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Chapter 3
NOSE AND PARANASAL SINUSES DISEASES

A bunch of dry steppe grass...
I feel its fragrance, although it is dry!
For it reveals a full smell
Of steppe at once...
A. Maykov

3.1. NOSE AND PARANASAL SINUSES CLINICAL ANATOMY

The upper respiratory tract includes the nose, paranasal sinuses, pharynx, and larynx. The nose (*nasus*) is the initial part of the respiratory tract; the peripheral part of olfactory system is located in the nasal cavity. Inclinical anatomy, nose is separated into the external and internal nose (or nasal cavity).

External Nose Clinical Anatomy

The external nose (*nasus externus*) consists of an osteocartilaginous structure covered with skin and has a shape of a triangular pyramid its base directed downward (fig. 3.1, a–c). The upper part of the external nose, which joins thefrontal bone, is called the root of the nose (*radix nasi*); it continues into the nasal dorsum (*dorsum nasi*) and finishes on the tip of the nose (*apex nasi*). The lateral surfaces of the nose, flexible in the tip area, represent the wings of the nose (*alae nasi*), and their free edges form the entrance of the nose, or nostrils (*nares*), separated one form another by a moving part of the nasal septum (*septum mobile nasi*).

The bony part of the nose frame consists of a pair of flat nasal bones (*ossa nasalia*) making the nasal dorsum. Frontal process of the maxilla (*processus frontalis maxillae*) is placed laterally to the nasal bones on the both sides together with cartilaginous part of the external nose forming the lateral nasal walls and nasal crest. In the anterior part, these bones, together with the anterior nasal spine, form a pyriform aperture (*apertura piriformis*) of the facial skeleton.

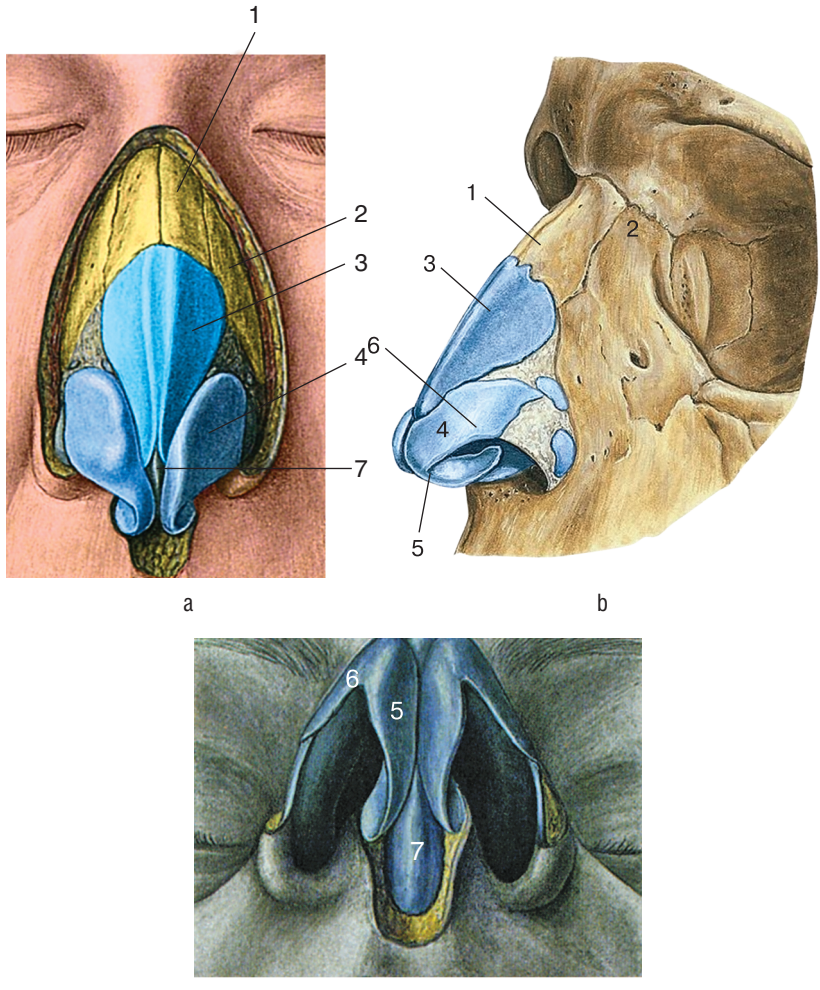

Fig. 3.1. External nose: a — frontal view; b — lateral view; c — nasal vestibule; 1 — nasal bones; 2 — frontal process of the maxilla; 3 — lateral processes of the septal nasal cartilage; 4 — major alar cartilage; 5 — medial crus; 6 — lateral crus; 7 — septum cartilage

The *cartilaginous part of the external nose* is tightly connected to the nose bones; it includes a pair of the upper lateral cartilages, i.e. the lateral process of septal nasal cartilage (*cartilago nasi lateralis*) and a pair of the lower lateral cartilages (major alar cartilages: *cartilago alaris major*). The major alar cartilage

forms the medial and lateral crus (*crus mediale et laterale*). Normally, between the lateral and major alar cartilages, there are non-constant minor alar cartilages of various sizes — the sesamoid cartilages (*cartilagines alares minores*).

The skin cover of the external nose has a lot of sebaceous glands, especially in the lower third. The skin also covers the walls of the vestibule of the nose (*vestibulum nasi*) for 4–5 mm. Here it has a big number of hairs which can be possible case of pyoderma, furuncles, and sycosis in that area.

Humans external nose muscles are rudimentary and do not have a big practical importance. They play a certain role in the expansion and contraction of the nasalcavity opening.

As all other soft tissues of the face, the external nose is abundantly supplied with blood (fig. 3.2), mainly from the *external carotid artery* system by the angular artery (*a. angularis*) from the anterior facial artery (*a. faciales anterior*), as well as from the *internal carotid artery* system by the dorsal artery of the nose (*a. dorsalis nasi*) which is formed by the terminal branch of the ophthalmic artery (*a. ophthalmica*). Coming together to the area of the root of the external nose, the angular artery and dorsal artery of the nose form a anastomosis between the internal and external carotid arteries (fig. 3.3).

Blood outflow from the external nose tissues goes to the facial vein (*v. facialis*) which is formed by the following veins:

- angular vein (*v. angularis*);
- external nasal veins (*vv. nasales externae*);

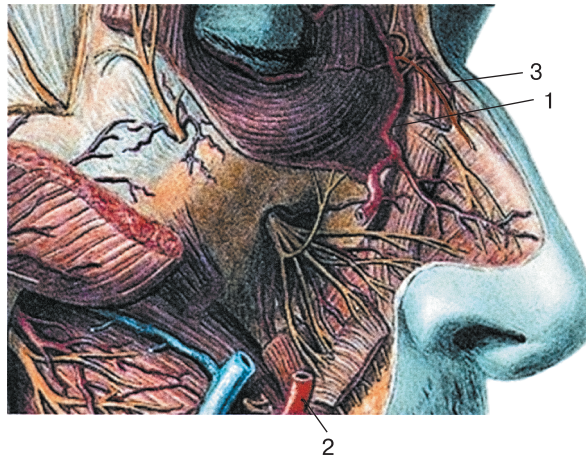

Fig. 3.2. Blood supply to the external nose: 1 — angular artery; 2 — facial artery; 3 — dorsal artery of the nose

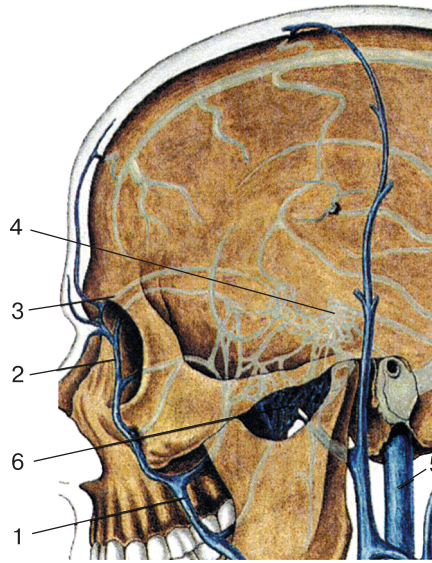

Fig. 3.3. Veins of the external nose: 1 — facial vein; 2 — angular vein; 3 — superior ophthalmic vein; 4 — cavernous sinus; 5 — internal jugular vein; 6 — pterygoid plexus

- superior and inferior labial veins (*vv. labiales superior et inferior*);
- deep facial vein (*v. facialis profunda*).

Then the facial vein enters the internal jugular vein (*v. jugularis interna*). ***From the clinical perspective it is important to note a connection between the angular vein and superior ophthalmic vein (v. ophthalmica superior) entering the cavernous sinus (sinus cavernosus).*** Due to that fact, infection can spread from an inflammatory focus of the external nose to the cavernous sinus and development of severe orbital and intracranial complications are possible.

From the external nose the lymph efflux goes to the submandibular and parotid lymph nodes.

Motor innervation of the external nose is provided by the facial nerve (*n. faciales*); sensitive innervation is provided by the first and second branches of the trigeminal nerve (*n. trigeminus*): the supraorbital and infraorbital nerves (*nn. supraorbitalis et infraorbitalis*).

Nasal Cavity Clinical Anatomy

The nasal cavity (*cavum nasi*) is located between the oral cavity (below), anterior cranial fossa (on top), and orbits (laterally). It is divided by the nasal septum into

two halves; in the anterior it is connected to the external environment by means of nostrils; in the rear part it is connected to the nasopharynx by means of choanae. Each half of the nose is surrounded by the four paranasal sinuses (fig. 3.4):

- maxillary (antrum of Highmore);
- ethmoid;
- frontal;
- sphenoid.

The nasal cavity is limited by the four walls: inferior, superior, medial, and lateral (fig. 3.5). In front, the *inferior wall* (the nasal cavity floor) is formed by two palatine process of maxilla, at the back it is formed by the horizontal plates of the palatine bone. Along the middle line these bones are connected by a suture. Congenital abnormalities of this connection cause various defects (such as cleft palate or cleft lip). In the anterior, at the nasal cavity bottom, there is an incisive canal (*canalis incisivus*) through which the nasopalatine nerve (*n. nasopalatinus*) and nasopalatine artery (*a. nasopalatina*) enter the mouth cavity. This should be taken into consideration at the moment of submucous resection of the nasal septum and other surgical interventions on this area in order to avoid serious bleeding. Newborns have the nasal cavity floor which touches dental buds located in the body of the maxilla.

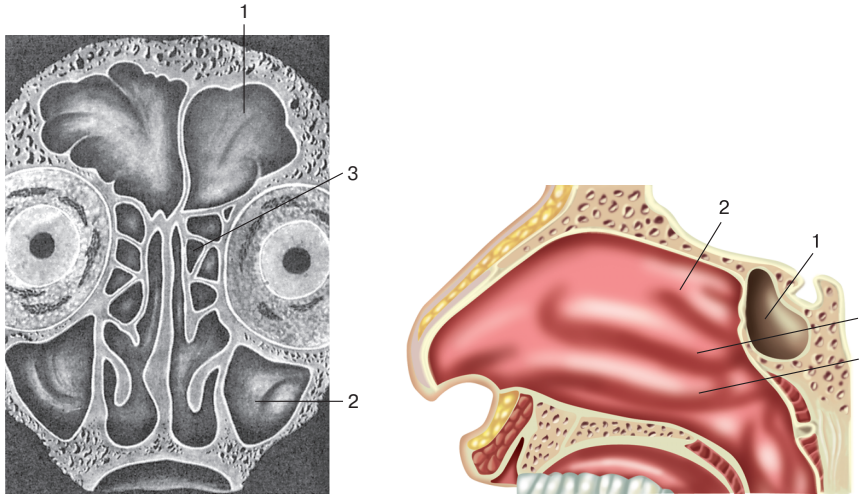

Fig. 3.4. Paranasal sinuses: a — frontal view: 1 — frontal sinus; 2 — maxillary sinus; 3 — ethmoid air cells; b — lateral view: 1 — sphenoid sinus; 2 — superior nasal concha; 3 — middle nasal concha; 4 — inferior nasal concha

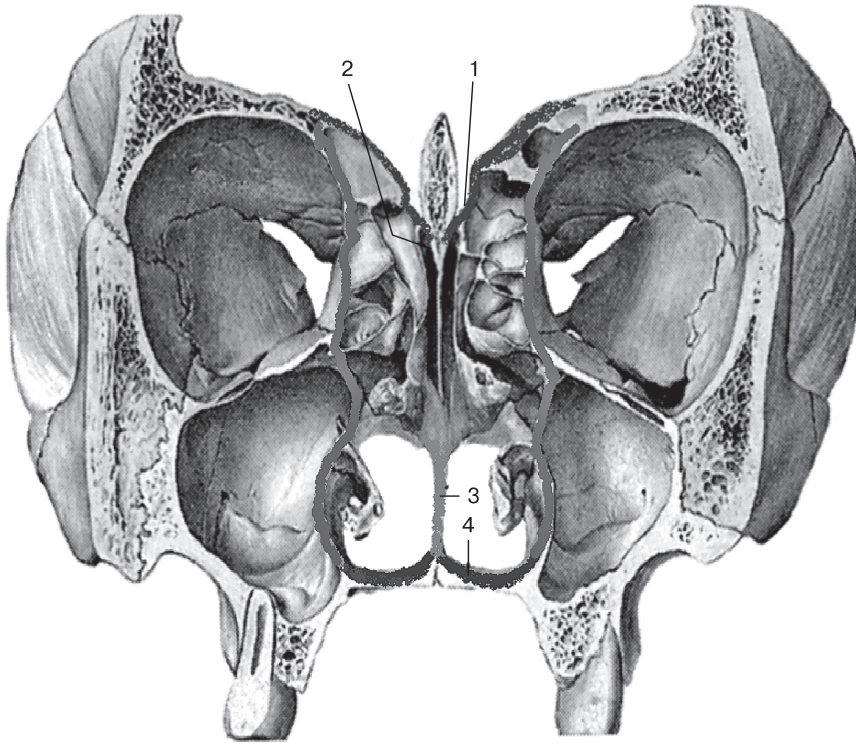

Fig. 3.5. Walls of the nasal cavity: 1 — superior; 2 — lateral; 3 — medial; 4 — inferior

The *nasal cavity upper wall*, *or roof*, is formed by the nasal bones in the anterior; its middle parts are formed by a perforated (cribriform) plate of the ethmoid bone (*lamina cribrosa ossis ethmoidalis*); its posterior part is formed by the anterior wall of the sphenoid sinus. Through the foramina of the cribriform plate of the ethmoid bone (25–30 foramina) olfactory filaments, anterior ethmoid artery, and vein enter the nasal cavity.

The newborns have the cribriform plate (*lamina cribrosa*) consisting of fibrous tissue ossifies by age 3.

In the medial wall, or the nasal septum (*septum nasi*) consists of the anterior cartilage part and posterior bony part (fig. 3.6). The cartilage part is formed by the septal nasal cartilage — the quadrangular cartilage (*cartilago septi nasi*) — the superior margin of which forms the anterior part of the nasal dorsum, whereas the anteroinferior margin is involved in the formation of the mobile part of the nasal septum (*pars mobilis septi nasi*).The rear superior and middle

areas of the bony part are formed by a perpendicular plate of the ethmoid bone (*lamina perpendicularis*) and the rear inferior area of the bony part is represented by a separate bone of the nasal septum, i.e. the vomer (*vomer*).

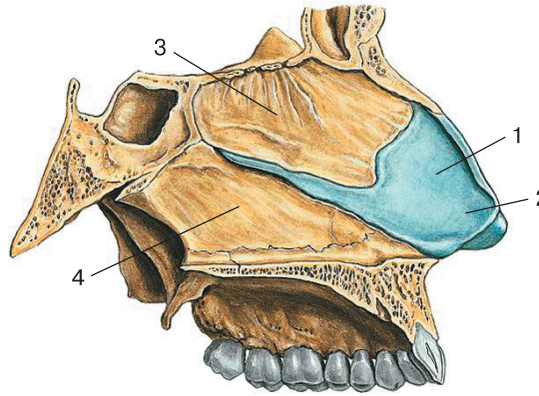

Fig. 3.6. Medial wall of the nasal cavity: 1 — nasal septum; 2 — mobile part of the nasal septum; 3 — perpendicular plate of the ethmoid bone; 4 — vomer

The newborns have a perpendicular plate of the ethmoid bone as a membranous structure. Between the perpendicular plate and vomer, as well as between the nasal septum cartilage and vomer there is a cartilage strip, i.e. the growth zone, thanks to which the nasal septum calcification occurs after the age of 10. Damage to the growth zone (for instance, during surgical interventions) can cause deformation of the nasal septum and external nose. As a result of different development speed of the bony and cartilage tissues, spikes and crests may form in the growth zone, thus causing nasal breathing impairment.

The lateral (side, external) wall of the nasal cavity is formed by several bones and has a more complex structure. Its anterior and central areas are formed by the frontal process of the maxilla, medial wall of the maxilla, lacrimal bone, and ethmoid bone cells. The posterior parts of the lateral wall are formed by the perpendicular plate of the palatine bone and medial plate of the pterygoid process of the sphenoid bone which form the choanae edges. Medially the choanae are limited by the posterior border of the vomer; laterally they are limited by the medial plate of the pterygoid process of the sphenoid bone; on top they are limited by the body of that bone, at the bottom they are limited by the posterior border of the horizontal plate of the palatine bone.

On the *lateral wall* there are the three nasal conchae (*conchae nasales*): inferior, middle, and superior (*conchae nasalis inferior, media et superior*). The inferior nasal concha is the biggest one; it is represented by its own bone, whereas the middle and superior conchae are formed by the ethmoid bone. All nasal conchae, being fixed to the lateral wall of the nasal cavity as horizontal plates, form under

Themselves the inferior, middle, and superior nasal meatuses. Between the nasal septum and nasal conchae, a cleft-like free area is formed; it expands from the nasal cavity floor to the nasal roof; this area is also called the common nasal meatus.

Children have narrower nasal meatuses, and their inferior nasal concha reaches the nasal cavity floor. This is why nasal breathing impairment in children happen more quickly even if the mucous membrane is slightly swollen in case of catarrhal inflammation. This fact impedes breast feeding because babies cannot suck without nasal breathing. Moreover, young children have a short and wide auditory tube located horizontally; this can provoke penetration of infected mucus from the nasopharynx through the auditory tube to the middle ear and development of acute otitis media.

The inferior nasal meatus (*meatus nasi inferior*) is located between the inferior nasal concha and the maxillary sinus wall. In the area of its arch, approximately one centimeter from the anterior border of the concha, there is a nasolacrimal duct (*ductus nasolacrimalis*) opening. This opening appears after the birth; delay of its opening impedes outflow of tears and leads to cystic expansion of the duct and narrowing of the nasal meatuses. The lateral wall of the inferior nasal meatus is thick (spongy) in the inferior parts, but closer to the place where the inferior nasal concha ends it becomes significantly thinner, that is why it is easier to perform maxillary sinus paracentesis exactly here at a distance of 1.5 cm from the anterior border of the concha.

The middle nasal meatus (meatus nasi medius) is located between the inferior and middle nasal concha. In this area, the lateral wall is complex and is represented by bony tissue, as well as by the mucous membrane reduplication, also called the fontanel. On the lateral wall of the middle nasal meatus under the nasal concha, there is a semilunar hiatus (*hiatus semilunaris*) the posterior part of which forms a small ethmoidal infundibulum (*infundibulum ethmoidale*; fig. 3.7). An outlet opening of the frontal sinus opens into the ethmoidal infundibulum in front and on the top, whereas a connection of the maxillary sinus opens at the rear and bottom part. The anterior ethmoidal air cells open into the semilunar hiatus. The connection of the maxillary sinus in the infundibulum is covered with the uncinate process (*processus uncinatus*) that limits

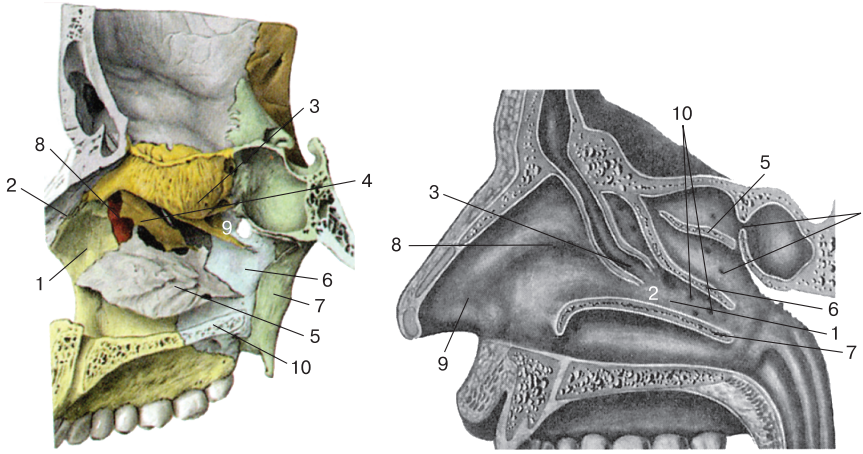

Fig. 3.7. Structure of the lateral wall of the nasal cavity: a — skeleton of the lateral wall of the nasal cavity after removal of soft tissues: 1 — frontal process of maxilla; 2 — nasal bone; 3 — superior nasal concha; 4 — middle nasal concha; 5 — inferior nasal concha; 6 — perpendicular plate of palatine bone; 7 — internal plate of pterygoid process of sphenoid bone; 8 — lacrimal bone; 9 — sphenopalatine foramen; 10 — horizontal plate of palatine bone; b — lateral wall of the nasal cavity after removal of nasal conchae: 1 — semilunar hiatus; 2 — ethmoidal infundibulum; 3 — opening of the frontal sinus duct; 4 — openings of the sphenoid sinus and posterior ethmoidal air cells; 5 — superior nasal concha; 6 — middle nasal concha; 7 — inferior nasal concha; 8 — agger nasi; 9 — anterior nasal valve; 10 — openings of the maxillary sinus and anterior ethmoidal air cells

the semilunar hiatus in the anterior; that is why usually outlet openings of the sinuses are not visible at the moment of rhinoscopy.

On the lateral wall of the nasal cavity in the area of the middle nasal concha border there is the *agger nasi* which represents a small ridge located parallel to the nasal dorsum. Sometimes its air cells significantly increase in size and block the entrance to the middle nasal meatus. From the bottom, the agger nasi borders with the surface of the uncinate process.

Pneumatized type of the anterior border of the middle nasal concha is common. It is referred to as a bulla (*concha bullosa ethmoidale*) formed by one of the ethmoidal air cells.

A bulla of the middle nasal concha may provoke disturbances of aeration of paranasal sinuses and their subsequent inflammation.

The system of anatomic structures in the anterior area of the middle nasal concha is called “the osteomeatal complex”. It includes the following:

- uncinate process;

- anterior ethmoidal air cells;
- infundibulum;
- opening of the maxillary sinus;
- lateral surface of the middle nasal concha.

The *uncinate process* (semilunar bony plate) forms the infundibulum medial wall. In front of the uncinate process, at the level where the superior border of the middle nasal concha ends, there are *agger nasi cells*. These cells may be represented by a single cavity, but more frequently this is a system of separate cells which open into the ethmoidal infundibulum. At the back of the uncinate process, under the anterior border of the middle nasal concha, there is a big block of the anterior ethmoidal cells — the ethmoid bulla (*bulla ethmoidalis*). And, finally, the opposite part of the nasal septum is also included in the osteomeatal complex (fig. 3.8).

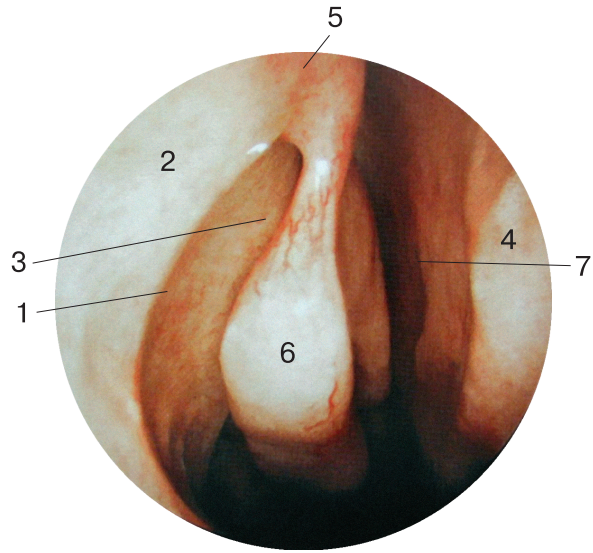

Fig. 3.8. The osteomeatal complex (endoscopic view): 1 — uncinate process; 2 — cells of the agger nasi; 3 — big ethmoidal bulla; 4 — nasal septum; 5 — base of the middle nasal concha; 6 — anterior part of the middle nasal concha; 7 — common nasal meatus

The superior nasal meatus (*meatus nasi superior*) extends from the middle nasal concha to the roof of the nose. At the level of the posterior border of the superior nasal concha, in the superior nasal meatus, there is a sphenoethmoidal recess (sphenoethmoidal space), where the sphenoid sinus (*ostium sphenoidale*) and posterior ethmoidal air cells open.

The nasal cavity and paranasal sinuses are covered with the mucous membrane except for the nasal vestibule which is covered with the skin containing hairs and sebaceous glands.

In the nasal cavity, depending on the mucous membrane structure and function, the following two regions identified: respiratory (breathing) and olfactory.

The respiratory region of the nose (*regio respiratoria*) takes the area from the nasal cavity floor to the level of the inferior border of the middle nasal concha. In this area, the mucous membrane is covered with multi-layered columnar ciliated epithelium (fig. 3.9). The apical surface of ciliated cells has about 200 thin 3–5 μm long cilia formingcovering almost all surface. Cilia motion are directed towards the nasopharynx, and, in the anterior part, they are in directed motion towards the vestibule. The vibration frequency of cilia is about 6–8 per second. Moreover, the mucous membrane contains a lot of goblet cells, which produce mucus, and branched serous and seromucous tubular alveolar glands.

Fig. 3.9. Ciliated epithelium (photomicrography, ×2600)

The substance produced by glands goes to the surface through excretory ducts of the mucous membrane of the nose. Cilia are immersed in tubular alveolar glands substance; the normal mucus acidity (pH) ranges from 7.35 to 7.45. Alterations in the nasal mucus acidity towards more alkaline or more acidic slow down movements of cilia up to their complete stop and disappearance from the cells surface. Once pH is normalized, the function of cilia and mucociliary clearance can be restored. Long instillation of any medications into the nose will disturb the ciliated epithelium function; therefore, this should be taken into account during treatment of any nasal disease. Along its entire length the mucous membrane is tightly adherent to the perichondrium and periosteum; that is why during surgical interventions they are separated together.

On the medial surface of the inferior nasal concha and in the anterior pats of the middle nasal concha, the mucous membrane of the nasal cavity is thi-

ckened due to cavernous (spongy) tissue consisting of venous sinuses the walls of which have a lot of smooth muscles. Under the influence of certain stimulus (such as cold air or muscular exercise) the mucous membrane containing cavernous tissue may instantly swell up or contract causing constriction or expansion of the nasal meatuses and regulating the respiratory function. Normally throughout 24 hours patency of both halves of the nose is not similar: they experience alternating partial congestion and decongestion. Such alternating change is called the nasal cycle.

The cavernous tissue of the nasal conchae in children becomes fully developed by the age of 6. In the mucous membrane of the nasal septum, at a distance of 2.5–3 cm from its anterior margin, younger children may have a rudimentary olfactory organ — the vomeronasal organ (Jacobson's organ), where cysts and inflammations may develop.

The *olfactory region* (*regio olfactoria*) is located in the superior parts of the nasal cavity: from the inferior margin of the middle nasal concha up to the nasal roof (fig. 3.10). The area between the medial surface of the middle nasal concha and the opposite part of the nasal septum is called the olfactory cleft. In that region, the olfactory epithelium of the mucous membrane consists of three types of cells: olfactory bipolar neurons, basal cells, and supporting cells. Aslo ciliated epithelium cells can be found there which perform cleaning function. The surface of the olfactory epithelium is covered with mucus, which represents specific substance produced by tubular alveolar glands (olfactory, or Bowman glands). The olfactory receptor cells are of spindle shape; their round nucleus is displaced towards the basal pole. The apical part of the olfactory neuron (dendrites) has 10–20 long

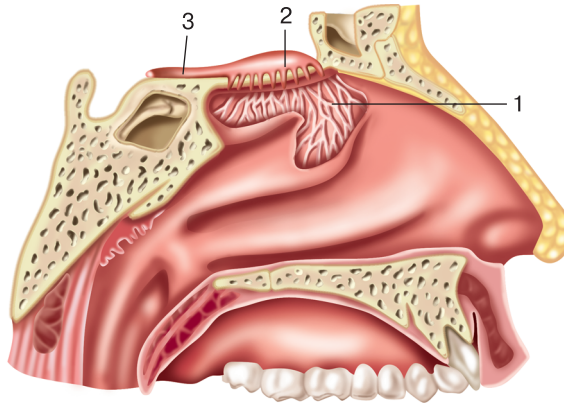

Fig. 3.10. The olfactory region of the nasal cavity: 1 — olfactory filaments; 2 — cribriform plate of the ethmoid bone; 3 — olfactory tract

fixed olfactory cilia coming out from the epithelium into the layer of olfactory mucus: they increase the receptor surface of the plasmalemma and contain chemoreceptor proteins, as well as G-proteins activating the second messengers. First, odorous substances are absorbed on olfactory mucus produced by Bowman glands and transported to the receptors by non-specific carrier proteins. Disturbance inodorous substances transport to the receptors may occur as a result of swelling of the mucous membrane and change in the secretion of olfactory mucus in case of inflammation or allergic reaction in the nasal cavity. Odorant molecules contact with chemoreceptor proteins launches a cascade of biochemical reactions leading to generation of receptor cell action potentials. Axons of olfactory neurons form around 20–25 thin filaments (*filae olfactoriae*) which, through the cribriform plate of the ethmoid bone, enter the olfactory bulb (*bulbus olfactorius*), and then enter the olfactory tract (*tr. olfactorius*). The olfactory system of humans can distinguish over two hundred natural and artificial smells.

Nasal Cavity Blood Supply

The biggest artery of the nasal cavity — the sphenopalatine artery (*a. sphenopalatina*) — is a branch of the maxillary artery arisingfrom the system of the external carotid artery (fig. 3.11). Passing through the sphenopalatine foramen (*foramen sphenopalatina*), next to the posterior border of the middle nasal concha, it supplies blood to the posterior parts of the nasal cavity, paranasal sinuses, and nasal septum.

The following arteries arise from it to the nasal cavity:

- posterior nasal lateral arteries (*aa. nasales posteriores laterales*);
- septal arteries (*a. nasalis septi*).

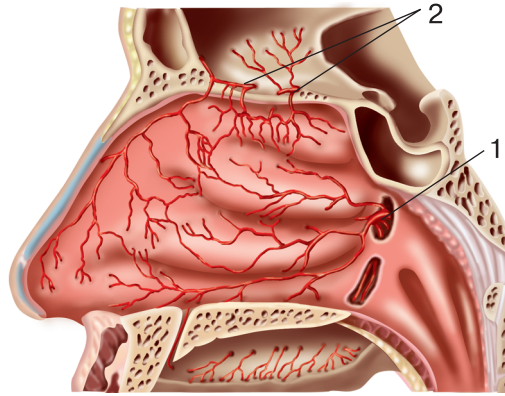

Fig. 3.11. Blood supply of the nasal cavity: 1 — sphenopalatine artery; 2 — ethmoid arteries

The anterosuperior regions of the nasal cavity and the ethmoidal labyrinth region are supplied by the ophthalmic artery (*a. ophthalmica*) from the system of the internal carotid artery. The following arteries arise from it and pass through the cribriform plate to the nasal cavity:

- anterior ethmoid artery (*a. ethmoidalis anterior*);
- posterior ethmoid artery (*a. ethmoidalis posterior*).

Nasal cavity blood supply has a dense arterial tree in the first third of the mucous membrane. In this part, referred to as Kiesselbach's area (*locus Kisselbachii)*, the mucous membrane is very thin, and nosebleed frequently arise from there. This is why Kiesselbach's area is called the bleeding zone of the nose.

Venous vessels. Nasal cavity venous system is connected to veins of the pterygoid plexus (*plexus pterygoideus*) and cavernous sinus (*sinus cavernosus*). Due to this, spread of infection and beginning of rhinogenous and orbital intracranial complications are possible.

Lymph flow. From the anterior parts of the nose lymph outflows to the submandibular lymph nodes and from the middle and posterior parts lymph outflows to the postpharyngeal lymph nodes and deep cervical lymph nodes. Tonsillitis, arising after a surgical intervention on the nasal cavity, can be explained by involvement of the deep cervical lymph nodes into inflammation leading to congestion of lymph in tonsils. Moreover, the lymphatic vessels of the nasal cavity are connected to the subdural and subarachnoid space; therefore, there is a risk of meningitis as a result of surgical interventions or inflammation in the nasal cavity.

Nasal Cavity Innervation

Following innervations types in nasal cavity are distinguished: olfactory, sensory, and vegetative. The olfactory innervation is provided by the olfactory nerve (*n. olfactorius*). Olfactory filaments, arising from sensory cells of the olfactory region (the first neuron) penetrate into the cranial cavity through the cribriform plate where they form the olfactory bulb (*bulbus olfactorius*). Here, the second neuron starts; its axons go together with the olfactory tract, pass through the parahippocampal gyrus (*gyrus parahippocampalis*) and end in the hippocampus (*hippocampus*) cortex, the olfactory centre of the cortex.

Sensory innervation of the nasal cavity is provided by the first and the second branches of the trigeminal nerve(the ophthalmic nerve (*n. ophthalmicus*) and maxillary nerve (*n. maxillaris)* respectively). The sympathetic and parasympathetic (vegetative) innervation of the nose and paranasal sinuses is represented by the nerve of the pterygoid canal (vidian nerve) which starts from the junction on the internal carotid artery (upper cervical sympathetic node) and from the geniculate ganglion of the facial nerve.

Paranasal Sinuses Clinical Anatomy

The paranasal sinuses (*sinus paranasalis*) are the air cells that surround the nasal cavity and have connections to it by having openings (foramina). The paranasal sinuses are represented by the following four pairs of sinuses:

- maxillary;
- frontal;
- ethmoidalair cells;
- sphenoid.

In clinical practice the sinuses distinguished as follows:

- anterior paranasal sinuses:
  - maxillary;
  - frontal;
  - anterior ethmoidal air cells;
- posterior paranasal sinuses:
  - sphenoid;
  - posterior ethmoidal air cells.

Such subdivision is convenient due to some difference in pathologies of the anterior and posterior sinuses. For instance, the anterior sinuses open into the nasal cavity through the middle nasal meatus, whereas the posterior sinuses open into the superior nasal meatus; this is important for diagnosis. Diseases of the posterior sinuses (especially the sphenoid sinuses) are less frequent than diseases of the anterior sinuses.

The *pair of maxillary sinuses* (*sinus maxillaris)* located in the body of the maxilla are the biggest ones: the volume of each is about 10.5–17.7 cm^3. The internal surface of the sinuses is covered with 0.1 mm thick mucous membrane, the upper layer of which is represented by multi-layered columnar ciliated epithelium. Cilia move the mucus spirally to the top, to the medial angle of the sinus, where the anastomosis with the middle nasal meatus is located. In the maxillary sinus following walls are distinguished: anterior, posterior, inferior, and medial.

Clinically, the medial (nasal) wall of the sinus, which corresponds to the large part of the inferior and middle nasal meatuses, is the most important. The medial wall is formed by a bony plate which, gradually becoming thinner, may transfer into the duplication of the mucous membrane in the area of the middle nasal meatus. In the anterior part of the middle meatus, in the semilunar hiatus, the duplication of the mucous membrane forms an infundibulum, at the bottom of which there is a opening (*ostium maxillare*) connecting the sinus to the nasal cavity.

The opening from the maxillary sinus (*ostium maxillare*) is located in the superior part of its medial wall, and, due to this, the outflow from this sinus is difficult. Sometimes during endoscopic examinations in the posterior parts of the semilunar hiatus an additional outlet foramen (*foramen accesorius*) in the maxillary sinus is found through which the mucous membrane with polyps can bulge into the nasopharynx forming a choanal polyp.

The anterior (facial) wall of the maxillary sinus extends from the inferior margin of the orbit to the alveolar process of the maxilla. This densest wall of the maxillary sinus is covered with the cheek soft tissues and can be palpated. The flat bone recession on the anterior surface of the facial wall, called canine fossa (*fossa canina*), is the thinnest part of the anterior wall. The depth of the canine fossa is about 4–7 mm on average. In case of enlarged fossa canina, the anterior and superior walls of the maxillary sinus are located in the immediate vicinity of its medial wall. This should be taken into consideration at the moment of the sinus paracentesissinus, as in such cases there is a risk that a paracentesis needle can penetrate into soft tissues of the cheek or into the orbit and that, sometimes, may lead to suppurative complications. Next to the superior border of the fossa canina there is the infraorbital foramen, through which the infraorbital nerve (*n. infraorbitalis*) goes out.

The superior (orbital) wall is the thinnest one, especially in the posterior part; dehiscence is frequent there. Canal of the infraorbital nerve passes through this wall. Sometimes the nerve and blood vessels immediately adjacent to to the mucous membrane covering the superior wall of the maxillary sinus; this should be taken into account at the moment of curettage of the mucous membrane during a surgical operation. The posterosuperior (medial) parts of the sinus adjancet with a group of posterior cells of the ethmoidal labyrinth and with the sphenoid sinus, so surgical access to them is convenient through the maxillary sinus as well. The venous plexus, connected to the orbit by means of the cavernous sinus of the dura mater facilitates spreading of a process to these regions and development of such dangerous complications as thrombosis of the cavernous sinus and orbital cellulitis.

The thick posterior wall of the sinus is adjacent to the pterygopalatine fossa where the maxillary nerve, pterygopalatine ganglion, maxillary artery, and pterygopalatine venous plexus are located.

The inferior wall (or the sinus floor) is formed by the alveolar process of the maxilla. As a rule, in case of medium-sized maxillary sinus, its floor is located approximately at the level of the nasal cavity floor, but often it can be located slightly below. If the maxillary sinus volume is increased, protrusion of tooth roots in the sinus is possible; this can be seen during X-ray examination or dur-

ing maxillary sinus surgery. Such anatomic feature increases the risk of odontogenic maxillary sinusitis (fig. 3.12). Sometimes are bone crests and bridges on the walls of the maxillary sinus dividing the sinus into bays and (very rarely) into separate cavities. Sinus size variation is common.

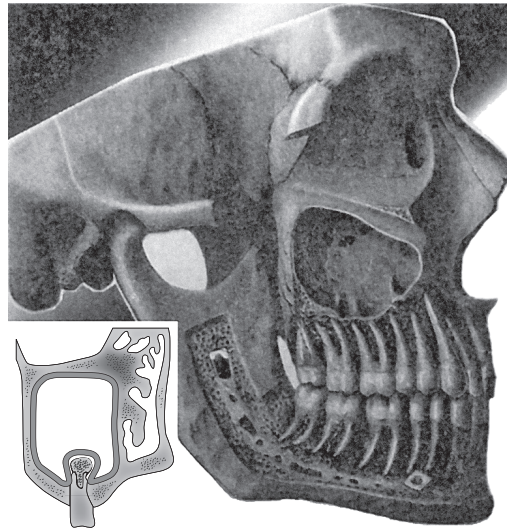

Fig. 3.12. Anatomical position of the maxillary sinus and tooth roots

Ethmoid sinuses (*sinus ethmoidalis*) consist of interconnected cells separated from each other by thin bony plates. The amount, volume, and location of ethmoidal air cells significantly vary, but their average number on each side amounts to 8–10. The ethmoidal labyrinth is represented by a single ethmoid bone bordering with the following sinuses: frontal (on the superior margin), sphenoid (on the posterior margin), and maxillary (on the lateral margin). Laterally the air cells of the ethmoidal labyrinth are adjacent to the lamina papyracea (or orbital lamina). If ethmoidal air cells are present in the orbit (it happens rather frequently), they border with the anterior cranial fossa. In such case the cribriform plate (*lamina cribrosa*) lies below the arch of the ethmoidal air cells, so at the moment the cells dissection one should keep the lateral direction in order to avoid penetration into the cranial cavity through the cribriform plate. Above the inferior nasal concha, the medial wall of the ethmoidal labyrinth is the lateral wall of the nasal cavity.

Depending on the location, the anterior and posterior air cells in the ethmoidal labyrinth are distinguished. The anterior air cells open into the

middle nasal meatus, whereas the posterior air cells open into the superior nasal meatus. The ophthalmic nerve passage is close to the ethmoid sinuses. The topographic anatomy of the ethmoidal labyrinth facilitates involvement of the orbit, cranial cavity, and ophthalmic nerve into a pathologic process.

The frontal sinuses (*sinus frontalis*) are paired and located in the squamous part of the frontal bone. Their configuration and size may vary; on average, the volume of each sinus is 4.7 cm^3; its triangular shape is seen on the sagittal section of the skull. The sinus is limited by four walls. The major part of the inferior (orbital) wall is represented by the superior wall of the orbit; on a small length it borders with the air cells of the ethmoidal labyrinth and with the nasal cavity. The anterior (facial) wall is the thickest (up to 5–8 mm). The posterior (cerebral) wall adjacent to the cranial fossa is thin, but relatively solid, and it consists of a compact bone. In the inferior part, the medial wall (septum of the frontal sinuses) is usually located on the center line and in the superior part it may decline to sides. The anterior and posterior walls join at an acute angle in the superior part. On the inferior wall of the sinus, in front of the septum, there is a foramen of the frontal sinus duct which connects the sinus to the nasal cavity. The length of the duct is about 10–15 and the width is 1–4 mm. It terminates in the anterior part of the semilunar hiatus in the middle nasal meatus. Sometimes the sinuses go laterally creating bays and bridges; sometimes large (over 10 cm^3), but can be absent at all; this shall be taken into consideration when a diagnosis is made.

The sphenoid sinuses (*sinus sphenoidalis*) are paired and located in the body of the sphenoid bone. The size of the sinuses may vary significantly; their volume amounts to 3–4 cm^3. Each sinus is limited by four walls. A septum between the sinuses divides the sinuses into two separate cavities each of which has its own opening leading to the common nasal meatus (sphenoethmoidal pocket). Such location of the connection of the sinus favors the outflow of its secretion to the nasopharynx. The inferior wall of the sinus partly constitutes the nasopharynx arch and partly constitutes the nasal cavity roof. Normally this wall consists of spongy tissue and is rather thick. The superior wall is represented by the inferior surface of the sella turcica; the hypophysis and a part of the frontal lobe of the brain with olfactory gyri are adjacent to it on the top. The posterior wall is the thickest and transfers into the basilar part of the occipital bone. The lateral wall is often thin (1–2 mm), the internal carotid artery and cavernous sinus are adjacent to it; the oculomotor nerve, the first branch of the trigeminal nerve, the fourth cranial nerve, and the sixth cranial nerve pass here.

Blood supply. The paranasal sinuses, as well as the nasal cavity, are supplied with blood from the maxillary artery (branch of the external carotid artery) and ophthalmic artery (branch of the internal carotid artery). The maxillary artery delivers blood mainly to the maxillary sinuses. The frontal sinus is supplied by the maxillary and ophthalmic arteries; the sphenoid sinus is supplied by the pterygopalatine artery and from branches of meningeal arteries. The ethmoidal air cellsare supplied by the lacrimal artery and ethmoidal artery.

The venous system of the sinuses consists of a wide-loop network, especially well developed in the anastomosis area. Venous blood outflows through the nasal cavity veins, but branches of the sinus veins have connections with the orbital veins and cranial cavity veins.

Lymph outflows from the paranasal sinuses mainly through the lymphatic system of the nasal cavity and is directed towards the submandibular and deep cervical lymph nodes.

The paranasal sinuses are innervated by the first and second branches of the trigeminal nerve, as well as from the pterygoid node. From the first branch — the ophthalmic nerve (*n. ophthalmicus*) — the anterior and posterior ethmoidal nerves (*n. ethmoidales anterior et posterior*) arise which innervate the superior levels of the nasal cavity and paranasal sinuses. From the second branch — the maxillary nerve (*n. maxillaris*) — the infraorbital nerve (*n. infraorbitalis*) arise which innervates the middle and inferior levels of the nasal cavity and paranasal sinuses.

3.2. NOSE AND PARANASAL SINUSES CLINICAL PHYSIOLOGY

The nose performs the following physiologic functions:

- respiration;
- olfaction;
- protection;
- speech formation.

Respiratory Function

The respiratory function is the main function of the nose. Normally, all inhaled and exhaled air passes through the nose. At the moment of breathing in, caused by the negative pressure in the thoracic cavity, the air goes to the both halves of the nose. The main air stream goes from bottom to top arch-wise in the common nasal meatus along the middle nasal concha, turns backwards and downwards, and goes to the direction of the choanae. At the moment of breathing in some air goes out from the paranasal sinuses and this helps to

warm up and humidify the inhaled air, as well as favors its partial diffusion into the olfactory region. At the moment of breathing out, the main amount of the air passes at the level of the inferior nasal concha; some air goes to the paranasal sinuses. Arch-shaped path, complex shape, and narrowness of the intranasal passages significantly impede passing of the air stream, and this has physiological importance: the air stream pressure on the mucous membrane participates in the respiratory reflex excitation. In case of mouth breathing, breathing in becomes less deep, which decreases the amount of oxygen entering the human body. In such case the negative pressure in the breast becomes also lowers, which, in its turn, leads to decrease in excursion of the lungs and subsequent hypoxia of the body. In addition to that, the outflow of venous blood from the cranial cavity decreases causing development of multiple pathological processes in brain, nervous system, vascular system, hematopoietic system, and other systems. This is especially dangerous for children.

Protective Function

At the moment of passing through the nose the inhaled air is cleaned, warmed up, and humidified. Moreover, the protective mechanisms include sneezing and discharge of mucus.

As a result of irritation caused by cold air entering the nose, the cavernous vascular spaces experience reflexive expansion and become filled with blood. The volume of the conchae increases, and the nasal passages, respectively, become narrower. In such conditions, the air stream that passes through the nasal cavity becomes finer and touches bigger surface of the mucous membrane, thus warming up more quickly. The lower the temperature of the ambient air is, the more evident the warming effect.

In the nasal cavity, the air is humidified by substance which is produced, as a result of reflex, by mucous glands and goblet cells, made up from lymph and lacrimal fluid. In 24 hours, about 300 ml of water in the form of vapor is exhaled from the nasal cavity of an adult; however, this volume depends on the humidity and temperature of the ambient air, condition of the nose and other factors.

The air is cleaned in the nose in several ways. Big dust particles are mechanically stopped by thick hair in the vestibule of the nose. Smaller particles of dust, which have passed through the first filter, together with microorganisms, deposit on the mucous membrane covered with mucous secretion. The mucus contains lysozyme, lactoferrin, and immunoglobulins, which exhibit antibacterial activity. The narrowness of passages favors precipitation of dust. About 40–60% of dust particles and microorganisms of the inhaled air is stopped in

the nasal mucus and neutralized or removed together with it. Self-cleaning of the respiratory tract, referred to as mucociliary clearance, is performed by ciliated epithelium. The surface of ciliated epithelium cells is covered with multiple cilia performing oscillatory motion.

Each ciliated cell has from fifty to two hundred 5–8 μm long cilia which have a diameter of 0.15–0.30 μm. Each such cilium has its own motion part: the axoneme. The cilia beat at a frequency of 6–8 times per second. The motion activity of the ciliated epithelium cilia provides movement of the nasal secretion including dust particles and microorganisms deposited on it towards the nasopharynx. Extraneous particles, bacteria, and chemical substances, entering the nasal cavity together with the inhaled air stream, stick to the mucus, get broken down by ferments, and absorbed. Only in the very anterior parts of the nose, at the anterior borders of the inferior nasal conchae, the mucus flow is directed toward the entrance of the nose. The total time of the mucus passage from the anterior parts of the nasal cavity to the nasopharynx is 10–20 min. The cilia motion is influenced by such factors as: temperature, exposure to chemical substances, change in acidity (pH), contact between the opposite surfaces of the mucous membrane, pathological processes in the nasal cavity. It is necessary to take into consideration the fact that any instillation of vasoconstrictors or any other nasal drops for a long period of time (over 2 weeks) can, along with curative effect, have negative consequences for the ciliated epithelium function.

Olfactory Function

The olfactory system is a chemical sense organ for which odorous molecules (odorivectors) represent an adequate stimulus. Odorous substances reach the olfactory region together with the air at the moment of breathing in through the nose. The olfactory region (*regio olfactorius*) begins with a 3–4 mm wide olfactory cleft (*rima olfactorius*), which is located between the inferior border of the middle nasal concha and nasal septum and continues upwards up to the roof of the nasal cavity. Diffusion of the air into the olfactory region is needed for odor perception. There are different olfactory theories.

- Chemical theory (Zvaardemaker's theory). Odorous molecules (odorivectors) are absorbed by the liquid that covers cilia of olfactory cells, and, coming into contact with cilia of these cells, they dissolve in the lipoid substance. The excitation arisen is transferred along the neuron chain to the cortical nucleus of the olfactory system.
- Physical theory (Henning's theory). Various groups of olfactory cells are excited in response to oscillations of a particular frequency common to a particular odorivector.

- Physical-and-chemical theory (Muller's theory). The olfactory organ becomes excited thanks to electrochemical energy of odorous substances.

The initial olfactory disturbance can occur when it is associated with damage to receptor cells, pathways, or central parts of the olfactory system; the secondary olfactory disturbance can occur due to any abnormality of the air inflow to the olfactory region. In case of inflammations, polyps on the mucous membrane, and atrophic processes in the nasal cavity, the olfaction suddenly decreases (hyposmia) and, sometimes absolutely disappears (anosmia). In addition, perverted sense of smell (cacosmia) can be encountered.

The paranasal sinuses mainly perform speech foramtion and protective function. Air cells are taking part in Nose and paranasal sinuses formation , so they — together with the pharynx, larynx, and oral cavity — participate in the generation of a personal voice tone, performing the resonance function. Small cavities (ethmoidal air cells, sphenoid sinuses) resonate high pitched sounds, whereas bigger cavities (maxillary and frontal sinuses) resonate low pitched sounds. To a certain extent, the location of the soft palate regulates the resonance through separation of the nasopharynx and, therefore, the nasal cavity, from the middle part of the pharynx and larynx from where the sound goes. Paralysis or absence of the soft palate is accompanied with *rhinolalia aperta;* obturation of the nasopharynx, choanae, or nasal cavity is accompanied with *rhinolalia clausa*.

3.3. EXTERNAL NOSE DISEASES

A good surgeon must have an eagle's eye,
a lion's heart, and a lady's hand.
Avicenna

Clinical presentation of diseases of the external nose is much similar to presentation of skin diseases of any other location. The most frequent diseases of the external nose are presented below including furuncle, erysipelas, sycosis, and thermal injuries, particular aspects of their clinical presentation, diagnostic methods, and treatment.

Abnormal Nose Development

Abnormalities include the organ development defects associated with the presence of pathologic mutant gene in the genotype resulting in embryogenesis disorder.