MATRIC NUMER: 17/MHS01/033

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LEVEL: 300L

DEPARTMENT: MEDICINE AND SURGERY

COURSE: GROSS ANATOMY OF THE HEAD AND NECK

COURSE CODE: ANA 301

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ASSIGNMENT TITLE: NOSE AND ORAL CAVITY.

1. Discuss the gross anatomy of the tongue and comment on its applied anatomy.

Answer: The tongue is a unique organ located in the oral cavity that not only facilitates perception of gustatory stimuli but also plays important roles in mastication and deglutition. Additionally, the tongue is an integral component of the speech pathway, as it helps with articulation.

It is a pink, muscular organ located within the oral cavity, that is kept moist by the products of the major and minor salivary glands, which aids the organ as it facilitates deglutition, speech, and gustatory perception.

While there is significant variability in the length of the tongue among individuals, on average, the organ is roughly 10 cm long. It has three main parts:

The **tip or apex** of the tongue is the most anterior, and most mobile aspect of the organ.

The tip is followed by **the body** of the tongue. It has a rough dorsal (superior) surface that abuts the palate and is populated with taste buds and lingual papillae, and a smooth ventral (inferior) surface that is attached to the floor of the oral cavity by the lingual frenulum.

The **base** of the tongue is the most posterior part of the organ. It is populated by numerous lymphoid aggregates known as the lingual tonsils along with foliate papillae along the posterolateral surface.

There are numerous important structures surrounding the tongue. It is limited anteriorly and laterally by the upper and lower rows of teeth. Superiorly, it is bordered by the hard (anterior part) and soft (posterior part) palates. Inferiorly, the root of the tongue is continuous with the mucosa of the floor of the oral cavity; with the sublingual salivary glands and vascular bundles being located below the mucosa of the floor of the oral cavity.

**MUSCLES OF THE TONGUE**

The tongue is chiefly a muscular organ with some amount of fatty and fibrous tissue distributed throughout its substance. All the muscles of the tongue are paired structures, with each copy being found on either side of the median fibrous septum. There are muscles that extend outside of the organ to anchor it to surrounding bony structures, known as extrinsic muscles. The other set of muscles are confined to each half of the organ and contribute to altering the shape of the organ; these are the intrinsic muscles.

***Intrinsic tongue muscles:***

The intrinsic tongue muscles are responsible for adjusting the shape and orientation of the organ. It is made up of four paired muscles, which are discussed below in a dorsoventral manner.

**The superior longitudinal muscles** are made up of a thin layer of muscle fibers traveling in a mixture of oblique and longitudinal axes just deep to the superior mucosal surface of the organ. These fibers arise from the median fibrous septum as well as the fibrous layer of submucosa from the level of the epiglottis. They eventually insert along the lateral and apical margins of the organ. These muscles are responsible for retracting and broadening the tongue, as well as elevating the tip of the tongue. The net effect of these muscles results in shortening of the organ.

Another set of muscles are deep to the superior longitudinal muscles. These are the **vertical** **muscles** that arise from the root of the organ and genioglossus muscle and insert into the median fibrous septum, along the entire length of the organ. These muscles facilitate flattening and widening of the tongue.

Deep to the ventral muscles is the layer of **transverse** **muscles** of the tongue. They take a lateral route, extending from either side of the medial lingual septum (origin) to the fibrous submucosa along the lateral margins of the tongue (insertion). As these muscles contract, they cause the tongue to narrow and elongate.

Finally, the **inferior** **longitudinal** **muscles** travel above the ventral submucosa of the tongue. These fibers travel between hyoglossus and genioglossus as it arises from the base of the tongue and body of the hyoid bone. The fibers end in the apex of the tongue; allowing the muscle to pull the tip of the tongue inferiorly and also shortening the organ.

The intrinsic tongue muscles can operate independently, or in combination with each other to give rise to numerous shapes. This is an important feature of the tongue as it facilitates molding of the food particles into a bolus in preparation for deglutition and speech.

***Extrinsic tongue muscles:***

While the shape of the tongue is determined by the intrinsic muscles of the tongue, movement of the organ within (and out of) the oral cavity is dependent on the extrinsic tongue muscles. There are four pairs of extrinsic muscles, which can be viewed as those arising from above the tongue, and those that originate from below the tongue.

**Styloglossus** and **palatoglossus** are the two muscles arising from above. **Palatoglossus** is anatomically a part of the pharyngeal group of muscles. However, its attachments to the tongue mean that it is also an extrinsic tongue muscle. It originates from the oral part of the aponeurosis of the soft palate. Here, and also at its insertion in the lateral margins of tongue, the muscle is wider than along its middle section.

Its role as an extrinsic tongue muscle is to elevate the dorsal surface of the tongue, and (while working synergistically with the contralateral palatoglossus) to act as a sphincter at the oropharyngeal isthmus.

**Styloglossus** originates from the anterolateral surface of the styloid process. Not only does it contribute to the stylomandibular ligament, but it also assists in retraction of the tongue (moving it posterosuperiorly). It is the smallest and shortest of the three styloid muscles. At the lateral margin of the tongue, the muscle bifurcates into longitudinal and oblique components. The former pierces the tongue on the dorsolateral aspect and integrates with the inferior longitudinal muscle; while the latter crosses over and decussates with hyoglossus.

**Genioglossus** and **hyoglossus** arise from **below**. **Genioglossus** originates from a slender tendon that is attached to the superior genial tubercle found on the inner surface of the symphysis menti. This attachment prevents the tongue from falling backward and obstructing the airway when an individual is supine. The lower fibers of the muscle also have indirect attachments to the anterior part of the body of the hyoid bone via its slender aponeurosis. It is a triangular, midline structure that travels posterosuperiorly at which point the upper fibers of the muscle interdigitate with the intrinsic muscles, before attaching along the length of the inferior surface of the tongue (extending from the root to the tip).

**Hyoglossus** originates from the entire greater cornu of the hyoid bone as a slender, quadrilateral muscle. It is often accompanied by chondroglossus (may be considered as part of the hyoglossus), which arises from the base of the lesser cornu of the hyoid bone. Hyoglossus takes a vertical course cranially, where it pierces the inferolateral margins of the tongue and subsequently blends between the inferior longitudinal muscles and the styloglossus.

The extrinsic muscles play an important role in pressing and molding the food bolus in preparation for the initial phase of swallowing. Additionally, they are used to move the bolus posteriorly into the oropharyngeal inlet. Furthermore, the action of palatoglossus closes off the oropharyngeal isthmus in order to prevent food from moving cranially during swallowing. Although some of these muscles are able to act in isolation, it is the combined effect of all the intrinsic and extrinsic muscles that allows the tongue to have significant flexibility.

**Histology**

The lingual mucosa is covered by stratified squamous epithelium with varying degrees of keratinization. Since the dorsal surface of the oral tongue is more at risk for desiccation and abrasions from contact with food boluses of varying temperatures and textures, it is covered by epithelium that is keratinized. However, the ventral surface of the tongue as well as the pharyngeal part, are relatively well protected from the harsh environment. Therefore, the epithelia in these areas are non-keratinized. The epithelium is adherent to the underlying striated muscle fibers of the tongue. There is a fibrous raphe in the midline of the tongue that marks the point of fusion of the embryonic lateral lingual swellings. Posteriorly, there is a variable amount of adipose tissue within the pharyngeal tongue.

The dorsal mucosa of the oral tongue is characterized by numerous raised structures known as **lingual** **papillae**. They give the characteristic rough appearance of the dorsal surface that is not appreciated on the ventral surface of the tongue. The pharyngeal tongue also has raised dome-like structures throughout the mucosa. However, these are lymphatic aggregates (i.e. lingual tonsils) and should not be confused with papillae.

***The lingual papillae:***

There are four types of lingual papillae found on the surface of the human tongue;

**Filiform** **papillae**: they are the most abundant of the four types of papillae. They are stretched, conical, grey-white papillae that are covered in a heavy coat of keratinized squamous epithelium. By making the dorsal surface of the tongue rough, these papillae provide friction to allow movement of the food bolus during chewing. It should be noted that these papillae do not possess taste buds.

**Fungiform** **papillae:** they are weakly keratinized and less abundant than the filiform papillae. However, they are scattered across the entire dorsal surface of the tongue. These highly vascular, mushroom-shaped papillae contain a few taste buds on the apical aspect.

**Foliate** **papillae**: they appear as bilaterally paired, parallel, longitudinal slits on the posterolateral margin of the tongue, near the sulcus terminalis. The mucosa is non-keratinized and the papillae are populated with numerous taste buds.

**Circumvallate** (**Vallate**) **:** they are organized linearly, as a set of four to six large papillae anterior to each limb of the sulcus terminalis (i.e. eight to twelve papillae in total). In longitudinal section, the characteristic furrow found within the papillae can be appreciated. These moats facilitate the drainage of serous salivary von Ebner glands that empty into the structure. The persistent lubrication creates a favorable environment for gustatory particles to dissolve so that they can be detected by the taste buds.

**The taste buds**

While taste buds are distributed throughout the entire oral cavity, they are at higher concentrations on the tongue. Each taste bud is clear, oval and covered by stratified squamous epithelium. A combination of elongated taste (gustatory), supportive, and basal stem cells can be found within each taste bud. The gustatory cells have an apical taste pore surrounded by numerous microvilli that binds dissolved molecules and brings them closer to the receptors responsible for taste. However, these cells have a relatively high turnover rate, as their shelf life is roughly seven to ten days. It is also called Caliculi gustatorii.

There are five gustatory sensations that are perceived by individuals. These are sweet, salty, sour, bitter, and umami. The microvilli found on the apical surface of the taste cells are equipped with various receptors that bind to varying molecules. The reaction generated from this compound-receptor interaction gives rise to varying action potentials that are subsequently perceived as taste. **Saltiness** is often associated with the cationic component of a compound (i.e. sodium ions), while **sourness** is related to the acidity (concentration of hydrogen ions) in the compound. Organic compounds such as carbohydrates or amino acids give rise to **sweet** taste, while **bitterness** is associated with long-chain organic compounds. The final taste - **umami** - also known as savory, is related to compounds with the left-handed chiral isomer of glutamic acid.

**Blood supply and lymphatic drainage of the tongue.**

***Arteries:***

The vascular supply to the tongue muscles is provided by derivatives of the **lingual** **artery**. This is a branch of the external carotid artery that traverses the region between the middle pharyngeal constrictor and hyoglossus in order to access the floor of the mouth. It takes a sharp superior turn at the anterior border of hyoglossus as it travels alongside CN IX. Of note, the tongue has good collateral supply as the lingual artery also anastomosis with the contralateral vessel. The named branches of the lingual artery are as follows:

The dorsal lingual arteries are relatively small derivatives of the lingual artery that arise medial to hyoglossus. In addition to supplying the dorsal mucosa of the tongue, it also gives branches to the palatoglossus, soft palate, palatine tonsils, and epiglottis.

Emerging at the anterior limit of the hyoglossus, the sublingual arteries course between the mylohyoid and genioglossus as it travels towards the sublingual glands in the floor of the oral cavity. As it arborizes, one of its branches anastomoses with the submental branches of the facial artery, while another traverses the gingiva of the mandible to anastomose with the analogous contralateral vessel.

As the lingual artery terminates near the lingual frenulum on the ventral surface of the tongue, it is referred to as the deep lingual artery.

The lingual artery is supported by other branches of the external carotid artery. The facial artery gives off the ascending palatine and tonsillar arteries that also supply the tongue. The ascending pharyngeal branch of the external carotid artery also supplies the organ.

***Veins:***

The veins of the tongue are named similarly to the arteries that they accompany. They are formed from numerous venous tributaries that eventually coalesce. As the deep lingual vein forms adjacent to the apex of the tongue, it courses along the ventral surface of the tongue (deep to the mucosa). As the deep lingual vein anastomosis with the sublingual vein, they become the vena comitans of CN XII. This venous network eventually drains to the lingual vein that later join the facial or the anterior division of the retromandibular veins. Here, they form the common facial vein, which is a tributary to the internal jugular vein. Alternatively, the venae comitantes may drain directly to the internal jugular vein.

The dorsal lingual veins are responsible for draining the lateral margins and dorsal surface of the tongue. They travel alongside the similarly named artery as they drain into the internal jugular vein.

***Lymphatic drainage:***

When discussing the lymphatic drainage of the tongue, it helps to group them according to the region of the tongue that they drain. The marginal and central groups drain the anterior parts of the tongue, while the dorsal group drains lymph from the posterior third of the organ. It is not uncommon to see the central area of the tongue draining to both marginal and dorsal groups of lymph vessels.

The marginal lymph vessels will carry lymph to the submandibular nodes or to the jugulo-omohyoid nodes. It is not uncommon to see lymph vessels decussating to drain to contralateral lymph nodes. The vessels from the central region may go to the deep cervical nodes, with a particular preference for the jugulo-omohyoid or jugulodigastric nodes. The dorsal group of vessels also pass laterally on either side to eventually join the marginal vessels in their course to the jugulo-omohyoid and jugulodigastric vessels.

**Innervation**

The tongue has multiple sources of innervation based on its embryological origins. The nerve supply to the tongue can be grouped based as efferent fibers that carry motor impulses, general sensory that conveys touch and proprioception, and special afferent that conveys gustatory impulses.

***Motor innervation***

The muscles of the tongue arise from occipital myotomes that migrated to the floor of the pharyngeal apparatus during development. These primitive myocytes took the fibers of CN XII along with them during their journey. As a result, CN XII provides motor innervation to all the muscles of the tongue, except palatoglossus. As CN XII pierces the ventrolateral part of the pharyngeal tongue, it gives a branch to the geniohyoid muscle. Subsequently, it bifurcates into medial and lateral branches. The medial branch innervates the posterior part of the transverse and vertical muscles, as well as the medial part of the inferior longitudinal muscle, and the entire genioglossus. The lateral branch of CN XII innervates the lateral part of the inferior longitudinal, superior longitudinal, hyoglossus and styloglossus muscles.

***Tactile sensory innervation***

The lingual nerve is a branch of CN V3. It is responsible for conveying general somatic afferent impulses from the anterior two-thirds of the tongue. Additionally, it also carries sensory information from the oral mucosa beneath the ventral surface of the tongue as well as the gingival mucosa of the lingual side of the mandible. General afferent impulses from the circumvallate papillae, along with the posterior third of the tongue are carried by fibers of CN IX.

***Taste innervation***

There are three cranial nerves responsible for conveying taste sensation from the tongue to the brain. These are CN VII, CN IX, and (to a lesser extent) CN X. The region of the tongue covered by each nerve is dependent on the proximity of the developing taste bud (and lingual papilla) to the free nerve ending. CN VII mitigates special sensory signals from the anterior two-thirds of the tongue, as well as from the inferior part of the soft palate.

Fibers of the chorda tympani travel by means of the lingual nerve to detect impulses from the sulcal tongue. The postsulcal tongue, circumvallate papillae, palatoglossal arches, and oropharynx are governed by CN IX. CN X only provides supply to taste buds in the extreme areas of the pharyngeal tongue. These impulses are conveyed by the internal laryngeal branch of the vagus nerve.

***Clinical Significance:***

A particular pharyngeal arch defect, known as Pierre Robin Syndrome, causes glossoptosis among other symptoms. This particular defect causes the tongue to be displaced posteriorly and may cause airway obstruction or apnea.

1. Write an essay on the air sinuses.

Answer: the air sinuses, otherwise known as paranasal sinuses, are extensions of the respiratory part of the nasal cavity that are filled with air.

There are four paired sinuses and each of them is named according to the bone in which they are located; maxillary bone, frontal bone, sphenoid bone and ethmoid bone.

Although the full functions of the paranasal sinuses are not known,

1. It is thought that they may contribute to the humidifying of inspired air.
2. They also aid in reducing the weight of the skull.
3. Improve our voices.
4. The mucus they produce protects the nose from pollutants, microorganisms, dirt etc.

Sinuses are formed in childhood by the nasal cavity eroding into surrounding bone. As they are outgrowths of the nasal cavity, they all drain back into it – openings to the paranasal sinuses are found on the roof and lateral walls of the nasal cavity. The inner surface is lined by a respiratory mucosa.

**THE AIR SINUSES**

***Frontal Sinuses:*** These are the most superior in location, found between the outer and inner tables of the frontal bones, posterior to the superciliary arches and the root of the nose. They are divided into right and left.  
 The right and left sinuses are variable in size, also, the septum between them isn’t always situated in the median plane but is always triangular-shaped.

They drain into the nasal cavity via the frontonasal duct, which opens out at the hiatus semilunaris of the middle nasal meatus on the lateral wall.

They are innervated by branches of the supra-orbital nerves (CN V1).

***Sphenoid Sinuses:*** The sphenoid sinuses also lie relatively superiorly, at the level of the spheno-ethmodial recess. They are found more posteriorly, and are related superiorly and laterally to the cranial cavity. The sphenoid sinuses drain out onto the roof of the nasal cavity. The relationships of this sinus are of clinical importance – the pituitary gland can be surgically accessed via passing through the nasal roof, into the sphenoid sinus and through the sphenoid bone. They can be multiple.

***Ethmoidal Sinuses***: They are also called ethmoidal cells. They are small invaginations of the mucous membrane of the middle and superior nasal meatus, into the ethmoid bone between the nasal cavity and orbit. They aren’t visible before a child is 2 years old, but they can be seen in CT scans.

There are three ethmoidal sinuses; anterior, middle and posterior. They empty into the nasal cavity at different places:

*Anterior Ethmoidal Cells* – empties into the hiatus semilunaris or the middle nasal meatus, through the ethmoidal infundibulum.

*Middle Ethmoidal Cells* – empties directly into the middle nasal meatus. Forms the ethmoid bulla for which it is named bullar cells.

*Posterior Ethmoidal Cells*– opens directly into the superior meatus.

***Maxillary Sinuses***: The largest of the sinuses. They occupy the body of the maxillae and communicate with the middle nasal meatus. It is located laterally and slightly inferiorly to the nasal cavities. It drains by the maxillary ostium into the middle nasal meatus of the nasal cavity by way of the semilunar hiatus.

**Clinical Significance:**

***Sinusitis***:

As the paranasal sinuses are continuous with the nasal cavity, an upper respiratory tract infection can spread to the sinuses. Infection of the sinuses causes inflammation (particularly pain and swelling) of the mucosa, and is known as sinusitis. If more than one sinus is affected, it is called pansinusitis.

***Inflammation***:

The maxillary nerve supplies both the maxillary sinus and maxillary teeth, and so inflammation of that sinus can present with toothache.