Basic Anatomy of the Oral Cavity

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Chapter I

Learning outcomes:
- State and explain the functions of the oral cavity
- State the most important nerves in the oral cavity
- Explain the innervation of the oral cavity
- State the most important blood vessels in the oral cavity
- Explain the vascularisation of the oral cavity
- Distinguish phases in jaw growth and development
- Describe the characteristics of dental arches
- Specify the parts of the jawbone
- Explain the Haversian canal system
- Explain the alveolar bone proper
- Explain the supporting alveolar bone
- Explain the trabecular bone
- Recognise basic structures on radiographic images of the maxilla and mandible
Chapter 1 Basic Anatomy of the Oral Cavity

The oral cavity (cavum oris) is the initial part of the digestive system and has a digestive, phonative, sensory, protective, respiratory, and social function. The digestive function includes mastication, saliva secretion, preparing bolus for deglutition, and deglutition in itself. The phonation includes the creation and articulation of sounds in conjunction with other speech organs. The sensory function of the oral cavity refers to sensations of taste, smell, touch, pain, and thermal changes. The protective function is primarily linked to the oral mucosa which mechanically protects deeper oral tissues, and to saliva which contains certain antimicrobial substances. During strenuous physical work, when there is an increased need for air or in case of nasal airway obstruction, the oral cavity assumes a respiratory function. The social function of the oral cavity is realised not only through speech (phonative function) but also through facial expressions and social contacts such as kissing.

The oral cavity is divided into the oral vestibule and the oral cavity proper (cavum oris proprium). The oral cavity proper is also referred to as the oral cavity in the narrower sense. The entrance to the oral cavity is referred to as oral fissure (rima oris) and is bounded by the lips. Posteriorly, the oral cavity terminates at the entrance to the pharynx. The cheeks constitute the lateral walls of the oral cavity. Anteriorly and laterally, the oral cavity proper is bounded by the U-shaped maxillary and mandibular dental arches. While the hard and soft palate constitute the roof of the oral cavity proper, the so-called diaphragma oris formed by both mylohyoid muscles, the anterior belly of the two-bellied (digastric) muscles, and the geniohyoid and genioglossus muscles, together with parts of the tongue, constitute the floor of the oral cavity. The tongue constitutes most of the oral cavity proper (Figures 1.1 and 1.2). The mucosa of the oral cavity is relatively thick and consists of a multi-layered squamous epithelium and connective tissue; it is richly supplied with blood vessels. The colour of the oral mucosa varies from light to dark pink. It is continuous with the skin of the lips and the mucosa of the soft palate and pharynx. The palate (palatum) constitutes the roof of the oral cavity and comprises a hard palate (anterior part) and a soft palate (posterior part). A longitudinal suture runs along the middle of the hard palate connecting the left and right parts of the upper jaw (maxilla). Shallow transverse palatine folds (rugae palatinae) can be found on the mucosa of the anterior part of the hard palate behind the incisors. The soft palate is composed of a musculotendinous plate which is covered on the underside by the oral mucosa and by the nasal mucosa superiorly. The tongue (lingua) is a muscular organ which is covered with oral mucosa and is involved in mastication, deglut-
tition, drinking, speech, and the perception of taste. Anatomically, the tongue is divided into three parts, namely, the root, the dorsum, and the apex. It is composed of seven muscles which extend perpendicular to its surface and are transverse and parallel to its longitudinal axis.

The mucosa of the dorsum of the tongue is permeated by numerous visible protrusions, referred to as lingual papillae; they play a role in mechanical, tactile, or gustatory recognition, which is important for mixing food. The lips (labia oris) are composed of muscles and connective tissue. They are richly supplied with blood vessels and nerves. The red part of the lip is covered by mucosa which constitutes the transition between the skin of the face and oral mucosa. The salivary glands in the oral cavity are divided into major and minor salivary glands. The labial mucosa contains minor salivary glands the size of pin heads. The largest part of the total saliva volume is secreted by the major salivary glands. The parotid gland (glandula parotis), the submandibular gland (glandula submandibularis), and the sublingual gland (glandula sublingualis) are the major salivary glands. As opposed to the minor salivary glands, the major salivary glands exist in pairs. The minor salivary glands are found in the cheeks, lips, tongue, palate, tonsils, and pharynx.

**Innervation of the oral cavity**

The oral cavity and the organs contained therein are innervated by several cranial nerves with their sensory and motor fibres, which are the following: *nervus trigeminus* (fifth cranial nerve), *nervus facialis* (seventh cranial nerve), *nervus glossopharyngeus* (ninth cranial nerve), and *nervus vagus* (tenth cranial nerve).

The trigeminal nerve (*nervus trigeminus*) is a nerve of the first pharyngeal arch which consists of a sensory and a motor part and innervates the masticatory muscles and some pharyngeal and supralingual muscles. It transmits general sensory information from the face and a large part of the forehead, teeth, lips, and the nasal cavity. The main branches of the trigeminal nerve are the ophthalmic nerve (*nervus ophtalmicus*), the maxillary nerve (*nervus maxillaris*), and the mandibular nerve (*nervus mandibularis*).
Chapter 1 Basic Anatomy of the Oral Cavity

The ophthalmic nerve innervates the eye-balls, sockets, frontal sinuses, nose, forehead, and the vertex. It is the first and smallest branch of the trigeminal nerve and contains only sensory nerve fibres. The branches of the ophthalmic nerve are as follows:

- the lacrimal nerve (*nervus lacrimalis*), which innervates the sockets, the skin of the upper eyelids and receives anastomoses from the post-ganglionic fibres of the pterygopalatine ganglion via the zygomatic nerve
- the frontal nerve (*nervus frontalis*), which innervates the forehead and vertex
- the nasociliary nerve (*nervus nasociliaris*), which innervates the eyeballs, the ethmoidal chambers, the nose, and the skin of the nasal bridge and the tip

The maxillary nerve is the second branch of the trigeminal nerve, which has purely sensory fibres which innervate the cheeks, lower eyelids, the lateral sides of the nose, the upper lip, teeth, the maxillary mucosa, the inlet of the sphenoid bone, the maxillary sinuses, the posterior ethmoidal chambers, the superior and middle nasal conchae, the palate and palatine tonsils, the roof of the pharynx, and the dura mater of the middle cranial fossa. The branches of the maxillary nerve are as follows:

- the posterior superior alveolar nerve (*nervus alveolaris superior posterior*), which innervates the maxillary molars and the maxillary sinuses
- the zygomatic nerve (*nervus zygomaticus*), which innervates the skin of the temples and the cheeks
- the pharyngeal nerve (*nervus pharyngeus*), which innervates the mucosa of the nasal part of the pharynx behind the auditory tube
- the greater palatine nerve (*nervus palatinus major*), which innervates the hard palate up to the incisive foramina

- the lesser palatine nerve (*nervus palatinus minor*), which innervates the soft palate
- the nasopalatine nerve (*nervus nasopalatinus*), which innervates the nose and the palatine gingiva of maxillary anterior teeth
- the middle superior alveolar nerve (*nervus alveolaris superior medius*), which innervates the maxillary sinuses and the maxillary premolars
- the anterior superior alveolar nerve (*nervus alveolaris superior anterior*), which innervates the maxillary anterior teeth
- the infraorbital nerve (*nervus infraorbitalis*), which innervates the skin on the front part of the cheeks, the lower eyelids, the lateral nasal surfaces, the upper lip, and the upper labial mucosa

The mandibular nerve is the third and the largest branch of the trigeminal nerve. It provides sensory innervation to the mandibular teeth and gingiva, the skin of the temples, a part of the ear, the lower lip, the lower part of the face, the anterior two-thirds of the tongue, and the mucosa of the oral cavity floor. It provides motor innervation to the masticatory muscles and the other muscles which develop from the first pharyngeal arch. The branches of the mandibular nerve are as follows:

- the buccal nerve (*nervus buccalis*), which innervates the mucosa and skin of the cheeks
- the lingual nerve (*nervus lingualis*), which innervates the floor of the oral cavity and the anterior two-thirds of the tongue
- the inferior alveolar nerve (*nervus alveolaris inferior*), which innervates all the mandibular teeth and the mandibular gingiva
- the mylohyoid nerve (*nervus mylohyoideus*), which innervates the mylohyoid muscle and the anterior belly of the digastric muscle
the mental nerve (nervus mentalis), which innervates the skin of the chin, the labial area, and the labial gingiva

the auriculotemporal nerve (nervus auriculotemporalis), which innervates the parotid gland and the temporomandibular joint

The facial nerve (nervus facialis) is a mixed cranial nerve which contains motor, gustatory, and parasympathetic fibres. It innervates the mimic muscles and transmits gustatory stimuli from the anterior two-thirds of the tongue. It supplies certain cranial and cervical ganglia with its preganglionic parasympathetic fibres.

The glossopharyngeal nerve (nervus glossopharyngeus) is a mixed cranial nerve which innervates the muscles of the soft palate and pharynx, the pharyngeal mucosa, the palatine arches, and the parotid salivary gland.

The vagus nerve (nervus vagus) is the longest cranial nerve with the most extensive distribution. It is comprised of mixed nerve fibres and provides innervation to the head, neck, chest cavity, and parts of the abdominal cavity.

Vascularisation of the oral cavity

The oral cavity is well supplied with blood vessels. It is therefore vital to be aware of its vascularisation for performing safe clinical work. The common carotid artery (arteria carotis communis), which is a branch of the brachiocephalic trunk, supplies arterial blood to the cranial and cervical organs. It bifurcates at the level of the larynx into the external (arteria carotis externa) and internal carotid arteries (arteria carotis interna). The external carotid artery supplies blood to all the cranial and cervical organs except for the brain, the eyes, and the inner ears, while the internal carotid artery supplies blood to the orbits, the anterior part of the nasal cavity, and the anterior two-thirds of the cerebrum. As opposed to the internal carotid artery which has no branches in the cervical area, the external carotid artery has several branches. The anterior branches of the external carotid artery include the arteria thyroidea superior (for the thyroid gland and larynx), the arteria lingualis (for the tongue and floor of the oral cavity), and the arteria facialis (for the submandibular salivary gland, the submental area, and the face). The middle branch of the external carotid artery is the arteria pharyngea ascendens, which supplies the pharynx. The posterior branches of the external carotid artery are the arteria occipitalis (for the occiput area) and the arteria auricularis posterior (for the area behind the ears). The external carotid artery terminates by splitting into the arteria maxillaris and the arteria temporalis superficialis. The most important arteries involved in the vascularisation of the oral cavity per se are the arteria lingualis, arteria facialis, and arteria maxillaris.

The lingual artery (arteria lingualis) splits into three parts:

the sublingual artery (arteria sublingualis)—a branch of the lingual artery which supplies the floor of the oral cavity and the sublingual salivary glands

the dorsal lingual artery (arteria dorsalis linguae)—a branch of the lingual artery which supplies the deep posterior parts of the tongue

the deep lingual artery (arteria profunda linguae)—the terminal branch of the lingual artery which branches out to supply the lingual muscles

The facial artery (arteria facialis) supplies the mimic muscles, the palatine tonsils, the palate, the submandibular salivary gland, and the lower and upper lips. The ascending palatine artery (arteria palatina ascendens) is a lateral branch of the facial artery which supplies the soft palate and the pharynx.
Chapter 1 Basic Anatomy of the Oral Cavity

The maxillary artery (arteria maxillaris) is the first terminal branch of the external carotid artery which supplies the external cerebral membrane, the mandibular teeth, the masticatory muscles and the temporomandibular joint, the external acoustic meatus and the tympanum, the palate, the maxillary teeth, and the nasal cavity. The maxillary artery branches extensively into the infratemporal and pterygopalatine fossae. Its most significant branches in the oral cavity are as follows:

- The inferior alveolar artery (arteria alveolaris inferior) – a branch which supplies blood to the mandibular teeth
- The posterior superior alveolar artery (arteria alveolaris superior posterior) – a branch which supplies blood to the maxillary molars and premolars
- The descending palatine artery (arteria palatina descendens) – a branch which supplies blood to the hard palate
- The greater palatine artery (arteria palatina major) – a branch of the descending palatine artery which supplies blood to the hard palate

The veins of the oral cavity generally follow the arteries and bear similar names. Veins in the palatal area drain into the pterygoid venous plexus, while the lingual veins drain into the internal jugular vein. Maxillary veins (venae maxillares) drain the pterygoid venous plexus.

Lymph from the upper lip, teeth, lateral parts of the anterior part of the tongue, and the gingiva drains into submandibular lymph nodes. Lymph from the lower lip and the apex of the tongue drains into submental lymph nodes. Lymph from the central and anterior part of the tongue drains into deep lower cervical lymph nodes, while lymph from the posterior part of the tongue drains into deep upper cervical lymph nodes. Parotid glands drain the lymph into the superficial and deep cervical lymph nodes; lymph from the submandibular glands drains into the deep cervical lymph nodes.

Dental arches and the alveolar bone

Teeth are placed in dental alveoli, which are arranged in the maxillary and mandibular dental arches. The shape and size of dental arches change with jaw growth and development. The jaws grow and develop in several stages:

- prenatal stage
- predental stage
- stage of deciduous teeth
- mixed dentition stage
- stage of permanent teeth

The prenatal stage in jaw growth and development takes place during intrauterine life, when a maxillary prognathism (the anterior part of the maxillary alveolar process stands out over the mandibular alveolar process) is seen during the first months. Between the second and third months of intrauterine life, embryonic progenia develops (the anterior part of the mandibular alveolar process stands out more than the maxillary alveolar process). Over time, the relationship between the maxilla and mandible changes. Before birth, the mandible once again retracts distally resulting in a prominent maxilla (prognathism) during birth, i.e. with a physiologically distal bite. The predental stage marks the jaw relationship before the appearance of the first deciduous teeth. In this period, the anterior part of the maxillary dental arch is 8 to 10 mm wide and flat, and a so-called incisal plane or plateau is detected. The mandibular dental arch is narrow and steep, which allows for sliding movements and facilitates sucking. The subsequent stage is characterised by the eruption of deciduous teeth and the forward positioning of the mandible. Gaps appear between the
deciduous teeth, which are referred to as physiological diastemata. These diastemata secure space for permanent teeth. Deciduous teeth exfoliate between 5 to 7 years of age which is coincided by the eruption of the first permanent teeth. This marks the beginning of the mixed dentition stage which consists of two phases. In the first phase between the 5 and 9 years of age, the first permanent molars erupt, and deciduous incisors are replaced by permanent ones. In the second phase, which occurs between the age of 9 and 12, the canines and premolars erupt. The second permanent molars erupt between 12 to 14 years of age. With the exfoliation of deciduous teeth, the stage of permanent dentition begins. Permanent dentition is complete with the eruption of third molars, which usually appear at the age of 18 years, although they can erupt earlier or much later.

The dental arches receive their final characteristics with the eruption of the permanent teeth. The characteristics of dental arches with properly positioned teeth (eugnathic dentition) are as follows:

- a wider maxillary dental arch compared to the mandibular arch
- pronounced vestibular overlap of the maxillary teeth
- semi-elliptical shape of the maxillary dental arch and a parabolic mandibular dental arch [Figures 1.3 and 1.4].
occlusion of teeth with two antagonists (except for mandibular central incisors and maxillary third molars)
pronounced anteroposterior occlusal curve (curve of Spee)

The alveolar bone is that part of the maxilla or the mandible which protects and anchors the teeth (Figure 1.5). The alveolar bone is also a part of the periodontium as the periodontal ligament connects it to the cementum. Every mature jawbone (maxilla or mandible) consists of two parts:

- a part which contains the dental roots, i.e. the alveolar bone (synonyms: alveolar process or alveolar ridge) and
- a bony part which is positioned apical to the root, i.e. the basal bone which constitutes the body of the maxilla or mandible.

The alveolar bone consists of cells and a partially calcified matrix composed of approximately 60% inorganic matter. The inorganic matter is embedded in the matrix between the bone cells and primarily consists of calcium hydroxyapatite and components such as magnesium, fluoride, calcium carbonate, and others to a far lesser extent. The calcified matrix consists of collagen fibres and intercellular substance.

During the initial stages of bone formation, the unmineralized calcified bone matrix is referred to as osteoid, which is subjected to mineralisation. It is formed by osteoblasts which are located in the periosteal surface of the bone surface and is 5–10 µm in thickness. Being a layer of newly mineralised matrix, it is comparable to predentine or pre-cementum. The matrix of the compact bone is formed in layers (lamellae) with osteocytes located between the rings of the matrix. The concentric lamellae form the Haversian canal system. The Haversian canal is the central vascular canal containing blood vessels, nerves, and small amounts of connective tissue. The Haversion canal system supplies the bone with nutrients.

The alveolar and basal bones are covered with periosteum. The alveolar bone is divided into the alveolar bone proper and the supporting alveolar bone, and they are composed of:

- fibres
- cells
- intercellular substance
- nerves
- blood vessels
- lymphatic vessels

The alveolar bone proper lines the tooth sockets. Although it is composed of compact bone, it can be considered a cribiform plate because it contains numerous cavities, through which Volkmann’s canals pass from the alveolar bone to periodontal ligament.

The alveolar bone proper consists of compact bone plates which envelop the teeth. The thickness of the alveolar bone proper ranges from 0.1 to 0.5 mm. Sharpey filaments, which are mineralised only in the peripheral parts, are anchored to the alveolar bone proper (at an angle of 90 degrees). On a radiograph, the alveolar bone proper appears as a uniform white line (lamina dura) which follows the outline of the teeth. The integrity of the lamina dura is an important feature to be considered in the analyses of radiographs of teeth and periadicular space; interruptions in the continuity of lamina dura usually indicate pathological changes.

The alveolar ridge is the most cervical part of the alveolar bone (Figure 1.6). In a healthy periodontium, the alveolar ridge lies 1 to 2 mm below the cementoenamel junction. The triangular part of the alveolar ridge between adjacent teeth is referred to as the interdental septum.

The supporting alveolar bone consists of a cortical and trabecular bone. The cortical
bone (or cortical plate) consists of compact bone on the facial and lingual surfaces of the alveolar bone. The cortical bone is usually 1 to 3 mm thicker in relation to the posterior teeth than the anterior teeth. The cortical bone is not visible on periapical or bite-wing radiographs; it is only visible on occlusal radiographs. The trabecular bone consists of spongy bone positioned between the alveolar bone proper and cortical bone plates. Radiographically, the trabecular bone is visible in the areas between the teeth and their roots.

The alveolar bone between two adjacent teeth (interdental septum) consists of the alveolar bone proper and the spongy part of the trabecular bone. The interdental septum is easy to visualise on x-ray images. The alveolar bone between roots of the same tooth is referred to as the interradicular septum.

Radiographic appearance of the maxilla and mandible

Use of radiographic equipment is an integral component of modern dentistry. Many dental procedures which follow modern standards of dentistry are unimaginable without the use of x-ray images. These images are used in pre-operative, operative, and postoperative dental treatment starting from diagnosis and therapy planning, through intraoperative radiographic evaluation, up till postoperative monitoring of the success of the performed procedure. Knowledge of the radiographic appearance of the maxilla and mandible constitutes the basis for analysing and interpreting intraoral and extraoral radiographs.

The differences in the way x-rays pass through different substances are of fundamental significance when recording radiographic images. Since x-rays are absorbed differently in the substances they penetrate, these substances are depicted differently on the images. The lower the absorption of x-rays, the darker the appearance on the image. For this reason, air appears as black areas on radiographs, fatty tissue appears as grey areas, soft tissues in different shades of grey, and mineralised tissues such as bones and metals appear as white areas. During interpretation of radiographs, it should be borne in mind that the structures which are closer to the radiographic film appear to be clearer, while those farther away are less sharp and blurry. Since an x-ray image is a two-dimensional depiction of a three-dimensional object, there occurs overlap of certain structures which can make it more difficult to interpret these images.

The radiographic appearance of a normal maxilla and mandible is depicted and described in Figures 1.7 and 1.8.