2 Nose, Nasal Sinuses, and Face

Applied Anatomy and Physiology

Basic Anatomy

External Nose

The supporting structure of the nose consists of bone, cartilage, and connective tissue. Figure 2.1 shows the most important elements. The bony superior part of the nasal pyramid is often broken in typical fractures of the nasal bones, but it may also be fractured in injuries to the central part of the face. The cartilage inferior portion is less at risk, at least in mild blunt trauma, because of its elastic structure, but it is endangered in stab wounds, lacerations, and gunshot injuries. The shape, position, and properties of the bone and cartilage of the nose have a considerable influence on the shape and esthetic harmony of the face (see p. 1) and on the function of the nasal cavity.

Fig. 2.1 The nasal skeleton.
1. labella; 2. nasal bone; 3. lateral nasal cartilage; 4. cartilaginous nasal septum; 5. alar cartilage with lateral (a) and medial crus (b); 6. nasal valve between the cranial alar and caudal lateral cartilages.

The bony portion of the nose is completely rigid. The flexible cartilaginous portion begins at the rhinion. The distal caudal lateral cartilages can move like the wings of a butterfly, whereas the alar cartilages move more like the wings of a bird. The nasal septum is the center of stability.
The following **blood vessels** in the external nose are of practical importance:
- Facial artery and its branches.
- Dorsal nasal artery, arising from the ophthalmic artery.

Profuse hemorrhage can arise from these vessels when the central part of the face is injured.

The angular vein is also clinically important. Thrombophlebitis arising from a furuncle of the upper lip or the nose can spread via the ophthalmic vein to the cavernous sinus, causing a cavernous sinus thrombosis (see p. 189 and Fig. 2.2).

The external nose derives its **sensory nerve supply** from the first and second branches of the trigeminal nerve (see Fig. 2.15a, b). The muscles derive their **motor nerve supply** from the facial nerve.

### Nasal Cavity

The interior of the nose is divided by the nasal septum into two cavities, which are usually unequal in size. Each side may be divided into the nasal vestibule and the nasal cavity proper (Fig. 2.3a, b). The nasal vestibule is covered by epidermis containing hairs (vibrissae) and sebaceous glands. The latter are the site of origin of a nasal furuncle, which can thus only develop in the nasal cavity in the vestibule.

The medial wall of the nasal vestibule encloses the supporting structure of the anterior part of the cartilaginous septum and the membranous septum—i.e., the **columella**. The roof of the vestibule is formed by the bird wing-shaped lower lateral or alar cartilage, the medial crus of which extends into the columella and the lateral crus of which supports the external wall of the vestibule (Figs. 2.1, 2.3a, b). The alar cartilage determines the shape of the nasal tip and the nasal apertures. Correcting this area is often an important part of rhinoplasty.

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**Fig. 2.2** Important vascular relationships in the face. 1, Site for ligation of the angular vein; 2, facial artery; 3, facial vein; 4, common carotid artery; 5, internal jugular vein; 6, pterygoid plexus; 7, sigmoid sinus; 8, inferior sagittal sinus; 9, superior sagittal sinus; 10, cavernous sinus; 11a, superior petrosal sinus; 11b, inferior petrosal sinus.

**Fig. 2.3a, b** a Section through the anterior nose, showing the vestibule and the limen nasi. The dashed line in b shows the sectional plane of a. The limen nasi is located at the junction of the pink and red areas. b Medial nasal wall. 1, Bony nasal bridge; 2, nasal septum; 3, upper lateral nasal cartilage; 4, nasal cavity; 5, alar cartilage; 6, nasal vestibule; 7, nasal ala; 8, nasal columella with medial crus of the cartilaginous ala; 9, filaments of the olfactory nerve; 10, olfactory bulb; 11, palatine bone; 12, perpendicular plate of the ethmoid; 13, vomer; 14, pharyngeal eustachian tube ostium.

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The internal nasal valve or limen nasi is a very important structure from the physiologic point of view. It lies at the junction of the vestibule and the nasal cavity. It is formed by a prominence of the anterior edge of the upper lateral or triangular cartilage on the lateral wall of the nose (Fig. 2.3a). The internal nasal valve is normally the narrowest point in the entire cross-section of the nasal cavity, making it an important factor in nasal respiration (see p. 135).

The nasal cavity extends from the internal nasal valve to the choana. The structure of the floor and roof of the nose, the medial wall, and the nasal septum is shown in Fig. 2.3a, b.

The outline of the lateral wall of the nasal cavity is more complex than that of the medial wall. It contains several structures that are important in the functioning of the nose and nasal cavity (Fig. 2.4):

- Three nasal turbinates (superior, middle, and inferior)
- Drainage of the paranasal sinuses (frontal sinus and maxillary sinus through the hiatus semilunaris in the middle meatus, located between the inferior and middle turbinate; the sphenoid sinus has an ostium of its own in the sphenoethmoidal recess)
- Opening of the nasolacrimal duct into the inferior meatus

The superior, middle, and inferior meatus are located inferior to the three turbinates (Fig. 2.4); the paranasal sinuses and the nasolacrimal duct open into them. These openings are of diagnostic and therapeutic importance.

- The inferior meatus, located between the floor of the nose and the insertion of the lower turbinate, lacks a sinus ostium, but contains the opening of the nasolacrimal duct ≈ 3 cm posterior to the external nasal opening and 3 mm posterior to the head of the inferior turbinate (Fig. 2.4).
- The middle meatus, between the inferior and middle turbinate, is of clinical importance because the frontal recess, the anterior ethmoid cells, and the maxillary antrum open into it (Fig. 2.4).
- The superior meatus, between the middle and superior turbinate, contains the opening for the posterior ethmoid cells. The sphenoid ostium is located on the anterior wall of the sphenoid sinus, at the level of the superior meatus (Fig. 2.4).
The nasal cavity is lined by two types of epithelium: respiratory and olfactory (Figs. 2.5a–d, 2.6a, b). Respiratory epithelium coats the entire airway and its projections and extensions (e.g., the paranasal sinuses and the middle ear), from the nasal introitus to the bronchi. It shows morphologic variation in different parts of the respiratory tract. Figure 2.5c, d shows the structure of the respiratory epithelium of the nasal cavity. The epithelium is columnar-ciliated with goblet cells and a layer of mixed glands, a fairly well demarcated lymphoid cell zone and well developed venous cavernous spaces in the turbinates and around the ostia (Fig. 2.5a).

The olfactory mucosa, innervated by fibers of the olfactory nerve, covers the area of the olfactory cleft, the cribri-
form plate, part of the superior turbinate, and the part of the septum lying opposite it. The structure is shown in Fig. 2.5d, and its topographic extent in Fig. 2.5c. Bowman glands occur specifically in this area. They produce a lipo-lipid secretion that covers the olfactory region and aids in olfactory perception due to the enzymes it contains. It is entirely dissimilar to the secretion of the glands of the respiratory epithelium.

**Paranasal Sinuses**

The paranasal sinuses are pneumatized cavities in the bone adjacent to the nose (Fig. 2.7a, b).

**Ostiomeatal Complex**

The ostiomeatal complex is a functional entity in the anterior ethmoid complex that represents the final common pathway for drainage and ventilation of the frontal, maxillary, and anterior ethmoid cells (see Fig. 2.9). As their dependent sinuses, can become diseased, contributing to the symptoms and pathophysiology of sinusitis.

**Ethmoidal Labyrinth**

The central structure in this system of pneumatized cavities is the ethmoid bone. The anterior ethmoid is the morphologic connection and secretion channel between the nose and the frontal and maxillary sinuses. The tight spaces and clefts normally ensure ventilation and drainage of the sinus mucosa. The anterior ethmoid is central to the pathogenesis of acute, recurrent, and chronic inflammations of the frontal and maxillary sinuses, since ≈ 90% of all diseases of the frontal and maxillary sinuses begin here.

The central part of the ethmoid bone is T-shaped. In the median plane, the crista galli projects into the anterior fossa (Fig. 2.8). The al cerebri inserts here. The perpendicular plate (lamina perpendicularis) abuts anteriorly onto the septal cartilage and dorsally onto the vomer. The paired ethmoid labyrinth is situated between the nose and orbit. It consists of 1 to 15 pneumatized cells lined with respiratory epithelium. The volume varies individually; roughly, it is the size of a matchbox standing on its short side.

The lamina cribrosa passes into the ethmoid notch (incisura ethmoidalis) of the frontal bone. The olfactory nerves extend from the olfactory rim to the olfactory bulb.

The ethmoid air cells are differentiated into anterior and posterior groups. They are derived from an embryonic paired anlage that coalesces in the first year of life to form a single ethmoid cell. There are communications between all of the ethmoid cells on one side. There are often also common ostia for the anterior ethmoid complex in the
Complications. These include CSF fistula, recurrent late meningitis, early or late brain abscess, osteomyelitis of the flat bones of the skull (see p. 190), and formation of mucoceles or pyoceles (see p. 184).

Other Possible Injuries to the Facial Skeleton

Injury to the facial nerve. See page 112.

Injuries to the lacrimal system (Fig. 2.113). These are quite commonly combined with injuries to the sinuses and the middle of the face. If possible, they should be repaired in the same session as the injuries to the sinuses and face. If this is not possible, or is not successful, stenosis or complete obstruction of the lacrimal sac or nasolacrimal duct may occur (see Fig. 2.113), requiring correction (dacryocystorhinostomy; see Fig. 2.113) either by an ophthalmic or rhinologic surgeon.

Injuries to the mandible and temporomandibular joint. These injuries are managed by a maxillofacial surgeon, who is also responsible for restoring correct occlusion.

The main symptoms of mandibular fractures include swelling of the lower part of the face, abnormal movement or deformity of the mandible, anomalies of occlusion, pain on movement, compression or torsion of the mandible, and possibly trismus.

Immediate first aid measures should be undertaken for comminuted fractures, particularly fractures of the chin with extensive soft-tissue injury. The patient should be intubated, or a tracheotomy should be performed, due to the danger of respiratory obstruction. Profuse bleeding should be arrested, if necessary with a pressure dressing. Soft-tissue defects or scars are dealt with in the usual way using plastic surgery reconstructive procedures.

Congenital Anomalies and Deformities of the Nose

Development of the embryonic face involves nine processes. Due to the complexity of these processes, congenital anomalies are relatively common, although many of them are only slight. Anomalies incompatible with life—e.g., arhinia—are extremely rare.

Cleft Face and Nose

Oblique facial clefs, even in a rudimentary form, are rare, as are transverse facial clefs, in which the angle of the mouth is located near the tragus, causing macrostomia.

Median clefs are more common, but are usually only rudimentary. They range in extent from hypertelorism, with or without a true median facial cleft and with or without meningoencephalocele, to dog nose, proboscis, or even double nose.

Treatment. Plastic surgery.

Cleft Lip, Jaw, and Palate

These anomalies are relatively common, affecting 1% of Caucasians.

Treatment. Reconstructive surgery, occasionally in stages, and orthodontic and prosthetic procedures. In addition, speech therapy may be needed. Treatment planning is described on page 281.

Cleft lip and palate present the rhinologist with several problems: firstly, anomalies of the external nose, such as a flattened nasal ala, and anomalies...
within the nose, such as dislocation of the septum; secondly, speech disorders, such as rhinolalia aperta of varying degrees of severity; and thirdly, abnormalities of tubal aeration which are regularly present, causing seromucotympanum or chronic otitis media.

Nasal Fistulas, Nasal Cysts, Dermoid Cysts, and Gliomas

Median nasal fistulas, from which a cloudy secretion may drain, usually end blindly at the level of the glabella or in the ethmoidal– septum region. This is also true of congenital nasal cysts, which develop at the same site, but also may arise in the nasal vestibule or nasal septum.

Dermoid cysts are more common. They often contain hair and accessory structures, such as ectodermal inclusions, which lie above, below, or within the frontal bone.

Gliomas are tumors of the frontal region or the root of the nose in the midline; they consist of solid glial tissue. All of these anomalies must be removed surgically.

Meningoencephalocele

Dural and brain herniations (hernias and celes) may be found in the nose, where they are easily mistaken for nasal polyps. They may also be located extranasally and be related to the frontal bone, ethmoid, or nasal septum. The causes are incomplete closure of the neuropore during the third week of embryonic development, and trauma (Fig. 2.114a, b). Meningoencephaloceles and gliomas can often be removed and the defect can nowadays be repaired endoscopically.

Diagnosis. MRI with contrast medium and CT.

Treatment. Surgical removal, closure of the dura, and osteoplastic correction of any existing hypertelorism, if required.

Stenosis and Atresia of the Nostrils

These are usually congenital, but may also be acquired—e.g., due to trauma or destructive infections.

Treatment. Plastic surgery.

Choanal Atresia

This is a bony or membranous occlusion of the posterior nasal opening, and may be bilateral. Girls are more often affected than boys. Hereditary factors have been demonstrated. The disorder is usually congenital, but it may also be acquired due to trauma. Incomplete atresia (stenosis) also occurs.

Clinical Features. Newborn babies with bilateral choanal atresia present with intermittent cyanosis, especially during feeding. Other symptoms include chronic purulent nasal discharge, inability to breathe through the nose or to sneeze, and anosmia.

Note: Bilateral atresia in the newborn is a life-threatening condition. As the infant is unable to breathe satisfactorily through the mouth due to the relatively high position of the larynx, it has to rely on nasal respiration during feeding. This poses a risk, in bilateral atresia at least, of asphyxia, cyanosis, atelectasis of the lungs, or aspiration pneumonia. Spontaneous feeding is difficult or impossible.
Diagnosis. The most reliable and simple test is to hold a cold metal spatula just beneath the nose and look for misting. Further tests include probing the nose with a smooth catheter and endoscopy of the nose and nasopharynx.

Differential diagnosis. This includes any disorders that cause nasal obstruction, especially polyps, foreign bodies, encephalocele, and tumors.

Treatment. When bilateral atresia has been recognized, the airway obstruction can be relieved by inserting an oropharyngeal airway until surgical correction can be arranged. Transpalatal surgery has now been largely superseded by dilation under direct vision of the posterior choana using a 120° endoscope in the pharynx.

In unilateral atresia, surgical correction can be deferred to a later date.

**Disorders of Shape of the External Nose**

Anomalies of the shape of the external nose often require rhinoplasty, both for esthetic reasons and because of impaired function.

Anomalies of the shape of the nose may be due to the cartilaginous or bony parts of the internal or external nose skeleton being too large or too small, or being improperly positioned in relation to each other or to surrounding structures. Analysis of the deformities is based on certain parameters, as illustrated in Figs. 2.115 and 2.116, on standardized photographs. Certain angles in the facial contour also have to be taken into account.

**Fundamentals of Rhinoplasty**

Rhinoplasty has two purposes:

1. It should restore a normal shape to the nose, so that it harmonizes with the rest of the face.
2. The function of the nose and nasal sinuses with regard to respiration, olfaction, etc., should be maintained, improved, and returned to normal.

This dual character of modern nasal surgery often requires correction of both the outside and inside of the nose—i.e., septorhinoplasty. These operations must be performed by a suitably trained rhinologist.
A distinction is made between corrective and reconstructive operations. In corrective rhinoplasty, and particularly for correction of the supporting framework of the nose, all of the surgical steps are performed from inside the nose, without an external incision (Fig. 2.117).

The principal steps in rhinoplasty are:
- An incision in the nasal vestibule or at the medial columella.
- Elevation of the soft tissue covering the nasal skeleton.
- Exposure, mobilization, and correction of all skeletal elements.
- Union of the mobilized and corrected skeletal parts to form a pleasing nasal framework and a functionally competent nasal cavity.
- Fixation of the mobilized, corrected skeletal elements in the required position.

Anomalies of the cartilaginous part of the nose include anomalies of the shape of the base of the nose—e.g., a hanging nasal tip, or a tip that is too flat or too wide, cleft, too long, or too short; nasal alae that are flaccid, too arched, or asymmetrical; a nasal columella that projects too much, is too retracted, too thick, too short, or too bent. The entire nose may also be too long or too short.

Anomalies of the bony part of the nose include anomalies of the shape of the bridge of the nose—e.g., hump nose, saddle nose, twisted nose, broad nose, or narrow nose; of the root of the nose; and of the nasal septum. The bony and cartilaginous parts of the nose usually need to be corrected together.

**Fig. 2.117a-f** Different nasal types.
- a Hump nose.
- b Overprojecting nose, functional tension nose.
- c Drooping nasal tip.
- d Saddle nose.
- e Short nose.
- f Deviated nose.

**Fig. 2.118** The splitting approach for cranial volume reduction of the alar cartilage.

**Approaches.** Three approaches have proved valuable for rhinoplasty:
- The splitting approach (Fig. 2.118).
- The delivery approach (Fig. 2.119).
- The open approach (Fig. 2.120).

Which approach is used depends on the specific morphologic problems. Other decisive factors are types of skin and connective tissue. Thick skin predisposes to healing problems, whereas thin skin limits the selection of surgical techniques—e.g., using tip or shield grafts that might remain visible through the skin.

Reconstructive rhinoplasty deals with partial loss of the soft tissue, of the skeleton of the nose, or total loss of the nose, and reconstruction of a complete nose. Local or distant flaps are used, depending on the type and extent of the defect (see p. 217).

**Hump Nose**
This is due to an excess of the bony or cartilaginous nasal skeleton. Usually, it does not cause any marked functional disturbance.

**Treatment.** Rhinoplasty is performed, with removal of the hump and narrowing of the nasal bridge. The principles of the procedure are shown in Figs. 2.121a,b and 2.122.
Saddle Nose
The term “saddle nose” denotes a multifactorial condition that is associated with destabilization or destruction of the bony or cartilaginous structures of the nose. Osseous forms of saddle nose are nowadays rare and usually result from dysplasia of the nasal bones or from nasal midfacial trauma.

Cartilaginous saddle nose is a more frequent concern for rhinologists. The central problem in this condition is the serious structural compromise caused by a loss of anterior septal cartilage between the rhinion (keystone area) and what is known as the septal pedestal at the level of the premaxilla and the anterior nasal spine.

Pathomechanism. The septal cartilage is partly or completely absent due to trauma, an incorrectly executed septoplasty, a septal abscess, or an infection; the condition may also be congenital.

Clinical Features. The profile of the nose is typical. The patient may also report nasal obstruction due to absence of support for the nasal valve and introitus.

Treatment. A reconstructive procedure is needed for surgical treatment of a saddle nose. Rhinoplasty is performed, with implantation of several struts and implants to restore the cartilaginous framework of the nose, particularly the important central structure of the anterior nasal septum.

Deviated Nose
The cartilaginous and bony nasal skeleton and nasal septum are most often involved here. The cause is usually trauma, but a deviant nose may be congen-