Chapter 1

The oral cavity in health

Learning outcomes

By the end of this chapter you should be able to:

1. Describe how the oral cavity, jaws, and face develop *in utero*.
2. Explain the structures and functions of the tissues and fluid of the oral cavity, including teeth, supporting structures, the tongue, and saliva.
3. Distinguish between the different types of cleft lip and cleft palate.
4. List primary and secondary dentition eruption dates.

INTRODUCTION

Before oral health educators (OHEs) can deliver dental health messages to patients and confidently discuss oral care and disease with them, they will need a basic understanding of how the mouth develops *in utero* (in the uterus), the anatomy of the oral cavity (Figures 1.1, 1.2, 1.3, and 1.4), and how the following structures function within it:

- Teeth (including dentition).
- Periodontium (the supporting structure of the tooth).
- Tongue.
- Salivary glands (and saliva).

Basic Guide to Oral Health Education and Promotion, Third Edition.
Alison Chapman and Simon H. Felton.

Companion website: www.wiley.com/go/felton/oralhealth

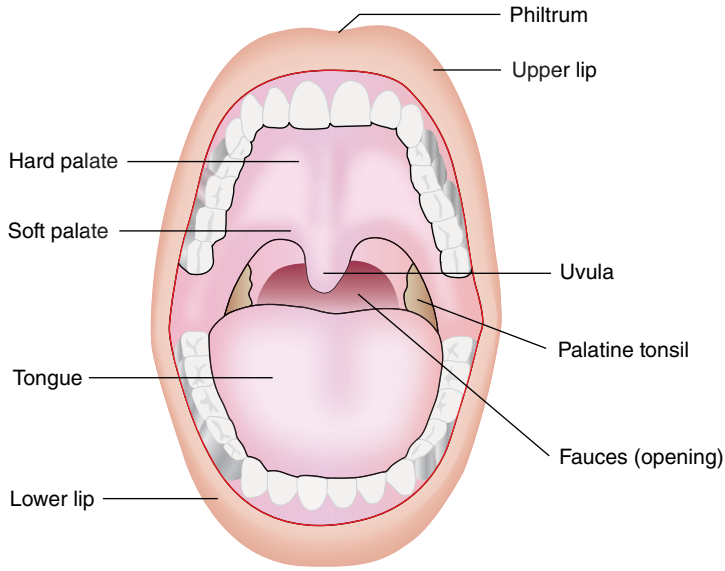

Figure 1.1 Structure of the oral cavity. Source: From [1]. Reproduced with permission of Elsevier.

Figure 1.2 A healthy mouth (white person). Source: [2]. Reproduced with permission of Blackwell.

Figure 1.3 A healthy mouth (black person). Source: Alison Chapman.

Figure 1.4 A healthy mouth (Asian person). Source: Alison Chapman.

ORAL EMBRYOLOGY

A basic understanding of the development of the face, oral cavity, and jaws in the embryo and developing foetus will help enable the OHE to discuss with patients certain oral manifestations of conditions that stem from *in utero* development; notably cleft lip and palate.

An *embryo* describes the growing organism up to 8 weeks *in utero*; a *foetus* describes the growing organism from 8 weeks *in utero*.

Development of the face

At approximately week 4 *in utero* (Figure 1.5), the embryo begins to develop five facial processes (or projections), which eventually form the face, oral cavity, palate, and jaws by week 8 [3]:

- Frontonasal process – forms the forehead, nose, and philtrum (groove in upper lip).
- Maxillary process (two projections) – forms the middle face and upper lip.
- Mandibular process (two projections) – forms the mandible (lower jaw) and lower lip.

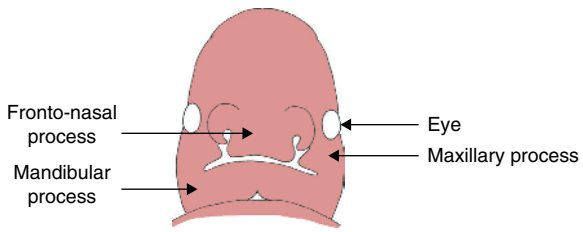

Figure 1.5 Facial development at 4 weeks *in utero*. Source: From [3]. Reproduced with permission of Wiley-Blackwell.

Development of the palate and nasal cavities

Week 5

The frontonasal and maxillary processes begin to form the nose and maxilla (upper jaw). However, if the nasal and maxillary processes fail to fuse, then a cleft will result. This is the most common craniofacial (skull and face) abnormality that babies are born with, and is thought to commonly result from a combination of genetic and environmental factors, or as part of a wider syndrome [4].

A baby can be born with a cleft lip, a cleft palate, or both. Cleft lip and/or palate occurs in 1–2 births out of every 1000 in developed countries [5]. Submucous cleft palate can also occur, which is a cleft in the soft palate and includes a split in the uvula. Surgery to close a gap is often undertaken when a baby is less than a year old.

A cleft lip can be anything from a small notch in the lip (incomplete cleft lip) to a wide gap that runs up to the nostril (complete cleft lip). It can also affect the gum, which, again, can be a small notch or complete separation of the gum.

A cleft lip can be either (Figure 1.6):

- Unilateral – affects one side of the mouth (incomplete or complete).
- Bilateral – affects both sides of the mouth (incomplete or complete).

A cleft palate is a gap in the roof of the mouth. A cleft can affect the soft palate (towards the throat) or the hard palate (towards the lips), or both. Like a cleft lip, a cleft palate can be unilateral or bilateral, and complete or incomplete (Figure 1.6)

Week 6

By week 6, the primary palate and nasal septum have developed. The septum divides the nasal cavity into two.

Week 8

By week 8, the palate is divided into oral and nasal cavities.

Development of the jaws (mandible and maxilla)

Week 6

By week 6, a band of dense fibrous tissue (Meckel's cartilage) forms and provides the structure around which the mandible forms.

Week 7

By week 7, bone develops, outlining the body of the mandible.

As the bone grows backwards two secondary cartilages develop; these eventually become the condyle and coronoid processes.

As the bone grows forward, the two sides are separated by a cartilage called the mandibular symphysis. The two sides will finally fuse into one bone approximately 2 years after birth.

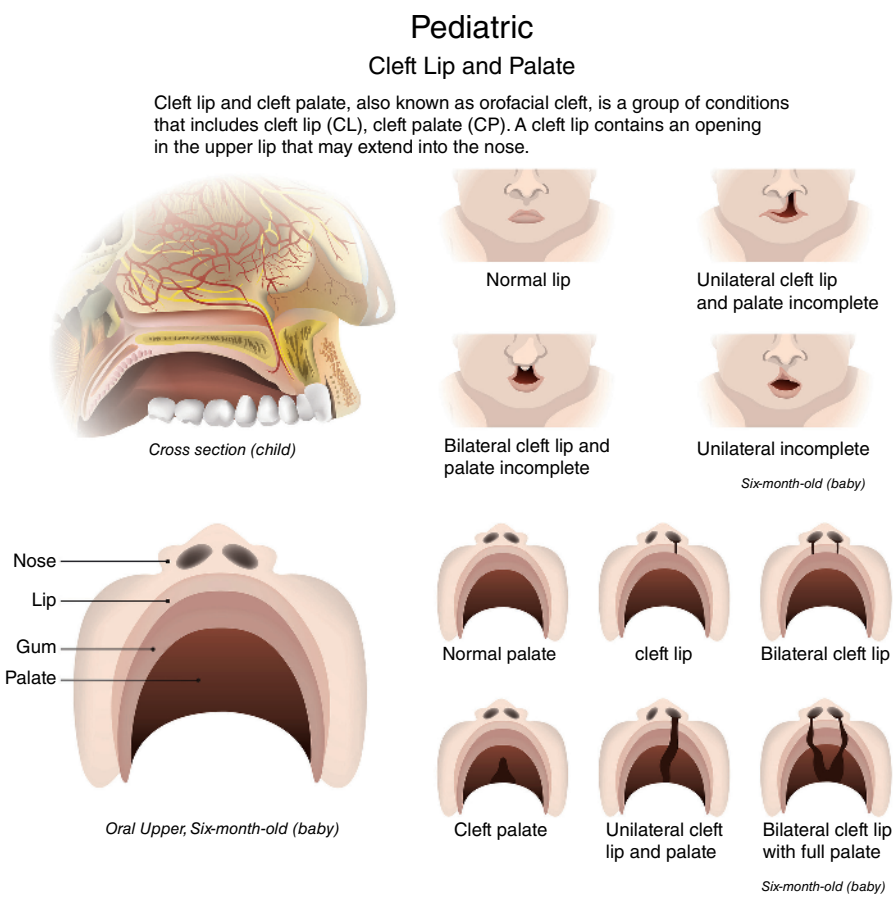

Figure 1.6 Cleft lip and palate in a six-month-old baby. Source: Dreamstime.com/Pattarawit Chompipat | ID 84347343. Reproduced with permission of Dreamstime.com.

Upward growth of bone begins along the mandibular arch forming the alveolar process, which will go on to surround the developing tooth germs.

Week 8

By week 8, ossification (bone development) of the maxilla begins.

Tooth germ development in the foetus

Tooth germ (tissue mass) develops in three stages known as bud, cap, and bell. The developing tooth germ can be affected by the mother's health (see Chapter 20).

1. Bud – at 8 weeks, clumps of cells form swellings called enamel organs. Each enamel organ is responsible for the development of a tooth.

2. Cap – the enamel organ continues to grow and by 12 weeks (the late cap stage), cells have formed the inner enamel epithelium and the outer enamel epithelium. Beneath the inner enamel epithelium, the concentration of cells will eventually become the pulp. The enamel organ is surrounded by a fibrous capsule (the dental follicle), which will eventually form the periodontal ligament.
3. Bell – by 14 weeks, the enamel organ will comprise different layers, which will continue to develop to form the various parts of the tooth.

MAIN FUNCTIONS OF THE ORAL CAVITY

The oral cavity is uniquely designed to carry out two main functions:

1. Begin the process of digestion. The cavity's hard and soft tissues, lubricated by saliva, are designed to withstand the stresses of:
   - Biting.
   - Chewing.
   - Swallowing.
2. Produce speech.

TEETH

Different types of teeth are designed (shaped) to carry out different functions. For example, canines are sharp and pointed for gripping and tearing food, while molars have flatter surfaces for chewing. Tooth form in relation to function is called morphology.

Dental nurses and healthcare workers may remember from their elementary studies that there are two types of dentition (a term used to describe the type, number and arrangement of natural teeth):

1. Primary (deciduous) dentition – consisting of 20 baby teeth.
2. Secondary (permanent) dentition – consisting of 32 adult teeth.

Primary dentition

There are three types of deciduous teeth that make up the primary dentition (Figure 1.7): incisors, canines, and molars (first and second). Table 1.1 details their notation (the code used by the dental profession to identify teeth), approximate eruption dates, and functions.

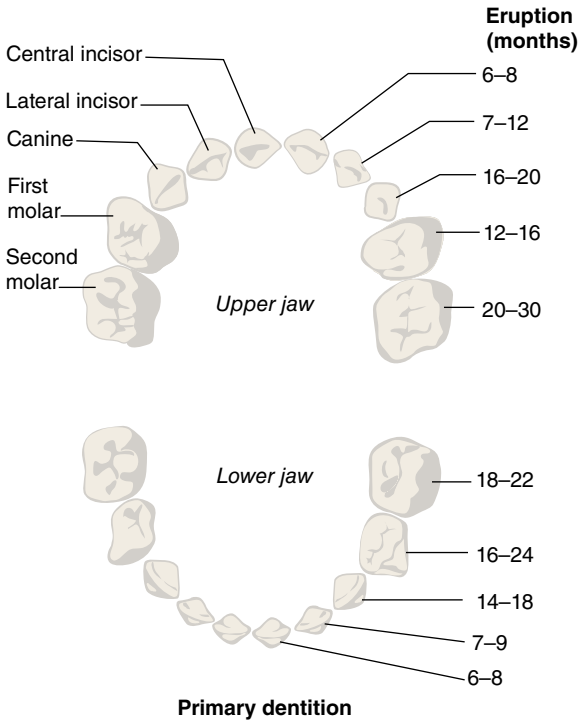

Figure 1.7 Primary dentition. Source: From [1]. Reproduced with permission of Elsevier.

Table 1.1 Primary dentition (notation, approximate eruption dates, and functions).

Tooth	Notation	Approximate eruption date	Function
Incisors	(a & b)	6–12 months (usually lowers first)	Biting
First molars	(d)	12–24 months	Chewing
Canines	(c)	14–20 months	Tearing
Second molars	(e)	18–30 months	Chewing

Table 1.2 FDI World Dental Federation notation for deciduous (primary) dentition.

Patient's upper right (5)	**Patient's upper left** (6)
55 54 53 52 51	61 62 63 64 65
85 84 83 82 81	71 72 73 74 75
Patient's lower right (8)	**Patient's lower left** (7)

Table 1.2 details the FDI World Dental Federation notation for primary dentition, which is a charting system commonly used by dentists to associate information to a specific tooth; where the quadrant number is the first digit applied, and the second number identifies the individual tooth.

Secondary dentition

There are four types of permanent teeth that make up the secondary dentition (Figure 1.8): incisors, canines, premolars, and molars. Table 1.3 details their notation, approximate exfoliation/eruption dates, and functions. Table 1.4 details the FDI World Dental Federation notation for secondary dentition.

It is important to remember that these exfoliation/eruption dates are only approximate and vary considerably in children and adolescents. The educator should be prepared to answer questions from parents who are worried that their child's teeth are not erupting at the same age as their friends' teeth. Parents often do not realise, for example, that no teeth fall out to make room for the first permanent molars (sixes), which appear behind the deciduous molars.

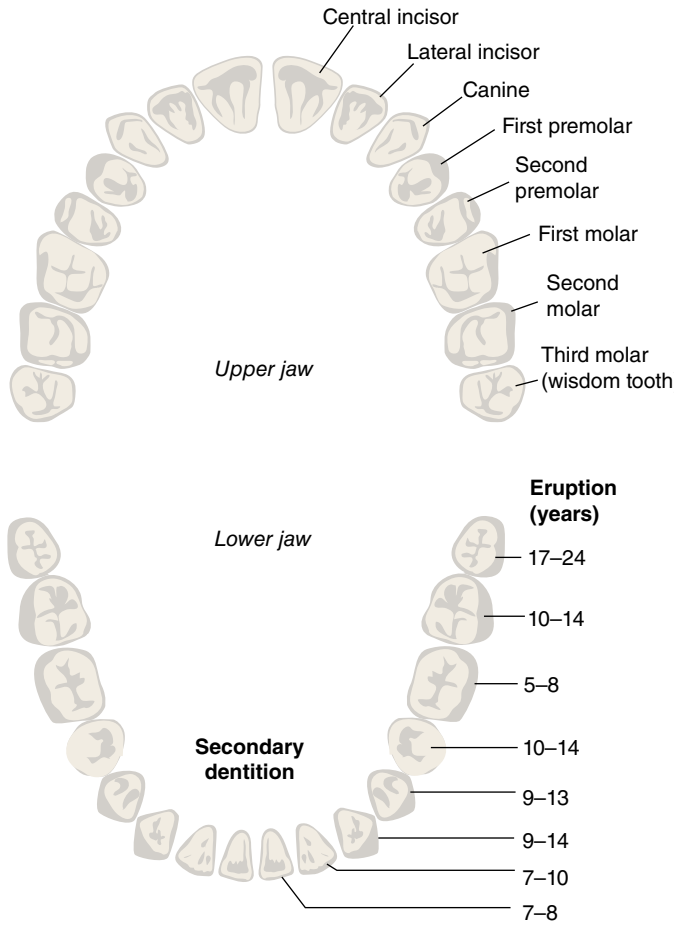

Figure 1.8 Secondary dentition. Source: From [1]. Reproduced with permission of Elsevier.

Table 1.3 Secondary dentition (notation, approximate exfoliation/eruption dates, and functions).

Tooth	Notation	Approximate exfoliation/ eruption dates	Function
First molars	(6)	6–7 years	Chewing
Lower central incisors	(1)	6–7 years	Biting
Upper central incisors	(1)	6–7 years	Biting
Lower lateral incisors	(2)	7–8 years	Biting
Upper lateral incisors	(2)	7–8 years	Biting
Lower canines	(3)	9–10 years	Tearing
First premolars	(4)	10–11 years	Chewing
Second premolars	(5)	11–12 years	Chewing
Upper canines	(3)	11–12 years	Tearing
Second molars	(7)	12–13 years	Chewing
Third molars	(8)	17–24 years	Chewing

Table 1.4 FDI World Dental Federation notation for permanent (secondary) dentition.

Patient's upper right (1)	**Patient's upper left (2)**
18 17 16 15 14 13 12 11	**21 22 23 24 25 26 27 28**
48 47 46 45 44 43 42 41	**31 32 33 34 35 36 37 38**
Patient's lower right (4)	**Patient's lower left (3)**

Structure of the tooth

Tooth structure (Figure 1.9) is complex and comprises several different hard layers that protect a soft, inner pulp (nerves and blood vessels).

Organic and inorganic tooth matter

The terms *organic* and *inorganic* are often mentioned in connection with tooth structure. Educators must know what these terms mean and their percentages in hard tooth structures.

Organic means *living* and describes the matrix (framework) of water, cells, fibres and proteins, which make the tooth a living structure.

Inorganic means *non-living* and describes the mineral content of the tooth, which gives it its strength. These minerals are complex calcium salts.

Table 1.5 shows the percentages of organic and inorganic matter in hard tooth structures.

It is also important to know the basic details about these three hard tooth substances, and also pulp.

Enamel

Enamel (Figure 1.9) is made up of prisms (crystals of hydroxyapatite) arranged vertically in a wavy pattern, which give it great strength. The prisms, which

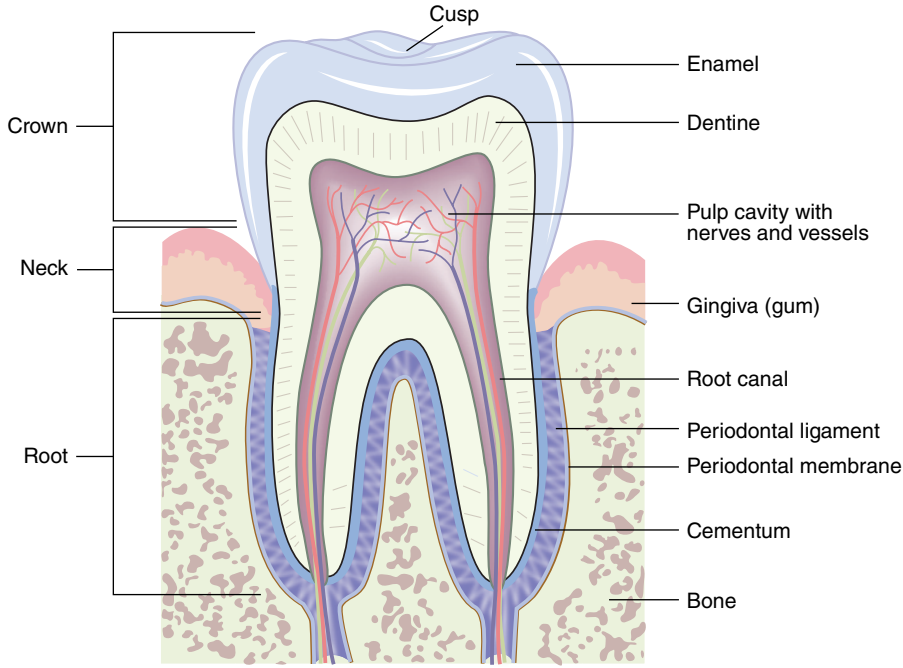

Figure 1.9 Structure of the tooth. Source: From [1]. Reproduced with permission of Elsevier.

Table 1.5 Percentages of organic and inorganic matter in hard tooth structures.

Structure	Inorganic	Organic
Enamel	96%	4%
Dentine	70%	30%
Cementum	45%	55%

resemble fish scales, are supported by a matrix of organic material including keratinised (*horn-like*) cells, which can be seen under an electron microscope.

Properties of enamel

Enamel is:

- The hardest substance in the human body.
- Brittle – it fractures when the underlying dentine is weakened by decay (caries).
- Insensitive to stimuli (e.g. hot, cold, and sweet substances).
- Darkens slightly with age – as secondary dentine is laid down and stains from proteins in the diet, tannin-rich food and drinks, and smoking are absorbed.

Enamel is also subject to three types of wear and tear (see Chapter 6). The educator needs to be aware of these and able to differentiate between them:

1. Erosion – usually seen on palatal and lingual (next to palate and tongue) surfaces.
2. Abrasion – usually seen on cervical (outer neck of tooth) surfaces.
3. Attrition – natural wear often seen on occlusal (biting) surfaces.

Dentine

Dentine constitutes the main bulk of the tooth (Figure 1.9) and consists of millions of microscopic tubules (fine tubes), running in a curved pattern from the pulp to the enamel on the crown and the cementum on the root.

Properties of dentine

Dentine is:

- Softer than enamel, but harder than cementum and bone.
- Light yellow in colour.
- Sensitive to stimuli (e.g. hot, cold, and sweet substances). Reasons for this sensitivity are not fully understood, but it usually lessens with age.

Dentine also changes throughout life. After a tooth is fully developed, more dentine is laid down and is called secondary dentine.

Cementum

Cementum covers the surface of the root (Figure 1.9) and provides an attachment for the periodontal ligament. The fibres of the ligament are fixed in the cementum and in the alveolar bone (see supporting structures of the tooth).

Properties of cementum

Cementum is of similar hardness to bone and thickens throughout life to counteract wear and tear caused by chewing and movement.

Pulp

Pulp is a soft living tissue within the pulp chamber and root canal of the tooth (Figure 1.9). It consists of blood vessels, nerves, fibres, and cells.

Properties of pulp

The pulp chamber shrinks with age as more secondary dentine is laid down, so that the tooth becomes less vulnerable to damage.

Supporting structures of the tooth

The periodontium (Figure 1.10) is the collective name for the supporting structures of the tooth.

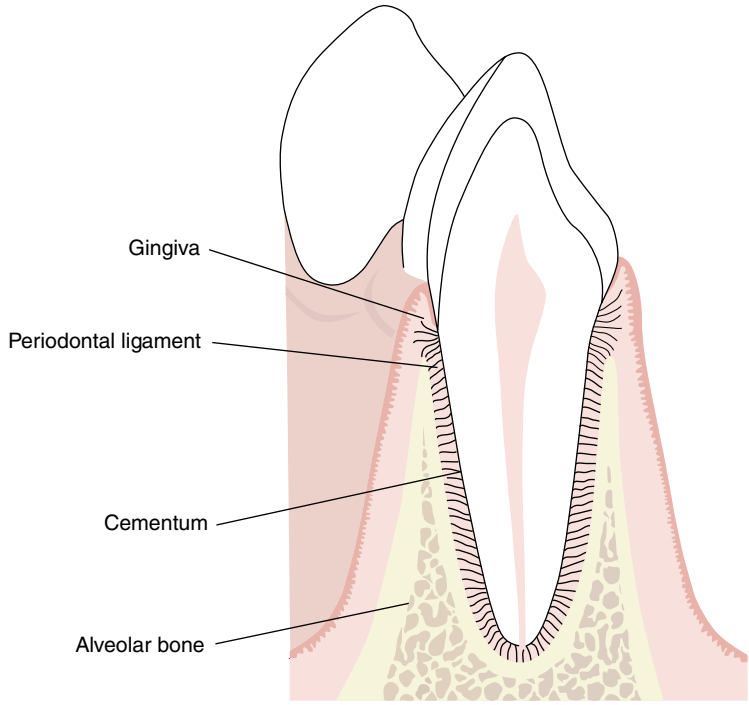

Figure 1.10 The periodontium. Source: From [6]. Reproduced with permission of Blackwell.

It comprises:

- Periodontal ligament.
- Cementum (part of the tooth and supporting structure).
- Alveolar bone (see later in chapter). This develops as the tooth erupts, forming the alveolus of the mandible and maxilla.
- Gingivae (gums).

The periodontal ligament

The periodontal ligament is a connective tissue that holds the tooth in place in the alveolar bone (assisted by cementum). The ligament is between 0.1–0.3 mm wide and contains blood vessels, nerves, cells, and collagen fibres [7].

The collagen fibres attach the tooth to the alveolar bone and run in different directions, which provide strength and flexibility, and act as a shock absorber for the tooth; teeth need to move slightly in their sockets in order to withstand the pressures of mastication (chewing). Imagine what it would feel like to bite hard with teeth rigidly cemented into bone.

Cementum

See *Structure of the tooth*.

Alveolar bone (also known as the alveolar ridge)

Alveolar bones are horseshoe-shaped projections of the maxilla and mandible. They provide an attachment for the fibres of the periodontal ligament, sockets for the teeth, and support the teeth by absorbing and distributing occlusal forces.

Gingivae

The gingivae (gums) consist of mucous membranes and underlying fibrous tissue, covering the alveolar bone.

Gingivae are divided into four sections (Figure 1.11):

1. Attached gingiva – a firm, pale pink (but may have some brown pigmentation), stippled gum tightly attached to the underlying alveolar bone. It is keratinised (hard and firm-like horn) to withstand the friction of chewing. Its orange-peel appearance (stippling) comes from tightly packed bundles of collagen fibres that attach it to the bone. Loss of stippling is one of the signs of gingivitis (see Chapter 3).
2. Free gingiva – where the gum meets the tooth. It is less tightly attached and not stippled. It is also keratinised and contoured to form little points of gum between teeth – the interdental papillae. The indentation between attached and free gingiva is called the free gingival groove.

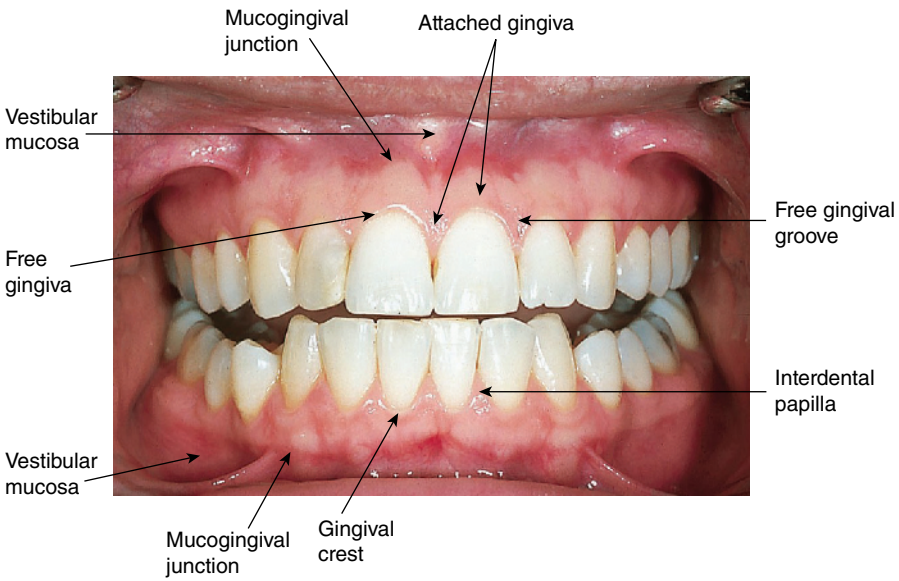

Figure 1.11 Gingivae. Source: [2]. Reproduced with permission of Blackwell.

3. Gingival crest – the edge of the gum and interdental papillae bordering the tooth. Behind the crest is the gingival sulcus (or crevice), which is not more than 2 mm in depth [7]. This base of the crevice is lined with a layer of cells called the junctional epithelium, which attaches the gum to the tooth. When this epithelium breaks down, in disease, periodontal ligament fibres are exposed to bacterial enzymes and toxins. As these fibres break down, a periodontal pocket is formed.
4. Mucogingival junction – the meeting point of the keratinised attached gingiva and the non-keratinised vestibular mucosa (soft, dark red tissue, which lines the inside of lips, cheeks, and the floor of the mouth).

THE TONGUE AND THE FLOOR OF THE MOUTH

The tongue is a muscular, mobile organ, which lies in the floor of the mouth, and is comprised of four surfaces:

1. Dorsal (upper) surface – covered by a thick, keratinised epithelium to withstand chewing, and a large number of projections called papillae. These papillae contain taste buds. The dorsal surface is divided into two sections:
   - Anterior (front) two-thirds (against the palate).
   - Posterior (back) third (towards the pharynx).
2. Ventral (under) surface – covered by a thin mucous membrane. In the middle of the front section, the mucosa is divided by a sharp fold (the *lingual frenulum*), which joins the tip of the tongue to the floor of the mouth.
3. Tip – the pointed front, which can be protruded or moved around the mouth by muscular action. For a baby, the tip of the tongue is an important sensory organ, which explores and identifies objects. It also acts as a great natural cleanser, removing food debris.
4. Root – the deep attachment of the tongue, which forms the anterior surface of the pharynx.

Muscles of the tongue

There are two groups of tongue muscles:

1. Intrinsic (inside) – which can alter its shape.
2. Extrinsic (outside) – which move the tongue and also help alter its shape.

Functions of the tongue

The main functions of the tongue are:

- Taste.
- Mastication (chewing).

- Deglutition (swallowing).
- Speech.
- Cleansing.
- Protection.

Taste

The tongue (and other parts of the oral cavity) is covered with taste buds that allow us to distinguish between sweet, sour, salt, bitter, and umami (savoury) tastes. An adult has approximately 9000 taste buds, which are mainly situated on the upper surface of the tongue (there are also some on the palate and even on the throat) [7].

Mastication

The tongue helps pass a soft mass of chewed food (bolus) along its dorsal surface and presses it against the hard palate.

Deglutition

The tongue helps pass the bolus towards the entrance of the oesophagus.

Speech

Tongue movement plays a major part in the production of different sounds.

Natural cleansing

Tongue muscles allow for tremendous movement, and the tongue can help remove food particles from all areas of the mouth (mainly using the tip).

Protection

The tongue moves saliva (which has an antibacterial property) around the oral cavity.

Conditions affecting the tongue

The following conditions affect the tongue (see Chapter 8 for more detail/images):

- Glossitis (inflammation of the tongue) – a symptom of conditions such as dry mouth, infections, injury from a burn, irritants, vitamin B complex deficiency, skin conditions (e.g. lichen planus), or an allergic reaction. The underlying cause needs to be treated.
- Soreness of the tongue, which may be due to a variety of reasons, including anaemia, vitamin B complex deficiency, and hormonal imbalance.
- Black hairy tongue – due to overgrowth of tongue papillae, stained by chromogenic bacteria, mouthwash (e.g. chlorhexidine gluconate), or smoking. Looks alarming, but is not serious.

- Geographic tongue (also called benign migratory glossitis) – smooth map-like irregular areas on the dorsal surface (where the papillae are missing), which come and go. It can be harmless, but is sometimes sore and often runs in families. It can also be an indication of other systemic conditions [7].

Piercing of the tongue can also cause problems and the educator should be able to advise patients on this matter (see Chapter 22).

The floor of the mouth

The educator must know that the floor of the mouth consists of a muscle called the mylohyoid and associated structures.

SALIVA

Incredible stuff, saliva! It is often taken for granted, and patients only realise how vital it is to the wellbeing of the oral cavity and the whole body, when its flow is diminished (see Chapter 7). Saliva is secreted by three major and numerous minor salivary glands. The minor glands are found in the lining of the oral cavity, on the inside of the lips, the cheeks, the palate, and even the pharynx.

Major salivary glands

The three major salivary glands (Figure 1.12) are as follows:

1. Parotid gland – situated in front of the ear. It is the largest salivary gland and produces 25% of the total volume of saliva [7]. It makes serous (watery) saliva, which is transported into the oral cavity by the parotid duct that opens adjacent to the upper molars. The parotid gland swells during mumps (*parotitis*).
2. Submandibular gland – situated beneath the mylohyoid muscle towards the base of the mandible. It is the middle of the three glands, in both size and position, and produces a mixture of serous and mucous saliva. It accounts for around 70% of total saliva and opens via the submandibular duct on the floor of the mouth [7].

   When dental nurses assist the dentist, they may occasionally notice a small fountain as the saliva appears from this duct (which can also happen when yawning).

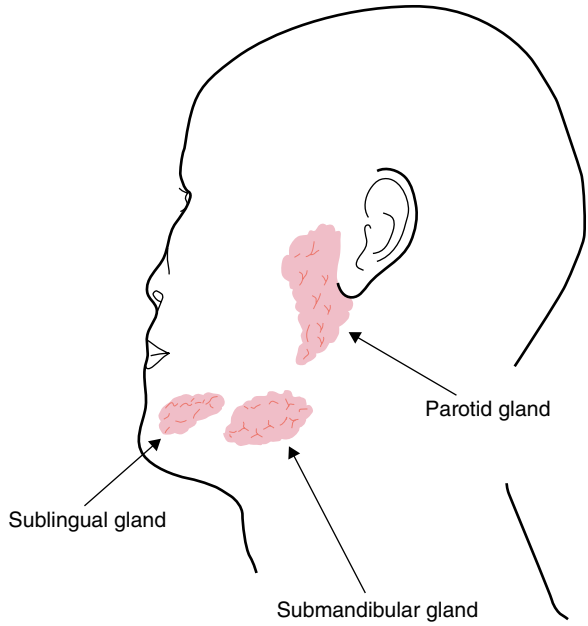

Figure 1.12 Major salivary glands. Source: From [8]. Reproduced with permission of Blackwell.

3. Sublingual gland – is also situated beneath the anterior floor of the mouth under the front of the tongue. It produces 5% of total saliva [7], mainly in the form of mucous, which drains through numerous small ducts on the ridge of the sublingual fold (the area next to the frenulum beneath the anterior of tongue).

Composition of saliva

Saliva is made up of 99.5% water and 0.5% dissolved substances, although the composition varies between individuals [7].

Dissolved substances include:

- Mucins – these are glycoproteins that give saliva its viscosity (stickiness), lubricate the oral tissues, and are the origin of the salivary pellicle (the sticky film which forms on teeth within minutes of cleaning).
- Enzymes – there are many, but the OHE needs only to remember the main ones:
  - Salivary amylase (ptyalin), which converts starch into maltose.
  - Lysozyme, which attacks the cell walls of bacteria, thus protecting the oral cavity from invading pathogens.
- Serum proteins – albumin and globulin (saliva is formed from serum; the watery basis of blood).

- Waste products – urea and uric acid.
- Gases – oxygen, nitrogen, and carbon dioxide in solution. The latter vaporises when it enters the mouth and is given off as a gas.
- Inorganic ions – including sodium, sulphate, potassium, calcium, phosphate, and chloride. The important ones to remember are calcium and phosphate ions, which are concerned with remineralisation of the teeth after an acid attack (see Chapter 5) and the development of calculus (see Chapter 2).
- Saliva also contains large numbers of microorganisms and remnants of food substances.

Functions of saliva

There are eight main functions of saliva:

1. Aids mastication and deglutition – mucous helps form the food bolus.
2. Oral hygiene – washing and antibacterial action helps control disease of the oral cavity. Lysozyme controls bacterial growth. This is why saliva is said to have antibacterial properties, and why animals instinctively lick their wounds.
3. Speech – a lubricant. For example, nervousness = production of adrenaline = reduction in saliva = dry mouth.
4. Taste – saliva dissolves substances and allows the taste buds to recognise taste.
5. Helps maintain water balance (of body) – when water balance is low, saliva is reduced, producing thirst.
6. Excretion – trace amounts of urea and uric acid (a minor role in total body excretion).
7. Digestion – salivary amylase begins the breakdown of cooked starch (a relatively minor role in the whole digestive process, but important in relation to sucrose intake and oral disease).
8. Buffering action – helps maintain the neutral pH of the mouth. The bicarbonate ion is vital to the health of the mouth as it is concerned with the buffering action of saliva. The average resting pH of the mouth (when no food has just been consumed) is 6.7. This is neutral, neither acid nor alkaline. (pH is a symbol used to indicate measurement of acidity or alkalinity of substances or liquids, and stands for the German term *potenz Hydrogen*.)

Facts about saliva

Here are some general points of interest about saliva:

- More is secreted when required (reflex action).
- Composition varies according to what is being eaten (e.g. more mucous with meat).

- Average amount produced daily by adults is 0.5–1 L. Certain medical conditions and disabilities cause the overproduction of saliva, resulting in dribbling (e.g. patients with Down's syndrome and Parkinson's disease, and fungal infections, such as angular cheilitis – see Chapter 8).
- Flow almost ceases during sleep.
- Saliva is sterile until it enters the mouth.
- Saliva tests can be used to solve crimes, since saliva contains deoxyribonucleic acid (DNA), which can be used to help identify individuals. Dental companies sell saliva testing kits, which can be used by OHEs to demonstrate saliva pH to patients.

Other additives within the mouth

Although saliva entering the mouth is sterile, it soon loses this property as it collects organic materials that are already present, including:

- Microorganisms: bacteria (mainly *streptococci*), viruses (e.g. herpes simplex), and fungi (e.g. *Candida albicans*).
- Leucocytes (white blood cells), which fight infection. Not present in *edentulous* (toothless) babies or in saliva collected from the duct, so presumed to come from gingival crevice after teeth erupt.
- Dietary substances (meal remains).

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