Anatomy of the nose and paranasal sinuses

The nose and paranasal sinuses are complex structures that play crucial roles in respiration, olfaction, and overall health.

Nasal Anatomy

External nasal anatomy
Nasal bones (weaker) and Frontal Process of the Maxilla (FPM) make up the bony pyramid that supports the external nasal framework. They attach to the facial skeleton and provide attachment for the nasal septum and lateral nasal cartilages. The lateral cartilages, include the upper lateral cartilages (form part of the internal nasal valve), lower lateral cartilages and alar cartilages.

The nasal septum is attached to the bony pyramid at the keystone area and the upper lateral cartilages are attached to the nasal bone and FPM superiorly. The upper and lower lateral cartilages are attached at the scroll area. The scroll area is where the lower border of the ULC and upper border of the LLC meets, and it also forms an important part of the internal nasal valve. The lower lateral cartilages (LLC) have lateral, intermediate and medial portions. The medial aspect of bilateral LLC's join to form the columella. Posterior to this is the fibrous septum devoid of cartilage (and hopefully the site of nasal piercings). Behind this is the nasal septum itself, the most caudal end.

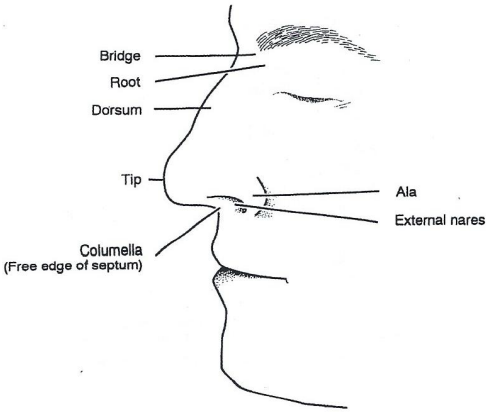
Internal nasal anatomy
This comprises the lateral nasal wall (with its projections), nasal septum and the ethmoidal labyrinth.

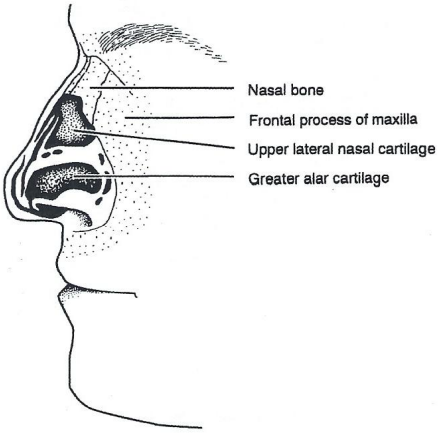
The lateral nasal wall comprises several bones:

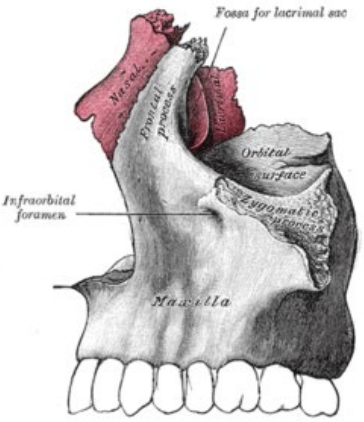
- Maxilla
    - Forms the anterior part of the lateral wall
- Perpendicular plate of the ethmoid bone
    - Contributes to the posterior part
- Lacrimal bone
    - The nasal surface lies posterior to the maxilla and houses the nasolacrimal duct
- Ethmoid bone:
    - Superior and middle turbinate's which project from the lateral nasal wall and increase the surface area for humidification and filtration
    - Uncinate process is a 'sickle' shaped bone that protects the maxillary sinus opening
    - Ethmoidal labyrinth – lateral masses, box-shaped structure between the nasal septum and nasal wall containing the ethmoid sinuses or air cells
    - Lamina papyracea – this forms the medial wall of the orbit separating the eye from the ethmoid sinuses
- Inferior turbinate
    - Is a separate bone projecting from the lateral nasal wall just above the nasal floor
- Medial pterygoid plate
    - Part of the sphenoid bone, part of the posterior part of the lateral nasal wall just anterior to the opening of the Eustachian tube

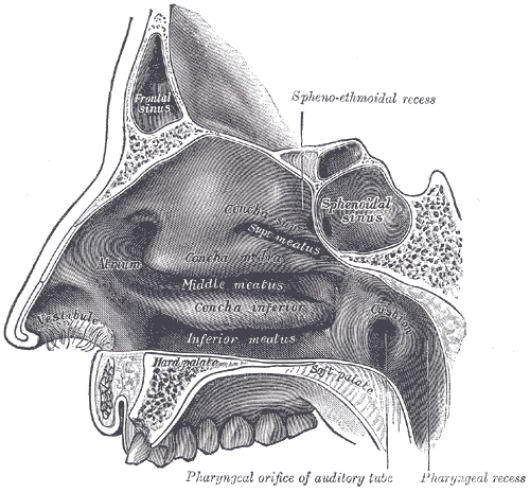
The nasal turbinates project from the lateral nasal wall and create spaces under each of them, namely; inferior meatus, middle meatus and superior meatus into which specific structures drain:

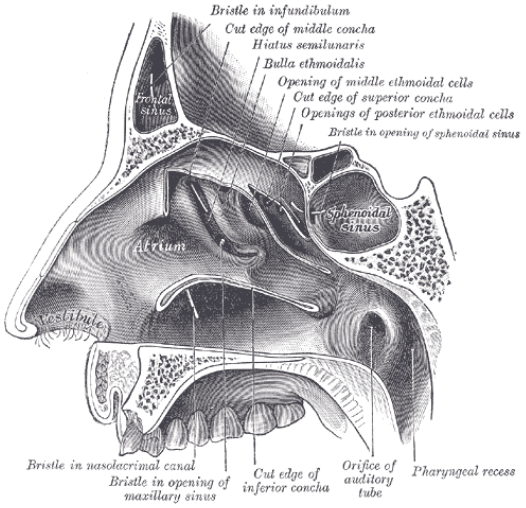
- Lacrimal duct into inferior meatus
- Maxillary sinus (via the hiatus semilunaris), anterior ethmoids and frontal sinus into the middle meatus
- Sphenoid sinus and posterior ethmoids into the superior meatus

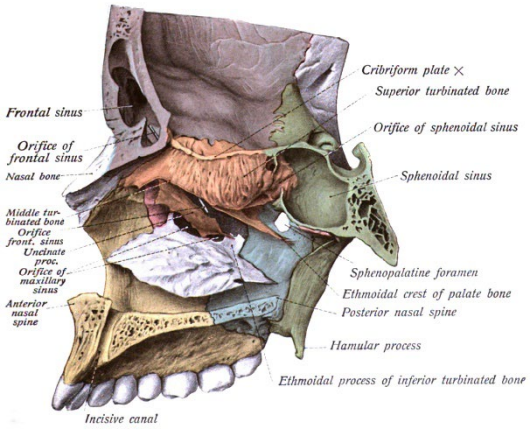


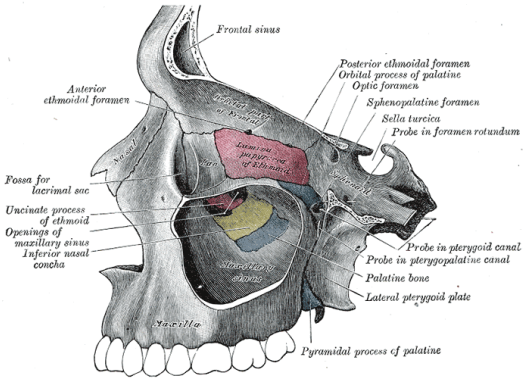












The nasal septal cartilage attaches to the maxillary crest inferiorly and the anterior nasal spine antero-inferiorly. The septum is partly cartilage and partly bone.
Bone:

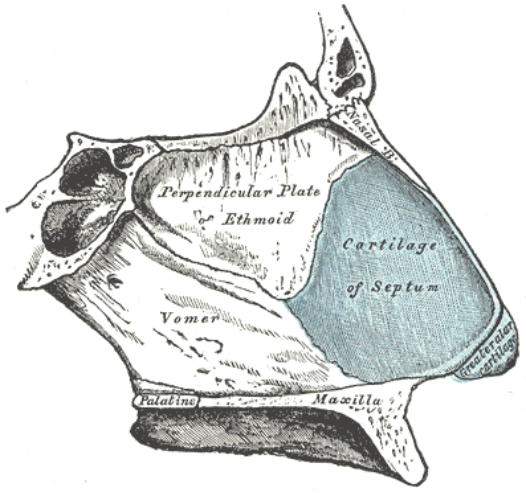
- Perpendicular plate of the ethmoid forms the superior part – attach to sphenoid rostrum posteriorly
- Vomer forms the postero-inferior part - attach to sphenoid rostrum posteriorly

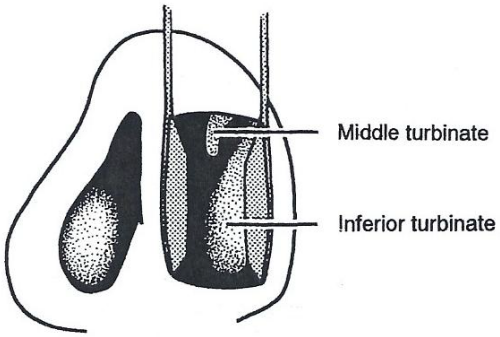
Cartilage:

- Quadrangular cartilage provides support to the anterior septum. It attaches to the bony vomer postero-inferiorly and the bony perpendicular plate of the ethmoid postero-superiorly.

The quadrangular cartilage and the latter two join the sphenoid rostrum posteriorly.

Clinical note:
The septum is derived from two separate embryological elements, the frontonasal process and the palatine process. A dense fibrous layer forms around the septum, namely the perichondrium (over the cartilage) and the periosteum (over the bone). The blood supply to the cartilage runs through this layer and has implications in surgery and trauma. In nasal trauma with septal fracture, vessels may be torn resulting in a **septal haematoma**. If not recognised and managed appropriately the cartilage may undergo ischaemic necrosis (as the blood vessels that supply it are pushed away) with subsequent "Saddle" nose deformity.





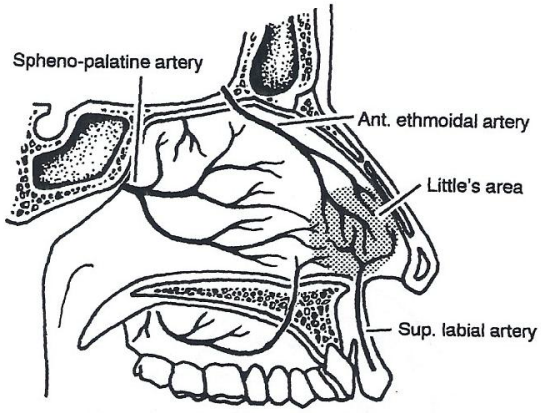
Blood supply
The blood supply to the nose is extensive and includes branches form both the internal carotid and external carotid arteries. The predominant artery involved in primary refractory epistaxis is the sphenopalatine artery, which provides supply to the majority of the lateral nasal wall.

<u>External carotid artery:</u>
Sphenopalatine artery (a branch of the maxillary artery) enters the lateral nasal wall via the sphenopalatine foramen and supplies most of the lateral nasal wall.
Superior labial artery (a branch of facial artery) gives a branch to the nasal septum.
Greater palatine (a branch of descending palatine artery) supplies the nasal septum.

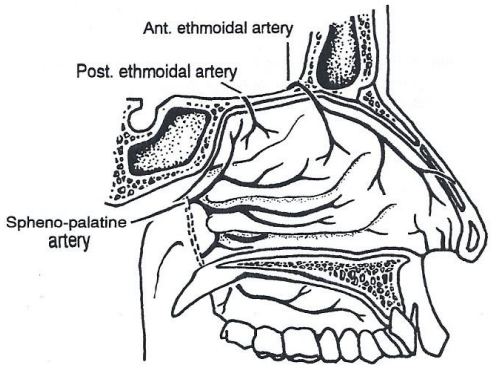
Internal carotid artery:
Anterior and posterior ethmoidal arteries are branches of the ophthalmic artery and supply the superior aspects of the nasal cavity (septum, turbinates, lateral nasal wall).

Little's area is an anatomical location over the anterior nasal septum where multiple blood vessels converge at **Kiesselbach's plexus**. Blood vessels that contribute are septal branches of the following:

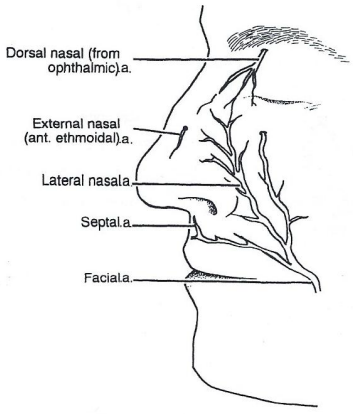
- Anterior ethmoidal artery
- Sphenopalatine artery
- Superior labial artery
- Greater palatine artery



Blood supply of septum – note that the posterior ethmoid and greater palatine arteries are not annotated.

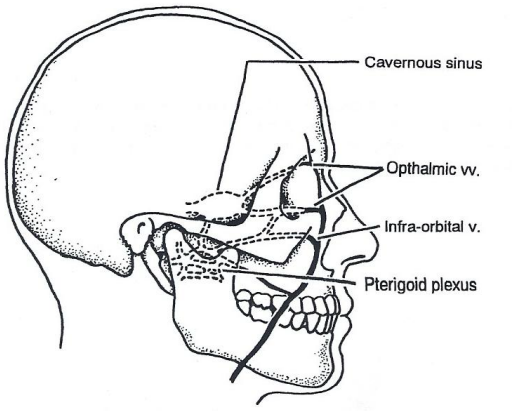


Blood supply to the lateral nasal wall

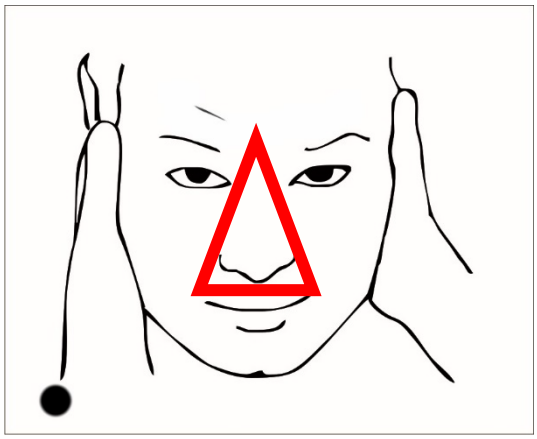


Chief arteries about the external nose

Venous drainage:
Venous drainage can take place to the facial veins or to the intra-cranial cavernous sinus. The reason being the venous connections are devoid of valves. This can have serious implications in infective nasal and sinus conditions, and the area is known as the danger triangle (shown in the picture below as the red triangle).



Connections of the facial veins to the cavernous sinus.



Clinical note:
The anterior ethmoidal artery runs through the roof of the ethmoid sinuses. In cases with significant fronto-nasal trauma that involve the ethmoid sinuses this artery may be injured resulting in significant epistaxis refractory to nasal packing. This requires imaging to identify potential ethmoidal bone and anterior skull base injury and referral as appropriate if epistaxis does not resolve.

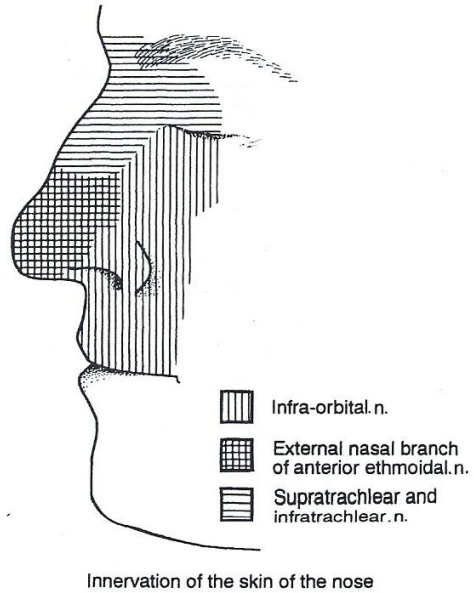
Nerve supply

Several nerves provide innervation for the nasal cavity:

Lateral wall:
- Anterior – anterior ethmoidal and anterior superior alveolar nerves
- Posterior – lateral branch of the sphenopalatine nerve and branches of the greater palatine nerve

Septum:
- Anterior ethmoidal and nasopalatine nerves

Roof:
- Olfactory nerve passes through the cribriform plate and innervates the olfactory mucosa



Innervation of the skin of the nose

Lymphatic drainage

Lymphatic drainage of the nose and paranasal sinuses can be divided into anterior and posterior groups. Anterior sinuses include the frontal, anterior ethmoids and anterior part of the maxillary sinus which all drain to the submandibular nodes.

Posterior sinuses include the posterior ethmoids, sphenoid and posterior maxillary sinus which drain to the retropharyngeal and superior deep cervical nodes. The lateral pharyngeal and retropharyngeal nodes are the main drainage sites for the posterior nasal structures. Lymphatic vessels run through the parapharyngeal space connecting the nasal cavity to these nodes.

Anatomy of the paranasal sinuses

The paranasal sinuses are paired bilateral cavities in the facial skeleton that develop as a result of pneumatisation into this bony framework.

Maxillary sinus
Largest of the paranasal sinuses and located behind the cheeks in the maxilla. Drains via the maxillary sinus ostium through the semilunar hiatus into the middle meatus.
Important related structures include:

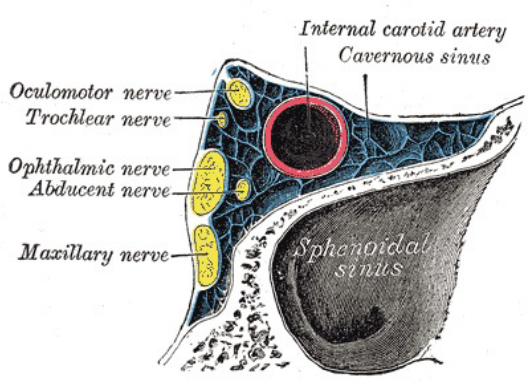
- Orbit and Infraorbital nerve superiorly
- Teeth and oral cavity inferiorly

Frontal sinus
Triangular cavities in the frontal bone which forms the forehead. Drains via the frontal sinus ostium to the frontal recess and then through the ethmoidal infundibulum into the middle meatus.
Important related structures include:

- Frontal lobe of the brain posteriorly
- Orbit inferiorly

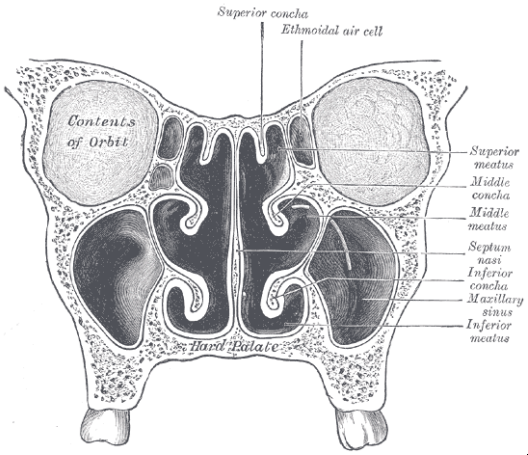
Sphenoid sinus
Most posteriorly located sinus in the sphenoid bone underneath the 'Sella turcica' (Turkish Saddle) in which the pituitary gland lies and the optic chiasm. It drains via the sphenoid sinus ostium into the sphenoethmoidal recess or superior meatus.
Important related structures include:

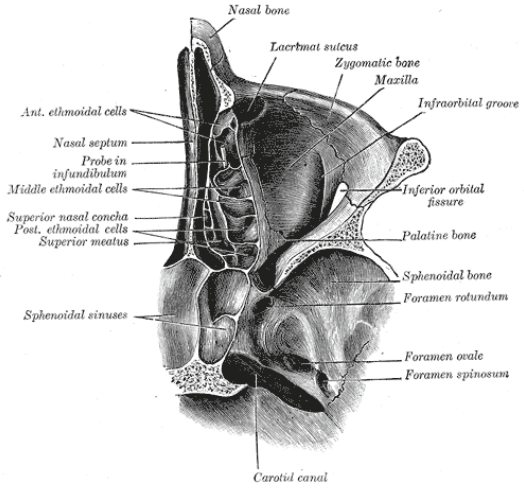
- Internal carotid artery, V2 (maxillary nerve), Cavernous sinus all lateral to it.
- Pituitary fossa above it.



Ethmoid cells (sinus)
A collection of fine air cells located between the orbit and the middle/superior turbinates. Divided into anterior ethmoids drain via the ethmoidal infundibulum into the middle meatus and posterior ethmoids which drain into the superior meatus.
Important related structures include:

- Lamina papyracea (Latin = Paper) and the orbit laterally
- Cribriform plate (anterior skull base) superiorly
- Anterior ethmoidal artery runs through its roof





Physiology of the nose and paranasal sinuses

The nose is a multifunctional organ that plays a crucial role in respiration, air conditioning, olfaction, and vocal resonance. Its functions are essential for maintaining respiratory health and sensory perception.

Respiration
Respiration is an essential function of the nose, especially in newborns who are obligate nasal breathers. The nose serves as the primary pathway for air to enter and exit the lungs. In cases of nasal obstruction, such as choanal atresia, respiratory distress can occur, highlighting the importance of nasal breathing for efficient gas exchange.

The nasal cycle, which involves alternating congestion and decongestion of the nasal mucosa, is influenced by autonomic innervation. Sympathetic stimulation (via superior cervical ganglion) causes vasoconstriction, reducing nasal resistance to increase airflow during active phase. Parasympathetic stimulation (via pterygopalatine ganglion) increases mucous secretion and vasodilation during rest to improve mucosal hydration and defence.

Conditioning of Inspired Air
The nose acts as an air conditioner for the lungs by regulating the temperature, humidity, and cleanliness of the air. This process involves several mechanisms:

- Warming: The nasal mucosa, rich in blood vessels, rapidly warms cold air to near body temperature. This warming process is crucial for maintaining optimal respiratory function.

- Moistening: The mucous membrane in the nasal cavity humidifies the air, ensuring that it is moist and warm by the time it reaches the lungs. This humidification process is essential for preventing dehydration of the respiratory tract.
- Filtration: The nose filters inspired air through several mechanisms:
    - Vestibular Hairs: These small hairs at the entrance of the nose trap large particles, such as dust and pollen.
    - Mucociliary Blanket: A layer of mucus is produced by goblet cells in the pseudostratified epithelium that lines the upper airway. Ciliated cells beat at 700-800 times per minute creating directional flow of mucus towards the nasal cavity and throat. The mucous layer has a gel layer at the bottom and a sol layer on top. This traps and removes finer particles, including pathogens, allergens and debris at a rate of 1-25mm/min (and moves them towards the throat or front of the nose for expulsion). Ciliary beat frequency increases with nitric oxide (NO) or mechanical stimulation and decreases with IL-13 and impaired clearance contributes to rhinosinusitis.
    - Lysozymes (Muramidase): Enzymes in nasal secretions help destroy bacteria and viruses, providing additional protection against infections.
    - Immunoglobulins (IgA and IgM) assist in mucosal immunity.
    - The turbulent airflow in the nose, enhanced by the turbinates, increases contact with the mucosal surfaces, allowing for efficient filtration and conditioning. By the time air reaches the pharynx, its humidity is approximately 75%, and its temperature is around 36°C, with most particulate matter removed.

Olfaction (Smell)

- Olfaction is the sense of smell, mediated by the olfactory epithelium in the nasal cavity. During quiet respiration, about 5-10% of inspired air passes through the olfactory cleft, while during sniffing, this increases to up to 20%.
- Odourants that enter the nose must pass through the olfactory cleft. They must be converted from an air phase to the aqueous phase of the olfactory mucous
- Mucous provides:
    - Moist/protective environment for olfactory neuroepithelium
    - Aids spread (diffusion) of odourants to olfactory receptors.
- The olfactory receptors bind odorant molecules, transmitting signals to the brain for smell perception.
- Retro nasal airflow from the nasopharynx occurs during swallowing which stimulates olfactory receptors adding ‘smell’ to taste.

Voice resonance

- The sinuses amplify and modulate sound during speech to improve vocal quality

Other

- Lightening of the skull – air-filled spaces rather than solid bone
- Facial growth – influence midfacial development
- Shock absorption – cushioning during facial trauma

Additional information

Please also see endoscopic videos of nose:
https://youtu.be/tSJFTdh_hLk; https://youtu.be/6ttFlcb4Ybo