaches into the orbit. Smaller targets like limited subperiosteal abscesses or mucocoeles can be approached via a circumscribed resection of the medial orbital wall (see Fig. 7.3c).

The procedure starts with a partial resection and medialization of the middle turbinates (see pages 54 and 106), and continues with an anteroposterior ethmoidectomy of sufficient length exposing the medial orbital wall. The latter is then opened using a semi-sharp dissector for infracturing the lamina papyracea and removing the bone plates.

The underlying periosteum, the periorbita, may have a strong texture resisting an incision, and can be well vascularized. After a first horizontal incision with a sharp sickle knife, the periorbita is opened on demand. Orbital fat will always protrude and become a visual obstacle. A broad medial protrusion may be the aim in case of orbital decompression for endocrine orbitopathy, but if it hampers the exposure of a circumscribed target it must be reduced or removed. Bipolar coagulation has proved useful to shrink the mass and to erect a superficial partition at the level of the orbital wall. One should be concerned not to injure the medial long eye muscle with instruments or cautery. Short compression with gauze soaked in diluted epinephrine helps to keep the orbital contents blood free for better identification, but a caveat is needed: Direct application of epinephrine near the optic nerve may induce a spasm of the central optic artery and thus provoke blindness. Any removal of circumscribed neoplasia or tumorlike lesions requires optimum visualization for precise dissection of the lesion and minimal destruction of healthy tissue. Ultrasound- or MRI-based navigation might become extremely valuable for this purpose, as are appropriate microinstruments such as the ball-tipped dissector and small double-cup forceps from ear surgery.

The incision of an orbital abscess (see Chapter 7) is left open to the ethmoid. In other cases, a closure of the opening in the orbital wall appears useful, which can be achieved by grafting a piece of mucoperiosteum, taken from the inferior turbinate, over the defect with fixation by fibrin glue and ethmoidal packing.

Lesions lateral and dorsal to the bulb and superior to the optic nerve are more safely exposed from above (see below) or via an infratemporal approach. Both ouvertures require additional microsurgical rather than endoscopic techniques. Inferior orbital fractures (blowout fractures) are managed by an infraorbital transfacial approach or transantrally if very small.

Endoscopic and Microscopic Surgery on the Anterior Skull Base

Indications

- Foreign body, injury, fracture, dural defect
- Malformation, fistula, meningocoele
- Inflammatory complications
- Neoplasia and tumorlike lesions
- Combined neurorhinosurgical approach

Principles

Transnasal ethmoidectomy provides a limited but direct endoscopic or microscopic view of the inferior surface of the anterior base of the skull (rhinobasis) from below, reaching from the frontal sinus over the central areas around the cribiform plate back to the sphenoid cavity with the sella turcica within its roof. Utilizing angled endoscopes or direct microscopy, the surgeon achieves a superb exposure, allowing precise management of localized skull base lesions with minimal invasion, in contrast to the inevitable injury with neurosurgical approaches from above, such as temporary cerebral displacement and abrasion of olfactory fibers. For these reasons endoscopic skull base surgery has gained increasing interest during recent years (Husain et al. 2003; Lopatin et al. 2003; Tosun et al. 2003; Casler et al. 2005). Besides this, the endoscopic access can expose suprabasal structures like the pituitary gland or tumors of the anterior cerebral fossa. Combined neurorhinosurgical endoscopic approaches, on the other hand, allow a complete exposure of the anterior skull base up to the optic chiasm, in combination with a one-stage revision of the paranasal pneumatization from above. They also spare more invasive transfacial and subcranial approaches.

Operative Technique

The anterior part of the anterior skull base is formed by the posterior wall of the frontal sinus and the roof of the orbit. In the middle lies the roof of the ethmoid, and posteriorly the sphenoid plane and the roof of the sphenoid sinus (see Fig. 2.68). The exposure of the ethmoid and sphenoid roof described for the intranasal endoscopic technique in the previous section was related only to dissection of the anterior skull base from below (Fig. 6.80). The posterior wall of the frontal sinus is suitable for only very limited endoscopic manipulation, but the superior and posterior walls of the sphenoid sinus are well within the reach of endoscopy.

Endoscopy of the anterior base of the skull is indicated for lesions of the anterior and middle ethmoid roof, especially the cribiform plate, for the olfactory rim, and for
the walls of the sphenoid sinus, whereas lesions of the sphenoid plane requiring attention are rare. For these reasons, anterior ethmoidectomy is the method of choice for access to the anterior base of the skull, followed by posterior ethmoidectomy with opening of the sphenoid sinus. Individual circumstances will decide which of these is used for adequate exposure. Particular procedures do not need to be described further at this point. Ethmoidectomy in these circumstances naturally includes the radical removal of the mucosa as far as this is necessary.

According to the extent of the lesion, a sufficient portion of the ethmoids is exenterated by an anteroposterior or posteroanterior ethmoidectomy. Particular attention is paid to a broad visualization of the compromised area. For this purpose a superior plastic correction of the nasal septum and a reduction of the middle and superior turbinates may be indicated. The mucoperiosteal lining covering the ethmoid roof is then circumcised and removed from the involved area until healthy bone margins are identified.

These borders have to be exposed by at least 1–2 mm. If possible, the overlying dura mater is dissected free from the underlying bone at the same distance in order to enable the interposition of a free graft (underlay technique). This maneuver, carried out with a curved semisharp dissector, and controlled by the endoscopic or microscopic visualization, is not difficult in plane areas. It becomes questionable or impossible at the incorporation of the nasal septum or superior conchae within the skull base, also at the fossa olfactoria, the frontoethmoidal transition, and the sphenoid. In these regions, the fixation of a free graft on the exposed inferior surface of the skull base (onlay technique) must suffice (Fig. 6.81 a–c). Its margins have to overlap the adjacent healthy bone by at least 1–2 mm and are fixed to the bone with fibrin tissue adhesive. This mucoperiosteal patch works as a free graft. It should fit snugly into the exposed area and must not be laid over neighboring mucosa. The technique is not difficult if the surgeon is familiar with bimanual endoscopy. After removal of as much of the middle turbinate as necessary, the ethmoid cells are cleared up to the base of the skull. Once the fistula has been found (Fig. 6.82a, b), the neighboring mucosa is removed delicately from the edge over a distance of 2–4 mm using fine curved double forceps. If the fistula reaches the nasal
7 Complications of Sinusitis

Indications

- Perifocal inflammation of facial soft tissues
- Chemosis, nasolacrimal stenosis
- Orbital abscess or phlegmon, optic nerve neuritis
- Mucopyocele
- Osteitis, osteomyelitis
- Meningitis, brain abscess
- Focal spread

Operative Technique

Orbital Complications

Orbital complications are most frequently due to an aggressive infection of the ethmoid. Blockade of the maxillary and frontal sinuses gives rise to tailback of secretions, thus provoking mucoceles with diplopia or pain as presenting symptoms.

Chronic conjunctivitis, blepharitis, and epiphora can be caused by chronic rhinosinusitis with or without stenosis of the nasolacrimal duct. Ophthalmological examination including probing and irrigation of the duct and radiological diagnosis will then indicate conservative or eventually rhinosurgical treatment of the underlying disease, which means an endoscopic revision of the adjacent sinuses, and a microscopic dacryocystorhinostomy if necessary (see Chapter 6).

Rhinogenous orbital cellulitis and subperiostal abscess are regularly caused by invasive inflammation from the ethmoid through the lamina papyracea into the orbit. This proliferation is especially easy during childhood. The alarming symptoms of chemosis and orbital protrusion (Fig. 7.2) are, therefore, generally addressed in infants by an initially conservative treatment under ophthalmological supervision over 24–36 hours before ethmoidectomy should become necessary.

In adults, this decision is facilitated by the evidence of chronic ethmoiditis (Fig. 7.3a–c). Endoscopic total eth-

Principles

Inflammatory invasions of soft tissues and bone beyond the borders of the paranasal sinuses are termed complications. They may involve adjacent structures or remote areas by superficial or hematogenous dissemination. In the past, radical eradication, mostly with external approaches, exposing the starting point at a paranasal sinus together with the healthy neighborhood were regarded as mandatory. Modern endoscopic surgery has changed the strategy: Sanitation of the focus by one of the standard operations described in Chapter 6 in facultative combination with an eventual neurosurgical or ophthalmological intervention supported by high-dosage antibiotics has proved successful. It must be stressed that early perifocal edema and phlegmon during childhood should only reluctantly be treated with surgery (Fig. 7.1).

Fig. 7.1 Initial orbital complication from rhinitis in an infant showing a swollen and reddened upper lid and chemosis.

Fig. 7.2 Orbital complication from rhinosinusitis with periocular venous congestion, edema, and slight protrusio bulbi.
Complications of Sinusitis

Moidalctomy is carried out according to the technique described in Chapter 6. A limited resection of the lamina papyracea is added, and the localized abscess is opened by a vertical incision of the periosteum with a sickle knife. A mild and careful spreading with a small Blakesley forceps will completely empty the abscess cavity, which should be monitored, and if necessary this manipulation process should be repeated the next day under local anesthesia and endoscopic visualization. Mann et al. (1997) had to repeat the maneuver in 6 of 26 children with a periorbital abscess. The healing process may be supported by insertion of a soft strap of cotton for 1–2 days.

**Orbital invasion from frontal sinusitis,** clinically suggested by the lateroinferior displacement of the eyeball (Fig. 7.4), will be detected on CT. It will be addressed by a frontal sinusotomy, if possible, endoscopically, combined with an anterior ethmoidectomy and medial orbitotomy.

**A deep retrobulbar abscess** (Fig. 7.5) originating from the posterior ethmoid may be drained endonasally, but the risk of injuring the optic nerve must be balanced against the higher expense but greater safety of a transcranial approach. A modified endoscopic Lothrop procedure has been recommended for cases with extension of

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Fig. 7.4 Severe lateroinferior displacement of the left eye due to frontoethmoidal sinusitis with orbital phlegmon.

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Fig. 7.3 a–c Advanced sinogenic orbital complication. a The facial aspect with periocular inflammation, chemosis, and protrusio bulbi.

b Necrotizing maxilloethmoiditis (○) in the CT scan. The medial orbital wall (arrow) is eroded and deflected by a subperiosteal abscess.

c Incision of the prominent periorbita after ethmoidectomy releases the abscess (+).