1

Oral embryology, histology and anatomy

Sheila Phillips

Summary

This chapter covers:

- Oral embryology
- Early tooth development
- Development of the dental tissues
- Histology of oral tissues
- Histology of dental tissues
- Oral anatomy
- Tooth morphology

Introduction

A basic understanding of the development, structure and relationship of the tissues and structures which constitute the oral cavity and its associated environment is fundamental to the practice of clinical dentistry. It enables the clinician better to appreciate how subsequent pathology change may be influenced by adjacent anatomical structures or tissues and therefore helps to provide a better understanding of the rationale for potential treatment options.

Oral embryology

Development of the face

4 weeks of intrauterine life

The primitive oral cavity, which is known as the **stomodeum**, develops five facial swellings (Figure 1.1): one frontonasal process, two maxillary processes and two mandibular processes. The frontonasal process eventually develops to form the forehead, nose and philtrum; the two maxillary processes form the middle face and upper lip; and the two mandibular processes form the mandible and lower lip.

Development of the palate

5 weeks of intrauterine life

The frontonasal process produces the medial and lateral nasal processes. Failure of fusion of the maxillary and medial nasal processes produces a **cleft lip**.

6 weeks of intrauterine life

The primary nasal septum and primary palate are formed, both derived from the fronto-nasal process (Figure 1.2). Two lateral palatal shelves develop behind the primary palate from the maxillary process. A secondary nasal septum grows behind the primary nasal septum from the roof of the primitive oral cavity dividing the nasal cavity into two.

8 weeks of intrauterine life

The palatal shelves contact each other forming the secondary palate; the shelves also contact anteriorly with the primary palate dividing the oral and nasal cavities.

Development of the jaws

The mandible

6 weeks of intrauterine life

The mandible appears as a band of dense fibrous tissue known a **Meckel's cartilage**; this cartilage provides a framework around which the bone will form.

7 weeks of intrauterine life

Bone formation commences at the mental foramen area and begins to spread backwards, forwards and upwards outlining the future body of the mandible. As the bone

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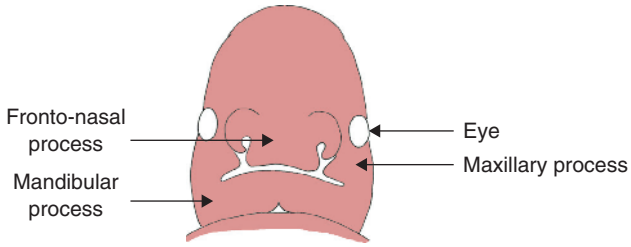


Figure 1.1 Facial development at 4 weeks of intrauterine life.

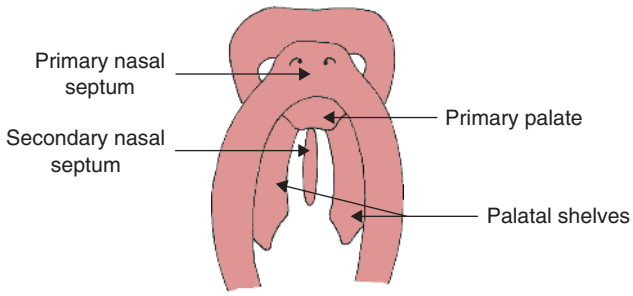


Figure 1.2 Palatal development at 6 weeks of intrauterine life.

grows backwards, two small secondary cartilages develop, which eventually form the **condyle** and **coronoid processes**. Anteriorly, the left and right mandibular plate of bone is separated by cartilage at the **mandibular symphysis**; these two plates eventually unite to form a single bone approximately 2 years after birth. The upward growth of bone increases the height of the mandible forming the alveolar process which will surround the developing tooth germ.

The maxilla

8 weeks of intrauterine life

Ossification of the maxilla commences at the area of the developing primary (deciduous) canines; from this area, bone formation spreads, developing the maxillary processes: palatal, zygomatic, frontal and alveolar. Growth of the maxilla occurs by remodelling of bone and by **sutural growth**. The stimulus for sutural bone growth is thought to be related to the tension produced by the displacement of bone. Growth carries the maxilla forwards and downwards as it increases in size.

Early tooth development

Development of primary epithelial band

- The first sign of tooth development occurs at the 6th week of intrauterine life.
- Underneath the oral ectodermal epithelium there is a condensation of mesenchymal cells in areas where teeth will eventually form.

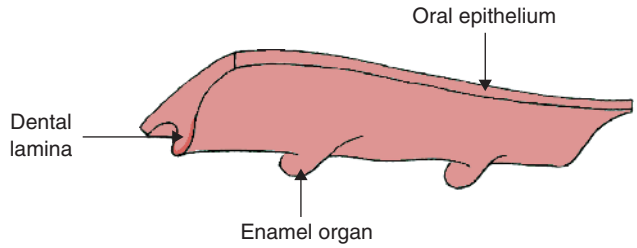


Figure 1.3 Dental lamina showing enamel organs. Reproduced by kind permission of R. Ireland.

- The ectodermal epithelium thickens in these areas and protrudes into the mesenchymal cells forming the primary epithelial band.

Development of the vestibular band and dental lamina

- At 7 weeks of intrauterine life.
- The primary epithelial band develops two processes the vestibular band and the dental lamina.
- The vestibular band forms buccally and will eventually form the vestibule, separating the lips and checks from the teeth and gingivae.
- The dental lamina forms lingually and develops into an arch shape band on which the tooth germs will develop (Figure 1.3).

Development of the tooth germ

The tooth germ develops in three stages: bud, cap and bell (Figure 1.4).

Bud

At 8 weeks of intrauterine life, clumps of mesenchymal cells induce the dental lamina to form swellings known as **enamel organs**. Each enamel organ will be responsible for the development of each tooth (Figure 1.4a).

Cap

As the enamel organs grow and increase in size, the inner aspect becomes concave resembling skull caps. By the late cap stage, at 12 weeks of intrauterine life, cells on the inner aspect of the enamel organ change from cuboidal to columnar forming the **inner enamel epithelium**. The outer layer of cells remains cuboidal and is known as the **outer enamel epithelium**. (Figure 1.4b)

Beneath the inner enamel epithelium the condensation of mesenchymal cells is termed the **dental papilla**; this will eventually become the pulp. A fibrous capsule surrounds each enamel organ and this is termed the **dental follicle**; this will eventually become the periodontal ligament.

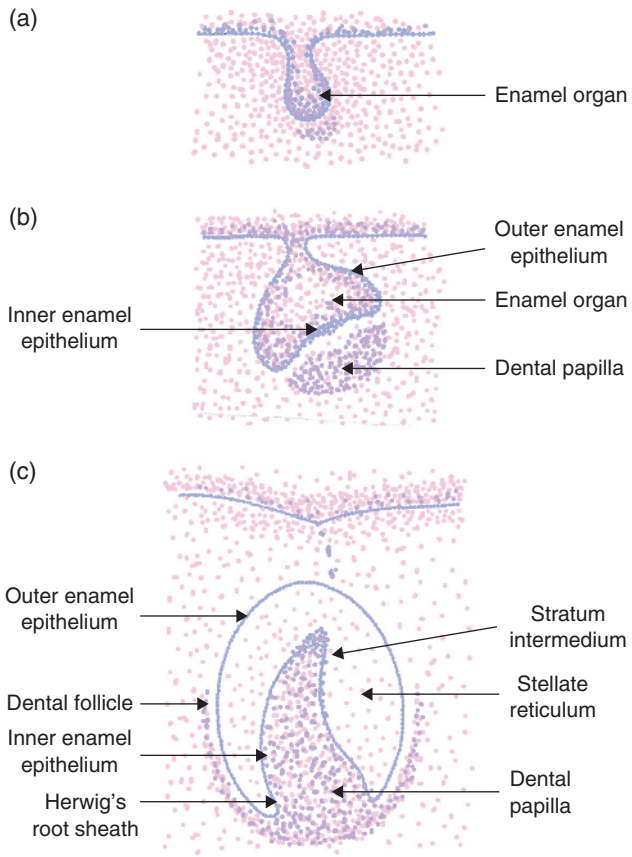


Figure 1.4 Stages in the development of the tooth germ.

Bell

By 14 weeks of intrauterine life (Figure 1.4c) the enamel organ consists of the following:

- **Inner enamel epithelium:**
  - Cells lining the inner surface of the enamel organ which are columnar in shape.
  - The inner enamel epithelium defines the shape of the crown.
  - They will eventually differentiate into enamel forming cells (**ameloblasts**).
- **Stratum intermedium:**
  - Lies over the inner enamel epithelium.
  - Consists of two to three layers of cells.
  - Transports nutrients to and from the ameloblasts.
- **Stellate reticulum:**
  - Lies between the stratum intermedium and the outer enamel epithelium.
  - It consists of star-shaped cells that protect the underlying dental tissues.
  - It also maintains the shape of the tooth.
- **Outer enamel epithelium:**
  - Cells lining the outer surface of the enamel organ. They are cuboidal in shape.
  - They maintain the shape of the enamel organ.
  - The outer enamel epithelium meets with the internal enamel epithelium at the cervical loop.
  - Eventually the inner and outer enamel epithelium grows downwards at the cervical loop forming **Hertwig's root sheath**, which maps out the shape of the root.

At the late bell stage the dental lamina disintegrates and is ready for the formation of dental hard tissue. Dentine formation always precedes enamel formation.

Development of the dental tissues

Dentine formation – (dentinogenesis)

- Late bell stage the inner enamel epithelium cells have mapped out the shape of the crown.
- The inner enamel epithelium cells induce cells at the periphery of the dental papilla to form columnar **odontoblast** cells (dentine-forming cells).
- Odontoblast cells begin to secrete an unmineralised dentine matrix.
- As more dentine matrix is deposited, the odontoblast cells retreat in the direction of the pulp leaving an elongated process known as the **odontoblast process**.
- The dentine matrix formed prior to mineralisation is termed **predentine**. A narrow layer of predentine is always present on the surface of the pulp.
- Mineralisation of dentine begins when the predentine is approximately 5 µm thick.
- Spherical zones of hydroxyapatite called **calcospherites** are formed within the dentine matrix.
- Mineralisation of the dentine matrix starts at random points and eventually these calcospherites fuse together to form mineralised dentine.
- Dentinal tubules form around each odontoblast process (Figure 1.5).
- The odontoblasts retreat in S-shaped curves towards the dental papilla.
- The first layer of mineralised dentine is called **mantle dentine** and the remaining bulk of the mineralised dentine is known as **circumpulpal dentine.**

Enamel formation (amelogenesis)

- Immediately after the first layer of dentine is formed, the inner enamel epithelium **ameloblast** cells (enamel forming cells).
- The ameloblast cell is columnar in shape with its base attached to cells of the stratum intermedium.
- At the secretory end of ameloblast cells is a pyramidal extension called the **Tomes' process** (Figure 1.6).
- The enamel matrix is secreted through the Tomes' process at the amelodentinal junction.

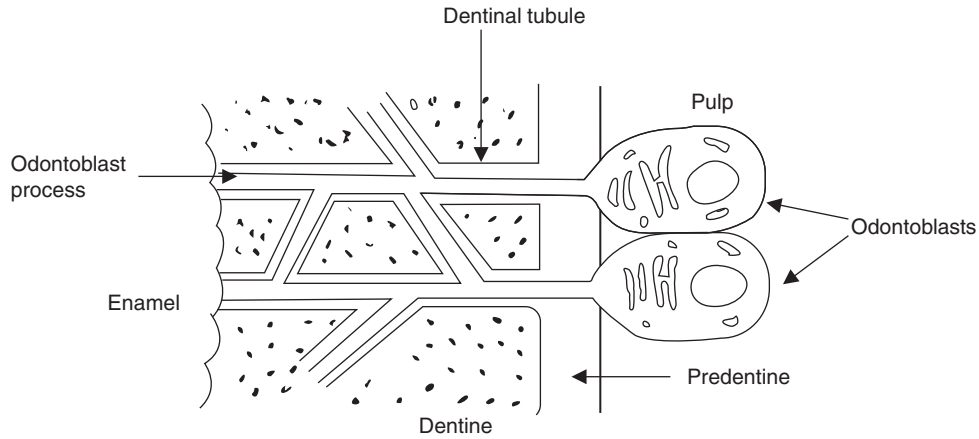


Figure 1.5 Diagram of odontoblast process and dentine tubules.

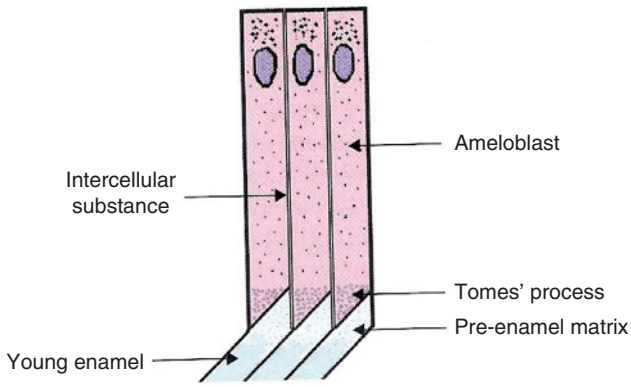


Figure 1.6 Diagram of enamel prism formation showing Tomes processes.

- Calcium and phosphate ions are secreted into the enamel matrix and mineralisation of enamel occurs immediately, forming hydroxyapatite crystallites.
- As more enamel matrix is secreted and mineralised, the ameloblast cells move away from the amelodentinal junction forming a pattern of crystallites, which are contained within enamel prisms.
- Enamel prisms are also known as enamel rods they run from the amelodentinal junction to the enamel surface.

Enamel maturation

- During maturation from pre-enamel to mature enamel, the enamel crystallites increase in size and the organic content is reduced.
- On completion of enamel formation the ameloblast cell loses the Tomes' process, flattens and becomes the **reduced enamel epithelium**.
- The reduced enamel epithelium protects the enamel during eruption and will eventually become the **junctional epithelium**.

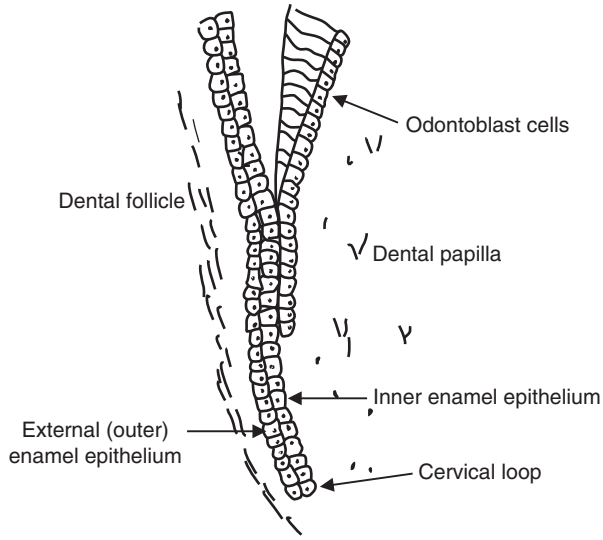


Figure 1.7 Diagram of Hertwig's root sheath.

Formation of the root

- Occurs when the crown has completed.
- The internal and external enamel epithelium grows downwards at the cervical loop to form a double layered epithelial wall – **Hertwig's root sheath** (Figure 1.7).
- The Hertwig's root sheath grows apically mapping out the shape of the root enclosing the dental papilla.
- The dental follicle lies external to the Hertwig's root sheath.

Cementum formation (cementogenesis)

- The Hertwig's root sheath induces the formation of odontoblast cells.

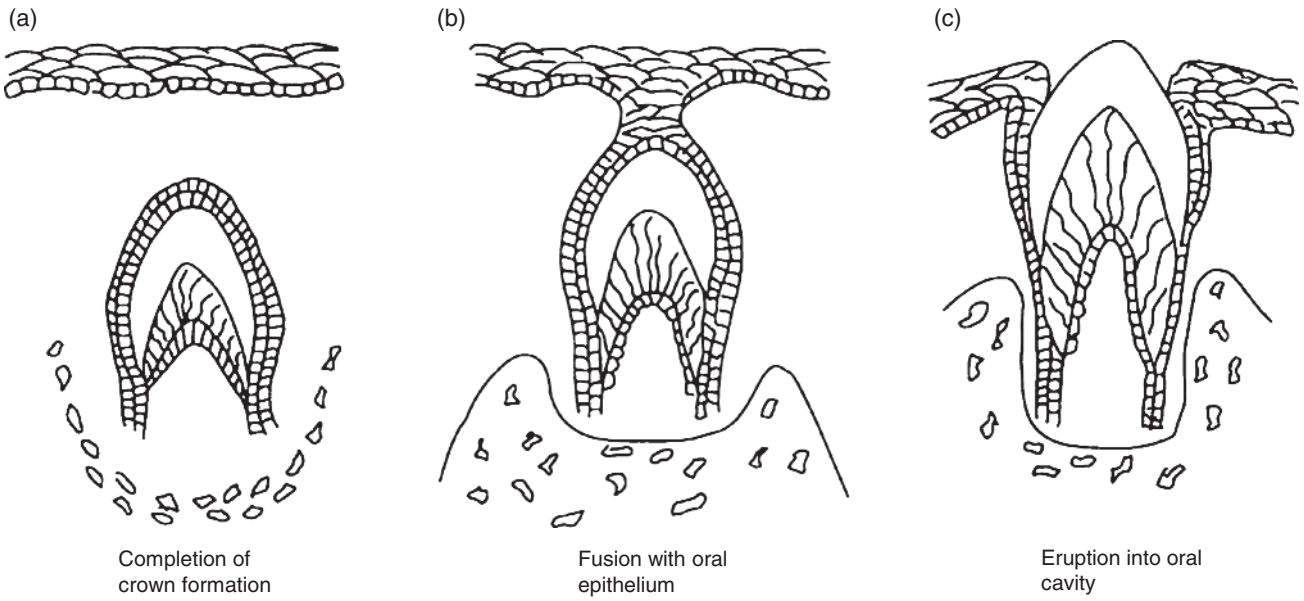


Figure 1.8 Diagram showing phases of tooth eruption.

- When root dentine has formed, Hertwig's root sheath fragments allowing adjacent cells from the dental follicle to come into contact with the root dentine.
- These cells differentiate into **cementoblasts** (**cementum-forming cells**).
- Cementoblasts are cuboidal in shape and form a single layer on the surface of the root dentine.
- The cementoblasts secrete cementum matrix and crystallites of hydroxyapatite are deposited in this matrix and mineralisation occurs.
- During formation, a thin layer of unmineralised cementum is always present on the surface; this is known as **cementoid**.

Formation of the periodontal ligament

- Cells within the dental follicle give rise to **fibroblasts** that secrete collagen.
- Once cementum formation has begun, collagen fibres within the dental follicle orientate themselves into bundles, which are perpendicular to the root surface.
- These fibres will form the **principal fibres** of the periodontal ligament.
- The ends of these fibres become embedded in the developing cementum and alveolar bone and are known as **Sharpey's fibres**.

Tooth eruption

Tooth eruption is the bodily movement of a tooth from its development position into its functional position in the oral cavity. It can be broken down into two phases; the per-functional eruptive phase and the functional eruptive phase (Figure 1.8).

Prefunctional phase

- During the prefunctional phase, crown formation has completed.
- As root formation begins the developing tooth begins to erupt.
- The overlying alveolar bone is resorbed by **osteoclasts** and gradually the tooth moves in an axial direction towards the oral cavity.
- The enamel surface of the tooth is covered by the reduced enamel epithelium which fuses with the oral epithelium.
- The pressure from the tip of the tooth breaks down the oral epithelium allowing the tooth to emerge into the oral cavity without any rupturing of blood vessels.
- Once the tooth has emerged, the reduced enamel epithelium is known as the **epithelial attachment**.
- Tooth eruption continues until the tooth contacts (occludes with) the opposing tooth in the opposite jaw.

Functional eruptive phase

- The functional eruptive phase continues throughout life due to functional changes.
- The alveolar bone continuously remodels in response to tooth movement and enamel wear allowing teeth to maintain contact with each other and with opposing teeth.

Mechanisms of tooth eruption

The eruptive force of tooth eruption is unclear; however, several theories have been put forward although there is little evidence to support them. These are:

- Root growth generates a force beneath the tooth, elevating the tooth towards the oral cavity.

Table 1.1 Approximate dates of tooth development, eruption and exfoliation for the primary dentition.

Tooth (in order of eruption)	Approximate initial calcification date	Approximate eruption date	Approximate exfoliation date
Upper and lower primary central incisors (A's)	3–4 months *in utero*	6–8 months	6–7 years
Upper and lower primary lateral incisors (B's)	4½ months *in utero*	7–9 months	7–8 years
Upper and lower primary first molars (D's)	5 months *in utero*	12–14 months	9–11 years
Upper and lower primary canines C's	5 months *in utero*	16–18 months	9–12 years
Upper and lower primary second molars E's	6 months *in utero*	20–24 months	10–12 years

Table 1.2 Approximate dates of tooth development and eruption for the permanent dentition.

Tooth (in order of eruption)	Approximate initial calcification date	Approximate eruption date
Upper and lower permanent first molars (6's)	At birth	6–7 years
Upper and lower permanent central incisors (1's)	3–4 months	6–7 years
Upper and lower permanent lateral incisors (2's)	Upper 10–12 months Lower 3–4 months	7–8 years
Lower permanent canines (3's)	4–5 months	9–10 years
Upper and lower permanent first premolars (4's)	1–2 years	10–11 years
Upper and lower permanent second premolars (5's)	2–3 years	11–12 years
Upper permanent canines (3's)	4–5 months	11–12 years
Upper and lower permanent second molars (7's)	2–3 years	12–13 years
Upper and lower permanent third molars (8's)	7–10 years	18+ years

- Remodelling and deposition of the bone beneath the developing tooth pushes the tooth upwards.
- Traction of the periodontal fibres exerts an upward pull on the tooth.
- Cellular proliferation at the base of the pulp creates pressure that pushes the tooth from the dental follicle.
- An increase in tissue fluid or blood pressure generates an eruptive force on the tooth.

The approximate initial calcification and eruption dates are listed in Tables 1.1 and 1.2.

Histology of oral tissues

The three primary layers of an embryo are described as:

- **Ectoderm** (the outermost layer). This develops into structures such as the nervous system, the epidermis and epidermal derivatives and the lining of various body cavities such as the mouth.
- **Mesoderm** (the middle layer), which forms into many of the bodily tissues and structures such as bone, muscle, connective tissue and skin.
- **Endoderm** (the innermost layer), which develops to form the digestive tract and part of the respiratory system.

The oral mucosa

The surface of the oral mucosa consists of **epithelial tissue**. Epithelial tissue is first classified according to the shape of the cells as being squamous (flat cells), cuboidal (cube shaped) or columnar (tall, narrow cells) and second by the number of cell layers. A single layer of epithelial cells is called simple and where there are several layers it is called stratified.

The oral mucosa consists of:

- A surface layer of **stratified squamous epithelium**.
- Underneath this there is a layer of highly vascular connective tissue, the **lamina propria** (Figure 1.9).
- The mucous membrane is attached to underlying structures by connective tissue of varying thickness (the **submucosa layer**), which contains larger arteries, veins and nerves.

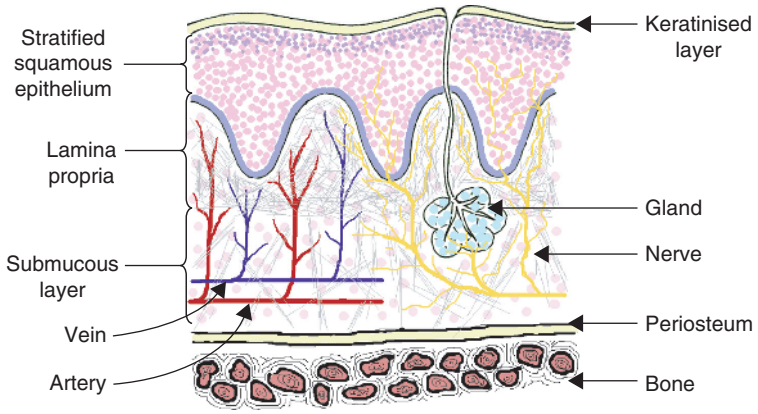


Figure 1.9 Diagram of the structure of the oral mucosa. Reproduced by kind permission of R. Ireland.

The structure of the mucous membrane varies in different parts of the oral cavity according to the variation in function. In areas subject to chewing such as the hard palate and the attached gingivae, the mucosa has a firm **keratinised epithelial layer** of fibrous protein (also found on the palms of the hands and soles of the feet). In other areas such as the cheeks and floor of the mouth that require more flexibility, this is reduced or absent. The cells of this keratin layer have no nuclei and no nerve supply.

Underneath the keratinised layer of cells is a non-keratinised layer of epithelial cells which have nuclei and act as cushion against mechanical forces. The deepest layer of these cells is known as the **basal layer** and is attached to the basal lamina.

The oral cavity is kept lubricated by mucus secretions from the major and minor salivary glands; this epithelium is sometimes termed mucous membrane.

There are three types of oral mucosa found in the oral cavity.

- **Lining mucosa:**
  - This covers the inside of the cheeks, lips, alveolar mucosa, soft palate, under surface of tongue and floor of the mouth.
  - This mucosa is non-keratinised and loosely attached.
  - It has a submucosa layer, which contains blood vessels and nerves.
  - Between the muscle layer and epithelium lay numerous minor salivary glands; sometimes these salivary ducts may become obstructed and a **mucocele** may develop.
- **Masticatory mucosa:**
  - This covers the hard palate and gingiva.
  - This mucosa has to withstand the friction of mastication; it is keratinised and firmly attached to the underlying bone.
  - A layer of connective tissue lies between the masticatory mucosa and bone and the submucosa layer is absent.
- **Specialised mucosa:**
  - This covers the dorsum of the tongue.
  - It is keratinised and contains special taste receptors.

Muscular tissue

Muscle develops from mesodermal tissue and is specialised tissue in that it has both the ability to contract and the ability to conduct electrical impulses. Muscles are classified both functionally as either voluntary or involuntary and structurally as either striated or smooth.

There are therefore three types of muscles:

- Smooth involuntary muscle (e.g. intestinal).
- Striated voluntary muscle (e.g. skeletal).
- Striated involuntary muscle (e.g. cardiac).

All the oral musculature consists of striated voluntary muscle. The cells are cylindrical, unbranched and multinucleate. They contain actin and myosin which are contractile proteins. The cells are arranged in bundles (fascicles) surrounded by connective tissue which also serves to anchor the muscle to bone in the form of a tendon.

Glandular tissue

The most important glands of the oral cavity are the salivary glands. The principal salivary glands are the **parotid** (situated buccal to the upper molars), **submandibular** and **sublingual** (located in the floor of the mouth). There are in addition a number of minor salivary glands on the surface of the tongue, the internal surfaces of the lips and in the buccal mucosa.

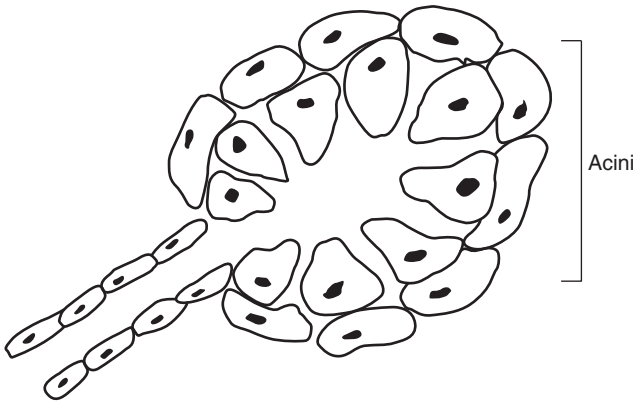


Figure 1.10 Diagram of secretory cells of salivary gland.

Production of saliva

- Each gland is made up of lobules, which resemble a bunch of grapes.
- The basic secretory units of salivary glands are clusters of cells called **acini** (Figure 1.10).
- These acinous epithelial cells consist of two types; serous cells which secrete a watery fluid low in mucous and mucous cells producing a glycoprotein (mucin) rich secretion.
- The serous cells are polyhedral in shape and produce a thin watery secretion.
- The mucous cells are cuboidal and produce a viscous secretion containing mucin.
- When mixed, the serous cells form a cap (demilune) around the periphery of the mucous cells.
- The parotid glands produce a serous secretion, the submandibular produce a mixture of serous and mucous and the sublingual glands produce a mainly mucous secretion.
- Secretion is under the control of the autonomic nervous system which controls both the volume and type of saliva produced.
- Saliva passes through the intercalated ducts, then the striated ducts and finally passes through the excretory ducts carrying the saliva to the oral cavity.

Constituents of saliva

The composition of saliva is subject to individual variation. It consists of 99.5% water and 0.5% dissolved substances that are made up of:

- **Salivary proteins**: these include:
  - **Glycoproteins** (**mucoids**): lubricate oral tissues; the acquired pellicle provides tooth protection.
  - **Enzyme amylase**: converts starch to maltose.
  - **Lactoferrins**: ferric iron is an essential microbial nutrient; lactoferrins bind to ferric ions producing an antibacterial effect.
  - **Lysozomes**: attack the cell walls of bacteria protecting the oral cavity from invading pathogens.
  - **Silaloperoxidase** (**lactoperoxidase**): controls established oral flora by controlling bacterial metabolism.
  - **Histatins**: inhibit *Candida albicans*.
  - **Statherin**: inhibits precipitation of calcium phosphates.
  - **Proline-rich proteins**: encourages adhesion of selected bacteria to the tooth surface. They inhibit precipitation of calcium phosphates.
  - **Salivary immunoglobulins**: produce protective antibodies which help to prevent infection.
- **Inorganic ions**: bicarbonate and phosphate ions provide a buffering action, which regulates the pH of the oral cavity. Calcium and phosphate ions maintain the integrity of teeth by providing minerals for newly erupted teeth, which helps with the posteruptive maturation of enamel and prevents tooth dissolution by enhancing the remineralisation of enamel. Small amounts of sodium, potassium, chloride, and sulphate can also be found in saliva.
- **Gases formed**: newly formed saliva contains dissolved oxygen, carbon dioxide and nitrogen.
- **Other additives**: urea is formed as a waste product. Saliva also contains a vast number of microorganisms and remnants of food substances.

Bone

Bone is a specialised form of dense connective tissue. Two types of bone can be distinguished:

- **Compact** (**cortical** or **lamellar**) **bone**: forms the outer layer of all bones and consists almost entirely of extracellular substance (**matrix**). It is built up of numerous vascular canals (**Haversian canals**) running along the long axis of the bone around which bone is deposited by **osteoblasts** in a series of concentric layers (**lamellae**) As the matrix is deposited, the osteoblasts become trapped in small hollows (**lacunae**) and cease to be active in laying down bone and become **osteocytes** (Figure 1.11). Osteocytes have several thin processes, which extend from the lacunae into small channels within the bone matrix (**canaliculi**).Compact bone is surrounded by a layer of dense connective tissue, the **periosteum**.
- **Trabecular bone** (**cancellous or spongy bone**): consists of delicate bars and sheets of bone (trabeculae), which branch and intersect to form a sponge like network but there are no Haversian systems.

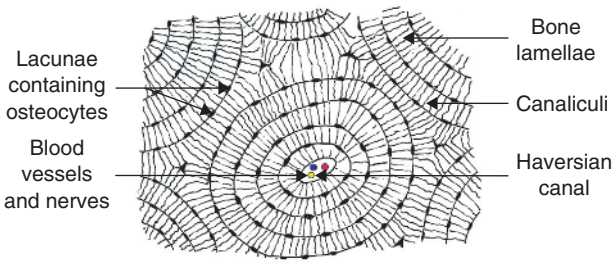


Figure 1.11 Cross-section of compact bone. Reproduced by kind permission of R. Ireland.

Bone is subject to constant remodelling by osteoblastic and osteoclastic (bone destroying) activity. The bone tissue of the maxilla is more vascular and less dense than that of the mandible.

Histology of dental tissues

Dentine

Physical characteristics of dentine

- Dentine is mineralised tissue forming the bulk of the tooth.
- It underlies the enamel in the crown area and is covered by the cementum in the root area.
- Dentine is pale yellow in colour and is harder than bone and cementum but not as hard as enamel.

Chemical composition of dentine

- 70% inorganic material (by weight) of which the main inorganic component is hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$].
- 20% organic material (by weight).The main organic component is collagen fibres embedded in amorphous ground substance.
- 10% water (by weight).

Structure of dentine

- Dentine consists of many dentinal tubules that run parallel to each other following a double curved course and extend from the pulp to the amelodentinal junction.
- Each dentinal tubule contains an odontoblast process surrounded by intercellular ground substance composed of fine collagenous fibrils.
- The odontoblast cells are a layer of closely arranged cells on the pulpal surface of the dentine with their nuclei situated at the basal (pulpal) end of each cell.

Features of dentine

The following features of dentine are significant:

- **Peritubular dentine**: this is highly mineralised dentine found within each dentinal tubule surrounding the odontoblast process and can be visualised as similar to 'furred' pipes.
- **Interglobular dentine**: these are areas of dentine that remain unmineralised.
- **Incremental lines**: these are produced due to the rhythmic pattern of dentinogenesis often referred as **contour lines of Owen**. These lines are seen when dentinogenesis is disrupted (as with amelogenesis).
- **Neonatal line**: this is only seen in primary teeth and first permanent molars as a line that marks dentine formation before and after birth.
- **Granular layer of Tomes**: this is a narrow layer of granular dentine found in root dentine immediately beneath the cementum.

Age changes in dentine

Secondary dentine

Dentine is a living tissue and with age more dentine continues to form slowly; this dentine is termed **secondary dentine**. Secondary dentine is laid down at the pulpal end of the primary dentine. As a result of this the pulp chamber reduces in size with age.

Peritubular dentine

Peritubular dentine tends to increase with age reducing the diameter of the dentinal tubules.

Translucent/sclerotic dentine

The tubules may also become completely obliterated and when this happens the dentine becomes more translucent; this is termed translucent or **sclerotic dentine**.

Reparative dentine

Reparative dentine or irregular secondary dentine is laid down on the pulpal surface of the dentine in response to an external stimulus, such as caries, cavity preparation or excessive wear. Following a severe stimulus, the odontoblast process may be destroyed and the contents of the tubule then necrose leaving the dentinal tubule empty; this is termed a **dead tract**.

Dentine hypersensitivity

There are many theories for the mechanism of dentine sensitivity. The principal current theories are:

- **Innervation theory**: the nerve fibres of the pulp pass into the dentinal tubules.
- **Odontoblast receptor theory**: the odontoblasts act as a receptor transmitting nerve impulses.
- **Brännström's hydrodynamic theory**: this suggests that there is movement of fluid within the dentinal tubules.

Enamel

Physical characteristics of enamel

- Enamel is highly mineralised and is the hardest tissue in the body.

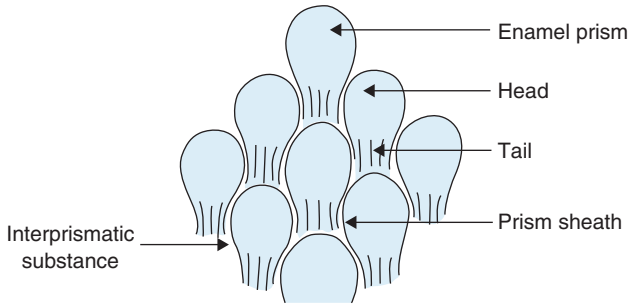


Figure 1.12 Diagram of magnified appearance of enamel prisms.

- Enamel covers the anatomical crown of the tooth and varies in thickness.
- It is semi-translucent and its colour can vary from bluish white to hues of yellow.

Chemical composition of enamel

- 96–97% inorganic material (by weight), the main inorganic component being hydroxyapatite.
- 1% organic material (by weight), the main organic component being protein.
- 2–3% water (by weight)

Structure of enamel

- Enamel is made up of millions of enamel prisms or rods, which run from the amelodentinal junction to the enamel surface.
- Each prism is made up of a large number of enamel crystallites.
- When viewed under a light microscope each prism resembles the rounded 'head' portion of a keyhole (Figure 1.12).
- The enamel crystallites run parallel to the long axis of the prism and in the 'tail' portion the enamel crystallites are inclined away from the long axis of the enamel prism.

Enamel is laid down in layers which produce **incremental growth lines**. After each successive layer the ameloblasts retreat so as not to be trapped within their matrix. Some growth lines mark daily deposits which are about 4 μm thick; these are called **cross striations**.

Features of enamel

The following features of enamel are significant:

- **Brown striae of Retzius**: these are brown lines indicating variations in weekly deposits that run obliquely from the amelodentinal junction towards the enamel surface. When the striae emerge onto the enamel surface a series of grooves may be seen; these are termed **perikymata** grooves.
- **Hunter–Schreger bands**: when viewed under a light microscope, broad dark and light bands can be seen running obliquely from the amelodentinal junction to two-thirds of the thickness of the enamel. They are curved with the convexity of the curve always facing rootwards.
- **Neonatal line**: since this line marks the disruption in amelogenesis at birth, it can only be seen in primary teeth and first permanent molars. It can provide an important forensic landmark.
- **Enamel spindles**: this is when the dentinal tubules extend into the enamel and are found most frequently beneath cusps.
- **Lamellae**: these are sheets like faults that run vertically through the entire thickness of the enamel.
- **Enamel tufts**: these are pieces of incomplete mineralised enamel that resemble tufts of grass. They extend from the amelodentinal junction and follow the direction of the enamel prisms.
- **Amelodentinal junction**: the enamel and dentine meet at the amelodentinal junction; this junction has a scalloped appearance.

Cementum

Physical characteristics of cementum

- Cementum is a pale yellow calcified tissue covering the root dentine.
- It is softer than dentine and can easily be worn away resulting in exposure of the dentine.
- Its thickness varies according to location; it is thickest towards the apical third of the root and thinnest cervically.

Chemical composition of cementum

- 65% by weight inorganic (mainly hydroxyapatite).
- 23% organic (mainly collagen).
- 2% water.

Structure of cementum

Cementum has a similar structure to bone. It may be classified by the presence or absence of cells:

- **Acellular cementum**: it is the first cementum to form and is sometimes termed **primary cementum**. It covers the root dentine from the cement-enamel junction to near the root apex and does not contain cells.
- **Cellular cementum**: this is found as a thin layer at the apical third of the tooth. It is sometimes termed secondary cementum. As cellular cementum develops, the **cementoblasts** that have created the cementum become embedded within the cementum matrix and become inactivated; these cells are termed **cementocytes**. Cementocytes are contained in lacunae and their tiny processes spread along canaliculi to join up

with other cementocytes. Their processes are directed towards the periodontal ligament, from which they obtain nutrients.

Features of cementum

The following features of cementum are significant:

- **Cementoenamel junction**: this can be variable. In approximately 60% of teeth the cementum overlaps the enamel: in approximately 30% of teeth the cementum and enamel meet exactly and in approximately 10% of teeth the cementum and enamel do not meet thus leaving an area of dentine exposed.
- **Functional changes of cementum**: cementum formation continues throughout life. The attachment of the periodontal fibres in cementum can alter according to the functional needs of the tooth. Movement of teeth during orthodontic treatment or eruption can result in the periodontal fibres becoming re-arranged and re-attached in a new position.
- **Resorption of cementum**: resorption of the cementum is not fully understood; it can affect individual or groups of teeth. Resorption of cementum occurs when teeth are placed under excessive masticatory stress or orthodontic loading.
- **Hypercementosis:** hypercementosis is an increased thickening of cellular cementum. Chronic periapical inflammation around the apex of a root or excessive occlusal attrition may give rise to localised hypercementosis. Hypercementosis affecting all the teeth may be associated with Paget's disease.
- **Ankylosis**: ankylosis is a term used when the cementum of a tooth is fused with the alveolar bone of the tooth socket.
- **Concresence**: **i**s used to describe when two teeth are fused together by cementum.

Dental pulp

The dental pulp is what remains after dentine formation. It is surrounded by dentine and is contained in a rigid compartment.

Functions of pulp

The dental pulp has the following functions:

- At late bell stage the cells at the periphery of the pulp differentiate into odontoblasts forming dentine.
- It provides nutrients to the odontoblasts
- It acts as a sensory organ especially when dentine is exposed. The pulp rapidly responds to stimuli such as caries and attrition by laying down reparative or reactionary dentine.
- It mobilises defence cells when bacteria enter it.
- Cells proliferating in the pulpal tissue create pressure; this is thought to play a part in tooth eruption

Shape and form

Pulp is a soft vascular connective tissue occupying the centre of the tooth. The shape of the pulp approximately follows the shape of the outer surface of the tooth. The pulp is made up of a pulp chamber in the crown and root canals extending the length of the root. The shape and number of root canals can vary considerably. At the apex of each root is a foramen or foramina through which blood vessels, nerves and lymphatics pass. Small projections of the pulp are found under each cusp, these are known as pulp horns or **cornua**.

Cellular structure

- The pulp has a gelatinous consistency containing cells and intercellular substances.
- Odontoblasts can be found at the periphery of the pulp.
- At the time of eruption, a cell-free zone known as the **basal layer of Weil** often develops beneath the odontoblasts and deep to this zone can be found a cell-rich zone which contains a plexus of capillaries and nerves.
- Fibroblast cells are very numerous within the pulp and function to produce collagen. Defence cells (histiocytes) or fixed macrophages are the main defence cells found within the pulp.
- When the pulp is inflamed, histiocytes become free macrophages. Polymorphonuclear leucocytes can also be found in response to inflammation.

Intercellular substances

The intercellular substances consist of fibres and amorphous ground substance, blood vessels and nerves.

- Collagen fibres are scattered throughout the pulp and provide support to the pulpal tissue.
- The amorphous ground substance is a gelatinous substance that gives the pulp its shape.
- The pulp has a very rich supply of blood. Arterioles enter the pulp through the apical foramen and then ascend towards the crown area giving off several branches which anastomose (join together) with other arterioles. The arterioles terminate in a dense capillary plexus under the odontoblasts and drain into venules; these leave the pulp through the apical foramen.
- Both non-myelinated and myelinated nerve fibres enter the pulp through the apical foramen and generally follow the blood vessels.
- When the nerve fibres ascend towards the crown area they branch towards the periphery of the pulp and subdivide forming a network of fibres known as the **plexus of Raschkow** just beneath the cell free layer of

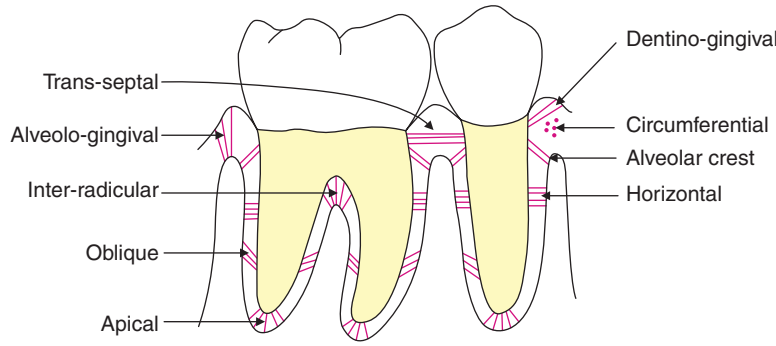


Figure 1.13 Gingival fibre groups of the periodontal membrane. Reproduced by kind permission of R. Ireland.

Weil. Some fibres cross the cell free layer of Weil passing through the odontoblasts and pre-dentine layer and enter the dentinal tubules.

Age changes

The primary changes are:

- A reduction in volume due to continuing dentine formation throughout life.
- A change in content resulting in more collagen, a reduced cellular content and a reduced nerve supply making the pulp less sensitive. Irregular calcifications (pulp stones) can be found but have little clinical significance except when undertaking root canal therapy.

Periodontal ligament

The periodontal ligament is a specialised fibrous connective tissue that surrounds the root area of the tooth. It consists mainly of collagenous fibres.

Function of the periodontal ligament

- It provides a support mechanism for the tooth; it cushions teeth against excessive occlusal forces preventing damage to the blood vessels and nerves at the root apex.
- It maintains the functional position of a tooth by keeping the teeth in contact and prevents the tooth from drifting or tilting
- The periodontal fibres undergo continuous change. Its cells form, maintain and repair the alveolar bone and cementum.
- Sensors in the periodontal ligament provide proprioceptive input, detecting pressures on the tooth
- The periodontal ligament has a rich supply of blood, which provides nutrients to the cementoblasts.

Structure of the periodontal ligament

- The predominant cells found within the periodontal ligament are fibroblasts. Cementoblasts cover the surface of the cementum and osteoblasts and osteoclasts cover the surface of alveolar bone.
- Remnants of the disintegrated Hertwig's root sheath remain into adult life and can be found between the collagen fibres of the periodontal ligament. They are known as the **epithelial cell rests of Malassez**.
- The blood supply runs along the long axis of the tooth close to the wall of the socket between the principal fibre bundles. Branches are given off forming a network of capillaries that encircles the tooth.
- The nerves follow the pathway of the blood vessels. Two types of nerve fibres are present: sensory nerve fibres responsible for pain and pressure and autonomic nerve fibres running alongside blood vessels and controlling the blood supply.

The periodontal ligament is made up of two groups of fibres, the gingival fibre groups and the principal fibre groups (Figure 1.13).

The gingival fibre groups of the periodontal ligament

- **Dentinogingival fibres** (free gingival fibres) are attached to the cementum and fan out into the gingival tissue.
- **Trans-septal fibres** run horizontally from the cervical area of one tooth to the adjacent tooth.
- **Alveologingival fibres** arise from the alveolar crest and run coronally into the attached and free gingiva.
- **Circumferential fibres (circular)** encircle the neck of the tooth.
- **Alveolar crest fibres** run from the cervical cementum to the alveolar crest.

The principal fibre groups of the periodontal ligament

These are:

- **Oblique fibres**, which run obliquely from alveolar bone to tooth.
- **Apical fibres**, which radiate from the apex of the tooth to the adjacent alveolar bone.

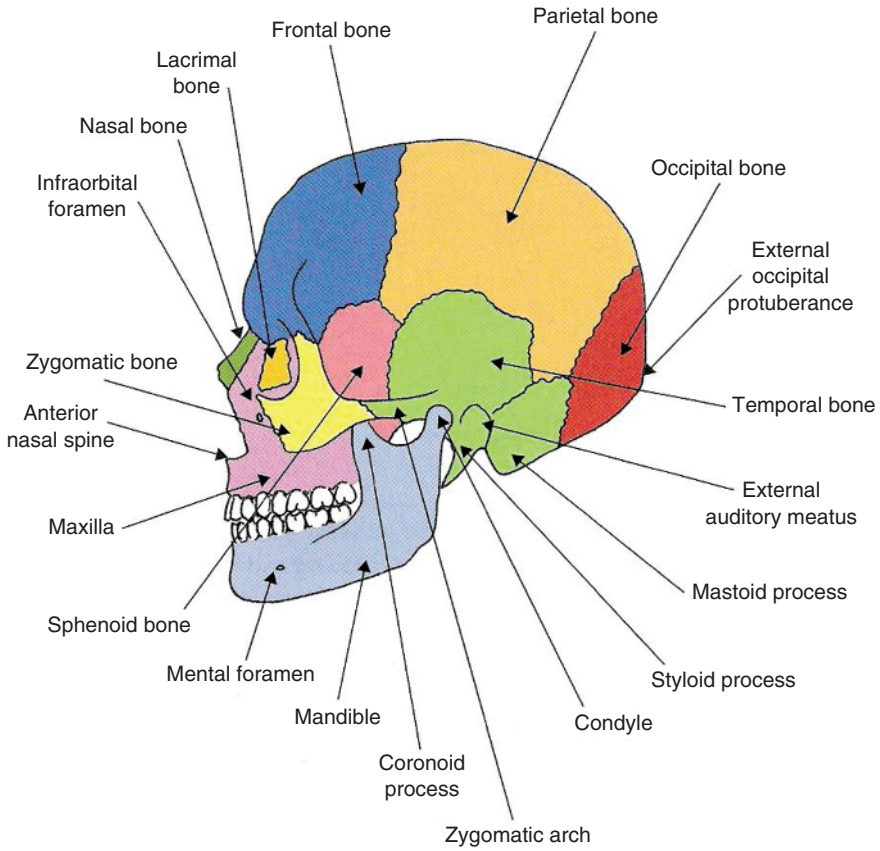


Figure 1.14 Bones of the skull. Reproduced by kind permission of R. Ireland.

Table 1.3 Bones of the cranium and facial region.

Cranium	Number	Facial region	Number
Frontal	1	Mandible	1
Ethmoid	1	Vomer	1
Occipital	1	Maxilla	2
Sphenoid	1	Palatal	2
Parietal	2	Zygomatic	2
Temporal	2	Nasal	2
		Lacrimal	2
		Inferior concha	2
Total	**8**	**Total**	**14**

- **Horizontal fibres**, which run horizontally from the cementum to the adjacent alveolar bone.
- **Inter-radicular fibres**, which are found between the roots of multi-rooted teeth and run from the root to the adjacent alveolar bone.

Oral anatomy

The skull

The skull consists of the bones of the cranium and the facial region (Figure 1.14).

Cranium

The **cranium** houses and protects the brain It consists of eight distinct bones which are joined together by sutures in the adult (Table 1.3).

Facial region

The **facial region** is made up of 14 separate bones, which include those that make up the jaws, cheeks and nose (Table 1.3).

The maxilla

The maxilla accommodates the upper dentition and forms the upper jaw. It is largely hollow because of the presence of the large **maxillary sinus** and consists of a roughly four-sided pyramidal body and four processes:

- The **frontal process** projects upwards and helps to form the lateral border of the nasal aperture and joins the frontal bone of the skull.
- The **zygomatic process** joins the zygomatic bone.
- The **horizontal palatine processes** from both maxillae form the anterior part of the hard palate. The horizontal plates of the palatine bone form the posterior part of the hard palate. The following foramina

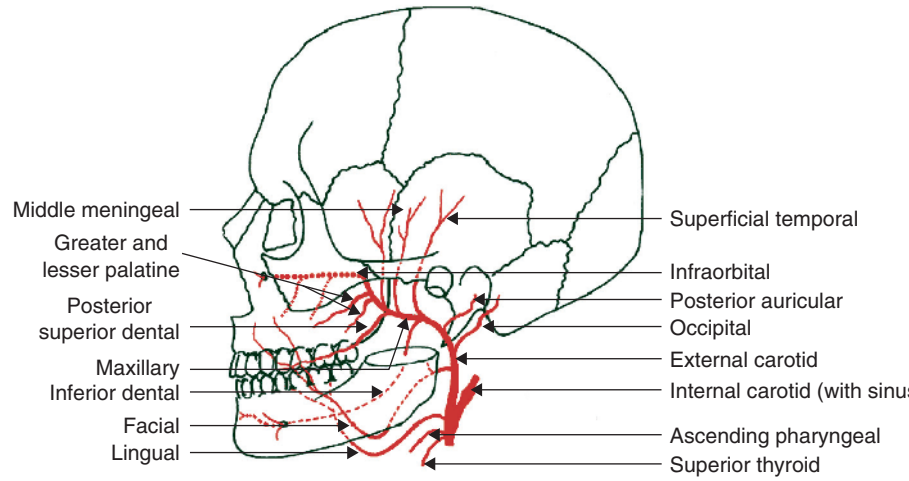


Figure 1.15 The arterial supply to the anterior part of the head. Reproduced by kind permission of R. Ireland.

can be found on the hard palate – the incisive foramen located at midline behind the central incisors through which pass the nasopalatine nerve and artery, the greater and lesser palatine foramina can be found on the posterior part of the hard palate through which pass the greater and lesser palatine nerve and artery.

- The curved **alveolar process** projects downwards and contains the sockets of the maxillary teeth.

An orbital plate forms the base of the orbit. On the anterior surface below the lower border of the orbit is the **infraorbital foramen** through which passes the infraorbital nerve and artery.

The mandible

Outer surface of the mandible

- The mandible has a horseshoe shaped body which extends upwards and backwards into the ramus.
- The ramus has two processes; the posterior **condylar process** which forms part of the temporomandibular joint and the **anterior coronoid process** to which the temporal muscle is attached.
- Anteriorly there is a triangular prominence near the midline called the **mental protuberance**.
- The **mental foramen**, through which the mental nerve and artery pass, is located buccally between the first and second premolars.
- Just posterior to the mental foramen can be found the **external oblique line** which gives attachment to the buccinator muscle.

Inner surface of the mandible (lingual)

- Anteriorly at the midline close to the lower border is a roughened oval depression called the **digastric fossa**, which is the area of attachment of the anterior belly of the digastric muscle.
- Also at the midline can be found the superior genial tubules, which provide attachment for the genioglossus muscle and the inferior genial tubules, which provide attachment for the geniohyoid muscle.
- There is a crest, the **mylohyoid line**, on the lingual surface extending from the third molar diagonally downwards and forwards from which the mylohyoid muscle takes its origin,
- Just below the mylohyoid line is a depression called the submandibular fossa which accommodates the submandibular salivary gland.
- Above the mylohyoid line anteriorly is the sublingual fossa which accommodates the sublingual salivary gland.
- In the centre of the inner surface of the ramus is the **mandibular foramen**, into which the inferior dental (alveolar) nerve and artery enter the inferior dental canal.
- Anteriorly to the mandibular foramen is a small projection of bone called the lingula which gives attachment to the sphenomandibular ligament.

Arterial supply to the oral region

The right and left common carotid arteries form the main blood supply to the head and neck. They ascend to the thyroid cartilage where they divide into the internal and external carotid arteries (Figure 1.15).

The internal carotid artery

The internal carotid artery enters the cranium through the carotid canal to supply the eye and the brain.

The external carotid artery

This has the following branches:

- **Superior thyroid artery**: this is the first branch of the external carotid artery and supplies the thyroid gland.

- **Ascending pharyngeal artery**: this supplies the pharyngeal wall.
- **Lingual artery**: this branch is given off at the level of the mandible; it enters the base of the tongue and divides into the sublingual, the dorsal lingual and the deep lingual arteries. The sublingual artery supplies the lingual gingiva, floor of the mouth and the sublingual salivary gland. The dorsal lingual artery supplies the posterior aspect of the tongue, pharyngeal surface and palatine tonsil. The deep lingual artery supplies the tip of the tongue.
- **Facial artery**: this branches off above the lingual artery to supply the superficial structures of the face. The facial artery has seven branches:
  - **Ascending palatine artery**: this supplies the soft palate. After giving off this branch, the facial nerve passes forwards and upwards entering the submandibular salivary gland. It then hooks around part of this salivary gland and the lower border of the mandible to emerge onto the face. At this point it gives off the submental artery.
  - **Submental artery**: this supplies the submandibular and sublingual salivary glands, adjacent muscles and skin area. After giving off this branch the facial artery runs obliquely across the face up to the medial corner of the eye, giving off the following branches:
  - **Inferior labial artery**: this supplies the lower lip
  - **Superior labial artery**: this supplies the upper lip
  - **Lateral nasal artery**: this supplies the skin and muscles of the nose.
  - **Angular artery**: this supplies the eyelids
  - **Supraorbital artery**: this supplies the forehead area.
- **Occipital artery**: this supplies the occipital scalp area.
- **Posterior auricular artery**: this branch is given off at the level of the ear lobe and supplies the outer ear and adjacent scalp area.
- **Superficial temporal artery**: this branch originates within the parotid gland; it supplies the parotid gland, masseter and temporalis muscles and the outer ear.
- **Maxillary artery**: the superficial temporal artery and the maxillary artery are the terminal branches of the external carotid. The maxillary artery is the largest and most complex branch supplying the deep structures of the face. The following branches are relevant to the oral cavity:
  - **Middle meningeal artery**: this artery enters the cranium through the foramen spinosum to supply the dura mater.
  - **Inferior dental artery**: this follows the same course as the inferior dental nerve. It enters the mandibular foramen to supply the mandibular molars and premolars. Just before the inferior dental artery enters the mandibular canal it gives off the mylohyoid branch that supplies the mylohyoid muscle. At the mental foramen area the inferior dental artery branches into two, the mental and incisive branches. The **mental branch** supplies the labial gingiva of mandibular anterior teeth, mucosa and skin of the lower lip and the chin. The **incisive branch** continues in the inferior dental canal to supply the mandibular anterior teeth.
  - **Posterior superior dental artery**: this supplies the maxillary molar teeth and adjacent buccal gingiva and maxillary sinus.
  - **Infraorbital artery**: this has two branches; the **middle superior dental** branch supplies the maxillary premolar teeth and adjacent buccal gingiva. The **anterior superior dental** branch supplies the maxillary canine, lateral and central teeth and adjacent buccal gingiva.
  - **Greater and lesser palatine arteries**: the greater palatine artery supplies the hard palate and the palatal gingiva. The lesser palatine artery supplies the soft palate.
  - **Nasopalatine artery**: this branches off the sphenopalatine artery and passes through the incisive foramen to join the greater palatine artery.
  - **Masseteric artery**: this supplies the masseter muscle.
  - **Temporal artery**: this supplies the temporalis muscle.
  - **Medial and lateral pterygoid arteries**: these supply the medial and lateral pterygoid muscles.
  - **Buccal artery**: supplies the cheek and buccinator muscle.

Venous drainage of the oral region

The venous drainage of the head and neck is almost entirely by branches of the internal jugular vein. The pathways of the veins are much more variable than the arteries and therefore their location is much less predictable. In addition there are numerous anastomoses with different veins.

The veins of the face are divided into superficial and deep veins.

Superficial veins

The superficial **temporal** and **facial** veins drain the superficial areas of the face.

The superficial temporal vein descends through the parotid gland and is joined by the maxillary vein to form the **retromandibular vein**. The retromandibular vein divides into posterior and anterior branches. The **posterior retromandibular vein** joins with the **posterior auricular vein** forming the **external jugular vein**. The anterior branch joins the facial vein forming the **common facial vein** draining into the internal jugular vein, which empties into the brachiocephalic vein.

Deep veins

The pterygoid plexus is a dense network of veins situated within the infratemporal fossa close to the lateral pterygoid muscle. This plexus drains the oral and nasal cavities and empties into the maxillary vein. The pterygoid plexus has direct communication with the cavernous sinuses within the cranium. Misplaced block local analgesic injections can penetrate this plexus and may result in a haematoma (bleeding into the tissues). Infections from the oral cavity may also track to the brain via this route.

Nerve supply of the oral region

The nervous system of the body is made up of the central nervous system (CNS – the brain and spinal cord) and the peripheral nervous system (PNS). The PNS is further subdivided into the sensory–somatic nervous system, consisting of 12 pairs of cranial nerves and 31 pairs of spinal nerves, and the autonomic nervous system which has nerve fibres running between the CNS and various internal organs (e.g. heart, lungs and salivary glands). The autonomic nervous system is further subdivided into the sympathetic nervous system (prepares the body for flight or fright by the release of acetyl choline and norepinephrine (noradrenaline)) and the parasympathetic nervous system (reverses the changes induced by the sympathetic nervous system).

The 12 pairs of cranial nerves arise directly from the brain. They are either:

- **Sensory**: they contain sensory (afferent) nerve fibres, which transmit stimuli such as pain, smell or visual images to the brain, e.g. the optic and ophthalmic nerves.
- **Motor**: these contain motor (efferent) nerve fibres and pass nerve impulses from the brain to muscles, e.g. the hypoglossal nerve.
- **Mixed**: as their name implies, contain both sensory and motor nerve fibres, e.g. the trigeminal, facial and glossopharyngeal nerves.

The 12 cranial nerves are:

I	Olfactory
II	Optic
III	Oculomotor
IV	Trochlear
V	Trigeminal
VI	Abducent
VII	Facial
VIII	Vestibulocochlear
IX	Glossopharyngeal
X	Vagus
XI	Accessory
XII	Hypoglossal

The trigeminal nerve – Vth cranial nerve

The trigeminal nerve is the main source of innervation for the oral cavity; it is the largest cranial nerve arising from the **pons**. At the **semilunar ganglion**, the trigeminal nerve divides into three divisions: the ophthalmic, the maxillary and the mandibular. It is the maxillary and mandibular divisions that innervate the teeth and their surrounding tissues.

Maxillary division

The maxillary nerve leaves the cranium through the **foramen rotundum** and enters the pterygopalatine fossa where it subdivides into three main branches, the zygomatic nerve, the pterygopalatine nerves and the infraorbital nerve.

- The **zygomatic nerve** enters the orbit through the inferior orbital fissure to supply sensory fibres to the zygomatic area of the face.
- The pterygopalatine ganglion gives rise to the **pterygopalatine nerves**, the nasopalatine, the greater palatine and the lesser palatine nerve. They supply the sensory fibres to the palatal mucosa of the hard palate and palatal gingiva. The **nasopalatine nerve** passes through the incisive foramen to supply the anterior region and the **greater palatine nerve** passes through the greater palatine foramen to supply the posterior premolar and molar regions. The **lesser palatine nerve** passes through the lesser palatine foramen to supply the soft palate.
- **The infraorbital nerve** enters the orbit through the inferior orbital fissure and passes along the infraorbital canal from where it finally emerges onto the face through the infraorbital foramen to supply the lower eyelid, the side of the nose and the upper lip. The infraorbital nerve gives off the superior alveolar nerve branches. These are:
  - The **posterior superior alveolar nerve:** this branch is given off just before the infraorbital nerve enters the canal. It passes downwards onto the posterior surface of the maxilla and enters very small canals that run above the tooth roots to supply sensory fibres to the maxillary third and second molar teeth and the distobuccal and palatal roots of the maxillary first molar. This nerve also supplies sensory fibres to the adjacent buccal gingiva and maxillary sinus.
  - The **middle superior alveolar nerve**: this is not always present. When it is, it arises from the infraorbital nerve within the infraorbital canal. It passes down the wall of the maxillary sinus to supply sensory fibres to the mesiopalatal root of the maxillary first molar and the first and second premolar teeth. This nerve also supplies sensory

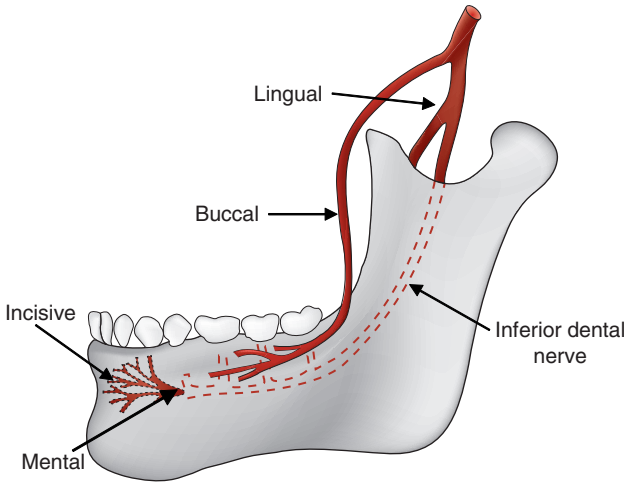


Figure 1.16 Diagram of the main branches of the mandibular nerve.

fibres to the adjacent buccal gingiva and maxillary sinus.

- The **anterior superior alveolar nerve**: this arises from the infraorbital nerve just before it emerges through the infraorbital foramen. It passes downwards inside the maxillary antrum. It supplies sensory fibres to the maxillary central and lateral incisor and canine teeth and to the adjacent labial gingiva. It also supplies the maxillary sinus.

The branches of the superior dental nerves form a plexus above the apices of the maxillary teeth.

Mandibular division

The mandibular division is the largest division of the trigeminal nerve. It contains both motor and sensory fibres. It leaves the cranium through the **foramen ovale** and enters the infratemporal fossa, (deep to the lateral pterygoid muscle) where it gives off the following branches (Figure 1.16):

- **Nerves to the muscles of mastication**: these branches supply motor fibres to the masseter, temporalis and lateral pterygoid muscle.
- **Buccal nerve (long buccal)**: this nerve supplies sensory fibres to the mucosa and skin of the cheek and the buccal gingiva of the lower molar teeth.
- **Auriculotemporal nerve**: this branch supplies sensory fibres to the temporomandibular joint, the skin of the outer ear and temporal area. It also carries parasympathetic fibres derived from the glossopharyngeal nerve to the parotid gland.
- **Lingual nerve**: this branch supplies sensory fibres to the lingual gingiva of all the lower teeth, the anterior two-thirds of the tongue and the floor of the mouth. The chorda tympani branch of the facial nerve joins the lingual nerve providing special taste fibres to the anterior two-thirds of the tongue. It also carries parasympathetic fibres to the submandibular ganglion to supply the submandibular and sublingual salivary glands.
- **Inferior dental (alveolar) nerve**: this nerve enters the inferior dental canal through the mandibular foramen. Just before it enters it gives off the **mylohyoid nerve** that supplies motor fibres to the mylohyoid muscle and the anterior belly of the digastric. Within the inferior dental canal, the inferior dental nerve gives off sensory fibres to the mandibular molars and premolars. At the mental foramen area the inferior dental nerve branches into the mental and incisive branch. The **mental branch** passes through the mental foramen to supply sensory fibres to the labial gingiva of mandibular anterior teeth, mucosa and skin of the lower lip and the chin. The **incisive branch** continues in the inferior dental canal to supply sensory fibres to the mandibular anterior teeth.

The facial nerve – VIIth cranial nerve

The facial nerve enters the internal auditory meatus and travels through the facial canal which is in the temporal bone. Within the facial canal it gives off the following branches (Figure 1.17):

- **Chorda tympani nerve**: this nerve joins the lingual nerve carrying special taste fibres to the anterior two-thirds of the tongue.
- **Greater petrosal nerve**: this nerve supplies parasympathetic fibres to the mucous membrane of the palate and nasal cavity.
- The facial nerve leaves the cranium through the stylomastoid foramen and gives off branches to the posterior belly of the digastric and stylohyoid muscle. It enters the parotid gland where it gives off five terminal branches: the **temporal**, **zygomatic**, **buccal**, **mandibular** and **cervical**. These branches supply motor fibres to the muscles of facial expression.

The glossopharyngeal nerve – IXth cranial nerve

The glossopharyngeal nerve leaves the cranium through the jugular foramen. It supplies sensory taste fibres to the posterior one-third of the tongue and sensory and motor fibres to the soft palate and pharynx. It also carries parasympathetic fibres to the auriculotemporal nerve and mandibular division of the trigeminal.

The hypoglossal nerve – XIIth cranial nerve

The hypoglossal nerve leaves the cranium through the hypoglossal canal. It supplies motor fibres to the intrinsic and extrinsic muscles of the tongue (except the palatoglossal muscle).

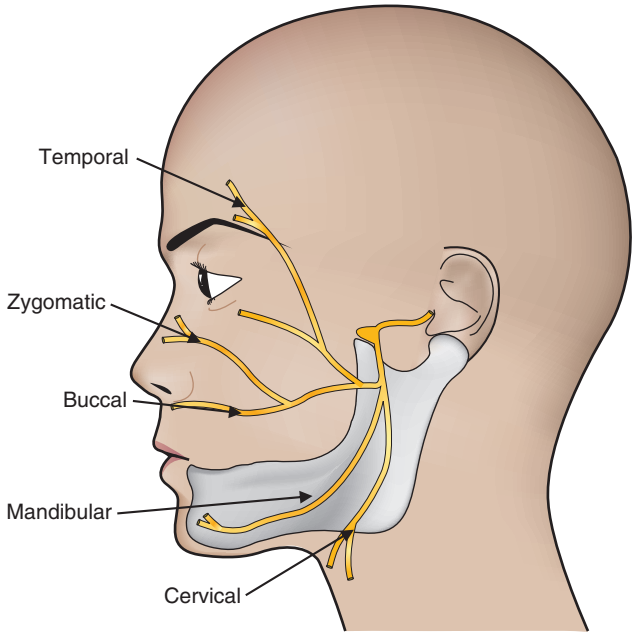


Figure 1.17 The course of the facial nerve.

Anatomy of the oral cavity

The oral cavity is bounded by the lips and cheeks anteriorly and it extends posteriorly to the palatoglossal and palatopharyngeal arches (pillars of the fauces). The hard palate forms the roof of the oral cavity and the floor of the mouth forms the floor, this space being occupied by the tongue. The oral cavity also contains the upper and lower alveolar ridges which house the teeth. The area between the lips and alveolar ridge and teeth is termed the **vestibular sulcus**.

The lips

The lips contain the orbicularis oris muscle. They are covered by skin externally and mucous membrane internally; where the external surface meets the internal surface a distinct line may be seen termed the **vermillion border**.

The external red border of the lips is termed the **vermillion zone**. A shallow depression extending from the midline of the nose to the centre of the upper lip is called the philtrum. The **nasolabial grooves** are shallow depressions extending from the corner of the nose to the corner of the lips. Between the lower lip and chin can be found a midline linear depression. This is called the **labiomental groove**.

The inner surface of the lip is tightly bound to connective tissue. At the midline, the upper and lower lips are attached to the alveolar ridges by a **labial fraenum**.

Cheeks

The bulk of the cheek is made up of the **buccinator muscle**, which is attached to the alveolar bone adjacent to the upper molar region, the external oblique line of the mandible and the **pterygomandibular raphe**; it inserts into the orbicularis oris muscle. The buccinator muscles give tone to the cheeks and play a part in mastication.

The cheeks are covered by skin externally and the internal surface is covered by non-keratinized mucosa, except at the occlusal level where it is keratinized; at the junction there is often a whitish horizontal line called the **linear alba**. The cheeks have numerous minor salivary glands and in the region of the maxillary second permanent molar the parotid duct (**Stensen's duct**) can be seen marked by the parotid papilla.

Floor of the mouth

The floor of the mouth is made up of the mylohyoid, genioglossus, geniohyoid and the digastric (anterior belly) muscles. The floor of the mouth is covered by non-keratinised mucosa.

The lingual fraenum connects the under surface of the tongue to the floor of the mouth. On either side on this fraenum can be found the submandibular salivary ducts (**Wharton's ducts**). The ducts of the sublingual glands are numerous and can be found along the sublingual folds or **plica sublingualis**.

The tongue

The tongue is a muscular organ that plays an important part in mastication, taste, cleansing, speech, deglutition, suckling and exploring.

The **inferior surface of the tongue** is covered by a thin non-keratinised mucosa which is continuous with the floor of the mouth. On either side of the lingual fraenum lie the fimbriated folds ('frilly' folds) of tissue. The deep lingual vein is also visible.

The **dorsum of the tongue** is divided into the anterior two-thirds that lie within the oral cavity and the posterior third that faces the pharynx (Figure 1.18). A 'V'-shaped groove termed the **sulcus terminalis** separates the anterior part from the posterior part. At the apex of the 'V' is a small pit called the **foramen caecum**. A median fibrous septum runs from the tip of the tongue dividing the tongue into two halves.

The anterior two thirds of the tongue are covered by specialised keratinised mucosa. Four types of papillae can be found on the surface:

- **Circumvallate papillae**: these vary from 10–14 and can be found immediately in front of the sulcus terminalis. They are the most conspicuous papillae being large mushroom shaped, 1–2 mm in diameter and surrounded by a trough. Within these troughs can be

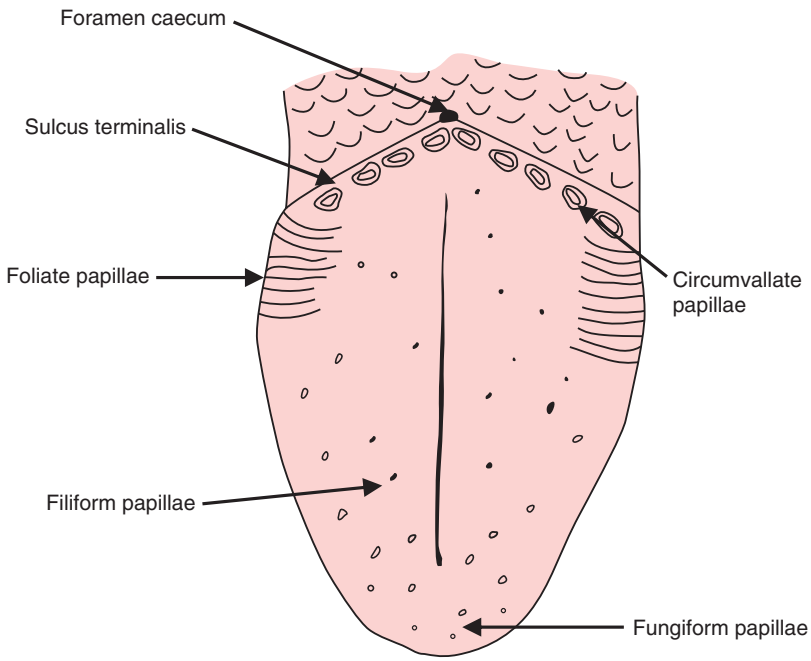


Figure 1.18 Diagram of the upper surface of the tongue.

Table 1.4 Intrinsic muscles of the tongue.

Intrinsic muscles of the tongue		
Muscle	Location	Function
Longitudinal fibres are grouped into superior and interior fibres	**Superior fibres**: found below the mucosa of the dorsum of the tongue, they run in an anterior–posterior direction from the tip of the tongue **Inferior fibres**: found at the base of the tongue they also run anterior–posterior direction	Contraction of the superior fibres causes the tip of the tongue to curl upwards and backwards Contraction of the inferior fibres pulls the tip of the tongue downwards When the inferior and superior fibres contract the tongue shortens in length
Transverse fibres	These fibres run horizontally from the fibrous septum to the borders of the tongue	Contraction narrows and increase the height of the tongue
Vertical fibres	These fibres run from the dorsum of the tongue to the under surface of the tongue	Contraction flattens and broadens the tongue

found taste buds and a special group of serous glands known as **Von Ebner's glands** which wash out these troughs.

- **Filiform papillae**: these are very numerous, conical elevations which create the rough texture of the tongue.
- **Fungiform papillae**: these are mushroom shaped, less numerous and can be seen as visible red dots at the tip and sides of tongue. They contain taste buds.
- **Foliate papillae**: found posteriorly along the lateral borders of the tongue, in parallel folds containing taste buds.

The posterior third of the tongue consists of lymphoid tissue covered by non-keratinized mucosa which has a nodular appearance.

Muscles of the tongue

The tongue consists of intrinsic muscles that alter the shape of the tongue and extrinsic muscles which move it to facilitate eating, swallowing and communication and originate from remote structures and insert into the tongue (Table.1.4).

A median fibrous septum divides the tongue into two halves, thus all the muscles are paired.

Table 1.5 Extrinsic muscles of the tongue.

Extrinsic muscles of the tongue			
Muscle	Point of origin	Point of insertion	Function
Genioglossus	Superior genial tubercle on the inner aspect of the mandible	Superior fibres insert into the under surface of the tongue	The superior fibres retract the tongue
		Inferior fibres insert onto the hyoid bone	The inferior fibres protrude the tongue when they contract
			The tongue is depressed when the superior and inferior fibres contract together
Hyoglossus	Hyoid bone	Side of the tongue	Depresses the dorsum of the tongue
Styloglossus	Styloid process	Side of the tongue	Draws the tongue upwards and backwards
Palatoglossus	Soft palate runs down the palatoglossal folds	Side of the tongue	Elevates the tongue to the palate and depresses the soft palate towards the tongue

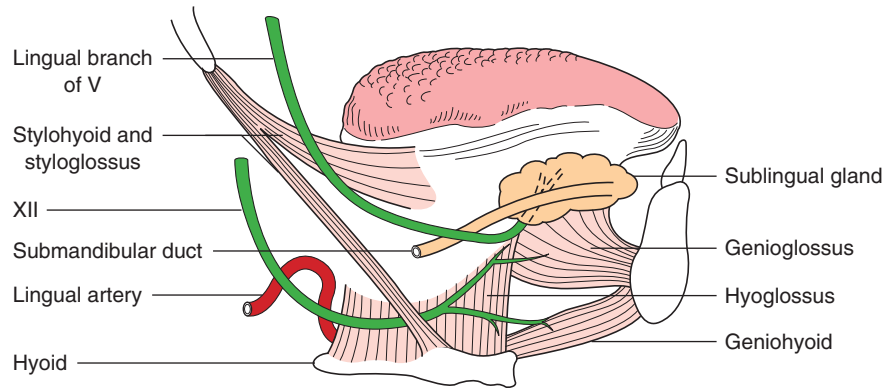


Figure 1.19 Diagram of the extrinsic muscles of the tongue. Reproduced with permission from Fiaz, O. and Moffat, D. Anatomy at a Glance, 2nd edn. Blackwell Publishing.

Extrinsic muscles

The extrinsic muscles of the tongue all have names ending in *-glossus* (Table 1.5 and Figure 1.19). Most of the muscles are innervated by the hypoglossal nerve (XIIth cranial nerve).

The palate

The palate separates the oral cavity from the nasal cavity. It is divided into the hard and soft palates.

Hard palate

The hard palate is lined with thick keratinised mucosa, which is tightly bound to the underlaying bone. Immediately behind the central incisors can be found the **incisive papilla**, an oval prominence overlaying the incisive foramen. Posterior to the incisive papilla is a midline ridge that extends vertically along the entire palate; this ridge is known as the **median palatine raphe**. Transverse ridges, the **palatine rugae**, radiate from the incisive papilla and the median palatine raphe. At the junction where the hard palate meets the soft palate lie two small indentations in the midline; these are two small salivary ducts known as **palatine foveae**.

Soft palate

The soft palate extends backwards and downwards from the posterior aspect of the hard palate. It closes off the nasopharynx from the oropharynx during swallowing. The soft palate consists of a sheet of fibrous tissue covered by non-keratinised mucosa: in the midline a small conical projection called the **uvula** extends from the free edge of the soft palate. Laterally to the soft palate on each side can be found the **palatopharyngeal** and **palatoglossal arches**. Between these arches lies the **palatine tonsil**.

The gingivae

The gingivae are the part of the oral mucosa that surrounds the teeth and covers the adjacent alveolar bone and the oral mucosa. The detailed structure of the gingival tissues is described in Chapter 5.

Table 1.6 Functions of saliva.

Action	Function
Lubrication and protection	Keeps oral mucosa moist, prevents dehydration of oral mucosa, protects teeth and mucosa, acts as a barrier to irritants, aids speech, mastication and swallowing
Cleansing action	Assists in the self cleansing of oral cavity, clears loose particles of food
Taste	Dissolves substances into solution facilitating taste
Digestion	Contains enzyme amylase which converts starch into maltose
Buffering action	Helps neutralize plaque acids by increasing the pH of plaque
Maintaining water balance	Dehydration causes a reduction of saliva giving rise to dry mouth, encouraging individuals to drink
Antimicrobial action	specific immunoglobulins and antibacterial and antifungal mechanisms help to control oral microflora
Providing an ion reservoir	Saliva is saturated with inorganic ions preventing or reducing tooth dissolution. The ions also enhance remineralisation of enamel

The alveolar mucosa

The alveolar mucosa is loosely attached to the underlying bone, is non-keratinised and appears dark red. The **mucogingival junction**, or health line demarcates the attached gingiva from the alveolar mucosa.

The salivary glands

Salivary glands are compound **exocrine glands** (glands that discharge secretions, usually through a tube or a duct, onto a surface). They have special epithelial secretory cells that produce saliva. Saliva is produced by both major and minor salivary glands. The major glands are the parotid, submandibular and sublingual glands; the minor salivary glands are found throughout the oral cavity.

The functions of saliva are listed in Table 1.6.

- P**arotid gland**: this is the largest of the major salivary glands. It is located below and in front of each ear and lies on the surface of the masseter muscle. The parotid gland produces a pure serous secretion that enters the oral cavity through the parotid duct opposite the upper second molar tooth. The parotid gland is enclosed in a strong fibrous capsule. Several important structures pass through the parotid gland; namely the facial nerve, facial vein, external carotid and temporal vein. The parotid gland is supplied by the glossopharyngeal nerve.
- **Submandibular gland**: this lies in the submandibular fossa below the mylohyoid line on the inner aspect of the mandible. Part of the gland extends posteriorly around the free boarder of the mylohyoid muscle to lie above the mylohyoid muscle. The submandibular gland produces a mixture of serous and mucous secretions that enter the oral cavity though a small lingual papilla (**lingual caruncle**) on either side of the lingual fraenum. The submandibular gland is contained in a loose capsule through which passes the facial artery. Innervation is by the chorda tympani branch of the facial nerve and the lingual nerve.
- **Sublingual gland**: this is the smallest of the major salivary glands. It lies within the sublingual fossa on the inner aspect of the mandible above the mylohyoid muscle and below the sublingual folds. The sublingual gland produces a mixed secretion that is predominantly mucous, which enters the oral cavity through 8–20 small ducts (**plica sublingualis**) along the sublingual folds. The sublingual gland is not capsulated. The nerve supply is the same as for the submandibular gland.

The parotid glands receive their parasympathetic innervation from the glossopharyngeal nerve via the auriculotemporal nerve. The submandibular and sublingual glands receive their parasympathetic innervation from the chordae tympani, (branch of the facial nerve) via the lingual nerve and submandibular ganglion. The sympathetic nerve fibres are derived from superior cervical ganglion and follow the external carotid artery to reach the salivary glands.

Salivary flow

Both parasympathetic and sympathetic nerve fibres innervate the acini controlling the flow of saliva. The parasympathetic nerves fibres stimulate saliva production and the sympathetic nerve fibres increase the salivary composition and to some extent the salivary flow, however to a much lesser extent than the parasympathetic stimulation.

The salivary glands are capable of secreting approximately 0.5–0.6 litres of saliva per day. The normal adult unstimulated flow of saliva is between 0.3–0.4 ml per minute, of which approximately 25% comes from the parotid glands, 60% from the submandibular glands, 7–8% from the sublingual glands and 7–8% from the minor salivary glands. When stimulated, the flow can range from 1.5–2.0 ml per minute. A number of factors influence the flow rate (Table 1.7).

Table 1.7 Factors that influence saliva flow.

Decrease flow	Increase flow
Dehydration, loss of body fluids	Smoking
Position of body – lying down, sleep	Sight & smell of food
Exposure to light – saliva decreases in darkness	Vomiting
Side effects of drugs	Mastication
Fright/flight response	Taste
Sjögren's syndrome	
Radiotherapy to head and neck	

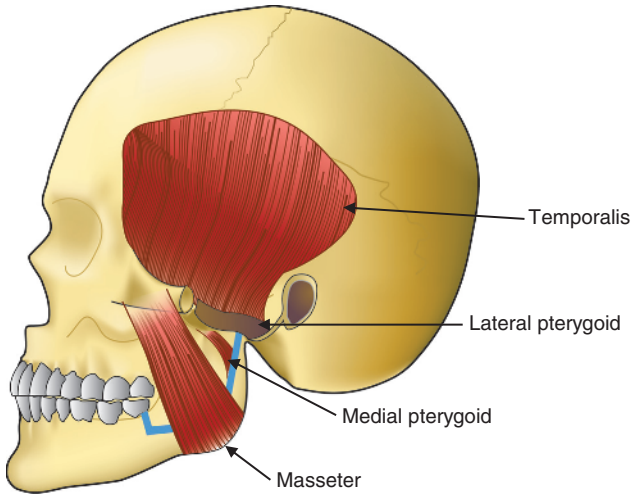


Figure 1.20 Diagram of the muscles of mastication.

Muscles of mastication

All of the muscles of mastication work together to perform a smooth co-ordinated series of movements of the mandible, they are innervated by the mandibular branch of the trigeminal nerve. The muscles of mastication can be seen in Figure 1.20; they are:

- **Temporalis**: an extensive fan-shaped muscle that covers the temporal region.
  Origin: superior and inferior temporal line of the parietal bone.
  Insertion: coronoid process and anterior border of the ramus of the mandible.
  Function: elevates and retracts the mandible. Mandibular condyles lead back to the glenoid fossa. This muscle is less powerful than the masseter.
- **Masseter**: a quadrangular muscle which has two heads deep and superficial.
  Origin: deep head is at the lower border of the zygomatic arch and the superficial head is at the zygoma.
  Insertion: lateral aspect of the ramus and the coronoid process of the mandible
  Function: elevates and retracts the mandibular condyles back to the glenoid fossa. This combination is important in closing of the mandible
- **Medial pterygoid**: a thick, quadrilateral muscle that has two heads, deep and superficial
  Origin: deep head is at the medial surface of the lateral pterygoid plate and its superficial head is from the tuberosity of the maxilla.
  Insertion: the inner surface of the ramus and angle of the mandible.
  Function: It elevates, protrudes; and when only one (e.g. right) medial pterygoid contracts, it results in the mandible moving towards the opposite side (left).
- **Lateral pterygoid**: a conical muscle with its apex pointing posteriorly.
  Origin: It has two areas of origin the infratemporal surface of the greater wing of the sphenoid bone and the lateral surface of lateral pterygoid plate.
  Insertion: is into the articular disc and capsule of the temporomandibular joint and neck of the condyle.
  Function: Protrudes mandible important in opening mouth. Acts with medial pterygoid of same side (e.g. right) to move mandible to opposite side (left).
- **Digastric**: has an anterior and posterior part connected by a strong tendon.
  Origin: the posterior part originates from the mastoid notch medial to the mastoid process; it passes forward and downwards to the hyoid bone where it joins the anterior part via the tendon. The tendon passes through a fibrous sling attaching it to the hyoid bone.
  Insertion: the anterior part passes upwards and forwards to insert into the digastric fossa of the mandible.
  Function: Aids the opening movement.

The muscles of mastication move the mandible at the temporomandibular joint. This is not a simple hinge movement but a complex movement involving a combination of several different muscles.

The **buccinator**, although a muscle of facial expression, aids in maintaining the position of food within the oral cavity during chewing.

The temporomandibular joint

The temporomandibular joint (TMJ) is a double **synovial joint** consisting of the condylar process of the mandible articulating with the squamous portion of the temporal bone (Figure 1.21). A synovial joint is a joint made up of bone ends covered with cartilage, ligaments, a cavity filled with synovial fluid (joint fluid) and an outside fibrous capsule.

The articular joint surface of the temporal bone consists of a concave articular fossa and a convex articular eminence anterior to it. There is a fibrocartilaginous

disc known as the **articular disc**; this disc is saddle-shaped and lies between the glenoid fossa and the condyle. The disc varies in thickness; the middle portion of the disc is thinner than the anteriorly and posteriorly portions. Posteriorly the disc is fused with the TMJ capsule and anteriorly it is attached to the lateral pterygoid muscle, dividing the joint into two distinctive compartments the upper and lower spaces. The upper joint space is bounded on the top by the articular fossa and the articular eminence. The lower joint space is bounded at the bottom by the condyle. The entire TMJ is enclosed in a fibrous capsule, the inner aspect of this capsule is lined with synovial membrane; this produces synovial fluid, which provides lubrication and nutrients to the TMJ.

The fibrous capsule is strengthened by the temporomandibular ligament, which runs from the articular eminence to the neck of the condyle. The sphenomandibular and stylomandibular ligaments limit excessive movements of the TMJ during mastication. The sphenomandibular ligament runs from the spine of the sphenoid to the mandibular lingula and the stylomandibular ligament runs from the styloid process of the temporal bone to the angle of the mandible.

The two movements that occur at this joint are forward gliding and a hinge-like rotation. When the jaw opens, the head of the mandible and articular disc move forwards on the articular surface. As this forward gliding movement occurs, the head of the mandible rotates on the lower surface of the articular disc. The disc serves to cushion and distribute the loading on the joint and provide stability during chewing. Tooth clenching (parafunction) or an alteration to the occlusal surfaces of the teeth such as due to an incorrectly contoured restoration, can initiate stresses in the joint which may lead to pain or dysfunction.

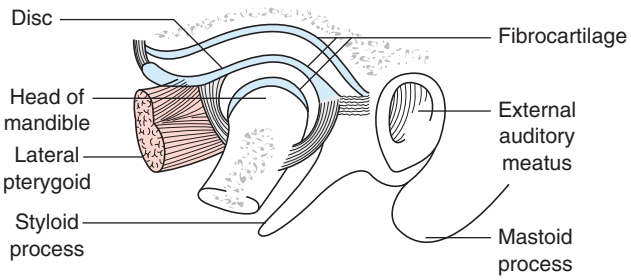


Figure 1.21 Diagram of the temporomandibular joint. Reproduced with permission from Fiaz, O. and Moffat, D. Anatomy at a Glance, 2nd edn. Blackwell Publishing.

Muscles of facial expression

The muscles of the face are collectively known as the muscles of facial expression. (Figure 1.22) They are responsible for facial expressions and also they aid speech and chewing and are of importance to musicians. They are a large group of superficial muscles, which have their insertion into the skin and not the bone; they are innervated by the facial nerve.

The **orbicularis oris** muscle controls the opening of the mouth and other muscles radiate outwards from the orbicularis oris to move the lips or the angles of the mouth; these are:

- **Risorius** – draws the angles of the mouth sideways as in a grin.
- **Zygomaticus** – pulls the upper lip upwards and laterally.

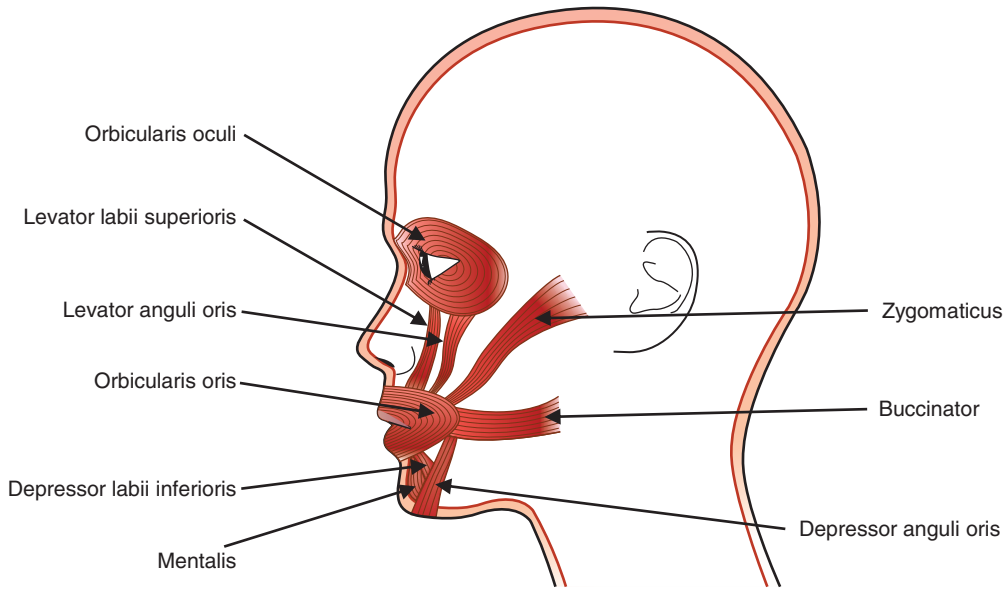


Figure 1.22 Diagram of the muscles of facial expression.

- **Levator anguli oris** – raises the angles of the mouth as in a smile.
- **Levator labii superioris** – raises the upper lip.
- **Mentalis** – turns the lower lip outwards as in pouting, wrinkles the skin of chin.
- **Depressor labii inferioris** – depresses and inverts the lower lip.
- **Depressor anguli oris** – depresses the angles of the mouth giving a sad appearance.

During chewing, the **buccinator** muscle works in conjunction with the masticatory muscles, by keeping the bolus of food on the occlusal surfaces of teeth. In infants, the buccinator provides suction for suckling at the breast.

Tooth morphology

During our life time we develop two dentitions: a primary dentition (deciduous) and a permanent dentition. The primary dentition consists of 20 teeth and the permanent dentition consists of 32 teeth. Teeth are arranged in maxillary (upper) and mandibular (lower) dental arches each arch is divided into left and right. There are four types of teeth: incisors, canines, premolars and molar teeth. Each primary tooth is recorded as a letter A, B, C, D and E and each permanent tooth is numbered from 1–8. (See Tables 1.1 and 1.2.)

Differences between primary and permanent teeth can be found in Chapter 12 Paediatric Dentistry.

Tooth identification

The main factors to look for when identifying teeth is size, shape, roots and colour.

A good understanding of the following terminology is essential (Table 1.8).

Table 1.8 Tooth identification terminology.

Terminology	
Mesial surface	Surfaces of teeth facing the midline
Distal surface	Surfaces of teeth faces away from midline
Lingual surface	Surfaces of teeth adjacent to the tongue
Palatal surface	Surfaces of teeth adjacent to the palate
Buccal surface	Surfaces of posterior teeth adjacent to the cheek (premolars and molars)
Labial surface	Surfaces of anterior teeth adjacent to the lip (incisors and canines)
Occlusal surface	Biting surface of posterior teeth
Incisal edge	Cutting edge of anterior teeth
Apex	Tip of the root
Bifurcation	Where a root divides into two
Cervical margin	The junction where the anatomical crown and anatomical root meet
Cingulum	Bulbous convex area found in the cervical third on palatal and lingual surfaces of anterior teeth.
Concave	Curved inwards making a depression
Contact area	An area where the crown of two adjacent teeth meet.
Convex	Curved outwards.
Fissure	A shallow groove found on the occlusal surfaces between the cusps
Fossa	A shallow rounded depression in a surface of a tooth
Marginal ridge	A ridge of enamel at the mesial and distal edges of a tooth.
Oblique ridge	A ridge of enamel running obliquely a cross the occlusal surface
Pit	Small pin point depression found in enamel
Transverse ridge	A ridge of enamel crossing the occlusal surface

The permanent teeth (Figure 1.23a)

Permanent incisors

Identifying features of the maxillary permanent central incisor

Crown

This is the largest of all permanent incisors.

Labial surface

- Labial surface is convex with two faint grooves running vertically onto incisal edge to produce three small protuberances called **mamelons** (only seen in newly erupted teeth).
- Mesial surface straight and the mesial incisal edge is almost a right angle.
- Distal incisal edge is more rounded.

Palatal surface

- Triangular in shape, concave in all directions producing the palatal fossa.
- Pronounced marginal ridges mesial and distal, which meet at a prominence called the **cingulum.**

Root

- Single root about 1½ times length of crown.
- The apex of the root frequently curves distally

Identifying features of the maxillary permanent lateral incisor

Crown

- Similar in form to the central incisors except it is much smaller. The crown can vary in shape.

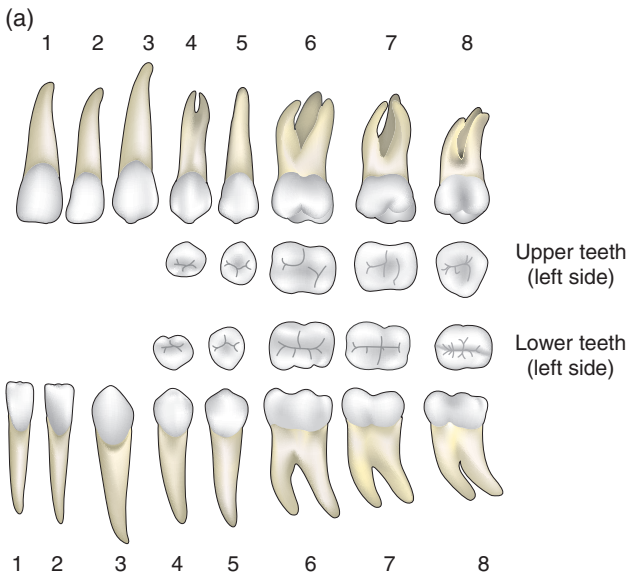


Figure 1.23a Upper and lower permanent teeth.

Labial surface

- More convex than the central incisors, mamelons and vertical grooves less prominent.
- Mesial incisal angle is sharper and distal incisal corner is more rounded than the central incisor.

Palatal surface

- Is triangular in form with rounded edges.
- Pronounced palatal fossa
- Often has a small pit where the marginal ridge meets the cingulum (**foramen caecum incisivum**).

Root

Single root, mesial and distal surfaces are flattened and grooved.

The apex of the root frequently curves distally.

Identifying features of the mandibular permanent central incisor

Crown

- Smallest tooth in the permanent dentition.

Labial surface

- Convex in cervical third and flattens out towards the incisal third.
- Mesial and distal incisal edge at right angles.
- Incisal edge has mamelons on newly erupted.

Lingual surface

- Is smooth and featureless, marginal ridges and cingulum being less developed.
- The crown is narrower on the lingual surface than the labial.

Root

- Single root, mesial and distal surface grooved, the distal groove being more marked.
- The apex of the root frequently curves distally.

Identifying features of the mandibular lateral permanent incisor

Crown

- Very similar to the lower central incisor. Crown appears fan shaped.

Labial surface

- The incisal edge mesiodistally is wider than the lower central and it follows the curve of the lower arch.
- Mesial side of crown is slightly longer than the distal.
- Distal incisal angle is rounded than the sharp mesial incisal angle.

Lingual surface

- Cingulum is off-centre to the distal, faint mesial and distal marginal ridges.

Root

- Single root.
- Crown of the lateral incisor tends to tilt distally on root, crown appears slightly askew.
- Mesial and distal surface grooved, the distal groove being more marked.
- The apex of the root frequently curves distally

Permanent canines

Identifying feature of the maxillary permanent canine

Crown

Labial surface

- Crown irregular diamond shape, convex in all directions.
- Incisal edge has a large pointed cusp. The distal slope of the cusp is longer than the mesial slope.
- Distal profile of crown more rounded than the mesial.
- The tip of the cusp is placed centrally in line with the long axis of the tooth.

Palatal surface

- Concave apart from a prominent convex cingulum.
- A vertical ridge runs from the cingulum to the tip of the cusp, on each side of this ridge is a depression (mesial and distal palatal fossae).
- The marginal ridges are also very prominent.

Root

- Single root, twice the length of the crown and the longest root of the permanent dentition.

- Mesial and distal surface is flattened and grooved. The distal groove may be more distinctive.

Identifying features of the mandibular permanent canine

Crown

- Resembles the upper canine; however, the crown of the lower canine is longer and narrower in the mesial distal direction.
- The single cusp is less pointed than the upper canine.

Labial surface

- Crown is convex.
- Mesial outline is straight and continuous with the mesial surface of the root.
- Distal outline is concave cervically but becomes convex at distal slope.
- Distal slope longer than the mesial slope.

Lingual surface

- Lingual surface concave.
- Cingulum is absent or very small.
- Marginal ridges not well defined.
- Faint ridge runs from the tip of the cusp to the cingulum, on each side are two shallow depressions (mesial and distal lingual fossae).

Root

- Single root.
- Mesial and distal surface is flattened and grooved.
- The apex of the root frequently curves distally.

Permanent premolars

Identifying features of the maxillary first permanent premolar

Crown

- Crown quadrilateral, two cusps buccal and palatal. Palatal cusp smaller in area and in height.
- Mesial slope of the buccal cusp is longer than the distal. (This is the reverse in the canine.)
- The cusps are separated by a fissure, which runs mesiodistal. The mesial fissure crosses the mesial marginal ridge and extends onto the mesial surface.
- The mesial surface has a marked depression called the **canine fossa**.

Roots

- Two roots, one buccal and palatal.
- Sometime has a single root which is grooved mesially and distally and may be bifurcated at the apex.

Identifying features of the maxillary second permanent premolar

Crown

- Crown appears smaller, less angular and oval in shape.
- Buccal and palatal cusps are almost equal in height and size.
- Distal slope of the buccal cusp is longer than the mesial.
- The tip of palatal cusp is always positioned off centre towards the mesial.
- A short fissure runs mesiodistally and confined to the occlusal surface.
- Mesial and distal surfaces are convex and the mesial surface does not have a canine fossa.

Root

- Single root, flattened mesially and distally.
- Roots are longer than the first premolar.

Identifying features of the mandibular first permanent premolar

Crown

- Crown appears circular in outline, except mesiolingually, where it is flattened.
- Two cusps one buccal and one lingual. Buccal cusp is much larger than the lingual cusp, it dominates the occlusal surface. The lingual cusp appears like a cingulum.
- The two cusps are connected by a central ridge of enamel – transverse ridge. On each side of this ridge is a mesial and distal fossa. The distal fossa is the larger.
- Mesial fissure runs from the mesial fossa and extends onto the lingual surface.
- Mesial and distal marginal ridges are well defined.

Root

- Single root, which is flattened on the mesial and distal surfaces, the mesial groove being more marked.
- The root may be bifurcated and curved distally.

Identifying features of the mandibular second permanent premolar

Crown

- Is larger than the lower first premolar.
- May either have two or three cusps, the three cusped type being more common.
- Mesial marginal ridge is higher than the distal.
- **Two cusped second premolar** – two cusps situated buccal and lingual.
- The cusps are connected by a faint ridge of enamel. On either side of this ridge lie the mesial and distal fossae, the distal fossa being the larger.

- A fissure runs from the mesial fossa to the distal fossa presenting either 'H' or 'C' fissure pattern.
- **Three-cusped second premolar** – more common. One buccal and two lingual cusps. Buccal cusp is the largest and the distolingual cusp is the smallest.
- The two lingual cusps are separated by a fissure which extends onto the lingual surface, presenting a 'Y'-shaped fissure pattern

Roots

- Single root. Grooves are not usually present.

Permanent molars

Identifying features of the maxillary first permanent molar

Crown

- Largest tooth in the upper arch.
- Rhomboid in outline with two acute and two obtuse angles.
- Four cusps: mesiopalatal, mesiobuccal, distopalatal and distobuccal.
- A fifth cusp may be present on the palatal side of the mesiopalatal cusp (**Cusp of Carabelli**).
- Mesiopalatal cusp is the largest, distopalatal cusp is the smallest.
- Buccal cusps are generally more pointed.
- Mesiopalatal cusp is joined to the distobuccal cusp by the oblique ridge. This divides the occlusal surface into two areas.
- Distal fissure runs parallel to the oblique ridge and extends onto the palatal surface.
- The mesial fissure runs from the mesial marginal ridge and extends buccally, between the two buccal cusps and extends onto the buccal surface.
- Occasionally the distal fissure may run across the oblique ridge joining the mesial fissure forming 'H'-shaped fissure pattern

Roots

- Three roots, two buccally and one palatally placed.
- Palatal root is the longest and most divergent. The buccal roots tend to curve distally.

Identifying features of the maxillary second permanent molar

Crown

- Is very similar to the upper first molar, rhomboid in outline.
- The crown is generally smaller.
- Distopalatal cusp is reduced in size and sometimes absent. If absent the occlusal outline is more triangular.
- Both distal cusps are smaller than the upper first molar.
- The cusp of Carabelli is never present.

Roots

- Three roots, similar to those of the upper first molar.
- Palatal root less divergent.
- Both buccal roots are same length, closer together with slight distal inclination.

Identifying features of the maxillary third permanent molar

Crown

- Similar to the upper first and second molars, but subject to considerable variations.
- Smaller than the upper first and second molars.
- Triangular in outline, distopalatal cusp is reduced in size.
- The distopalatal cusp is absent 50%, when this cusp is absent there is no oblique ridge.
- Largest cusp mesiopalatal.
- Occlusal surface usually has a wrinkled appearance due to additional fissures.
- Distal surface is more convex than the first and second molars, mainly because the distal surface is not in contact with a tooth.

Roots

- The roots are short, underdeveloped and rarely divergent.
- Roots often fused together with a distinct distal curve near the apex.

Identifying features of the mandibular first permanent molar

Crown

- This is the largest lower tooth.
- Rectangular in outline. Being longer mesial–distally than buccal–lingually.
- It has five cusps, three placed buccally (mesiobuccal, distobuccal, distal corner) and two cusps placed lingually (mesiolingual, distolingual).
- Lingual cusps more pointed.
- Occlusal surface has a central fossa where four fissures originate (mesial, distal, buccal and lingual).
- The mesial fissure runs mesially and bifurcates near the mesial marginal ridge.
- The distal fissure runs distally and bifurcates near the distal marginal ridge.
- A buccal fissure passes between the mesiobuccal and the distobuccal cusps and terminates on the buccal surface (buccal pit – **foramen caecum molarum**). Another buccal fissure runs between the distal and distal-buccal cusps and terminates on the buccal surface.
- The lingual fissure passes between the mesiolingual and distolingual cusp and extends slightly onto the lingual surface.

Roots

- Two roots, mesial and distal.
- Distal root is straight and shorter than the mesial root.
- Mesial root has a marked groove on the mesial surface and usually curves distally.

Identifying features of the mandibular second permanent molar

Crown

- Occlusal outline resembles a square with rounded corners.
- It has four cusps, two buccal (mesiobuccal and distobuccal) and two lingual (mesiolingual and distolingual).
- Lingual cusps are higher and slightly more pointed than the buccal cusps.
- Mesial cusps are larger than the distal cusps.
- The buccal surface is markedly convex while the lingual surface is flat.
- Distal surface slightly more convex than the mesial surface.
- Fissure pattern is similar to a 'hot cross bun'.
- The buccal fissure passes between the mesiobuccal and the distobuccal and terminates on the buccal surface.
- The lingual fissure passes between the mesiolingual and distolingual cusps and terminates on the lingual surface.

Roots

- Two roots, mesial and distal.
- Roots are closer together; occasionally the roots may be partially fused.
- Mesial root is larger than the distal.
- The roots curve distally.

Identifying features of the mandibular third permanent molar

Crown

- May be subject to considerable variations.
- A classic lower third molar has a crown form similar to the lower second molar, with four cusps.
- It is smaller and has many supplemental fissures.
- The occlusal outline may be similar to the other mandibular molars, some lower third molars a circular occlusal outline.
- The buccal surface is markedly convex while the lingual surface is flat.

Roots

- Two roots, mesial and distal.
- Similar to other lower molars, except that they are shorter and less developed and often fused together as one conical mass.
- The roots curve distally

Primary dentition

Incisors

- These teeth are smaller in size but similar in morphology to their permanent successors.
- The crowns are more bulbous.

Canines

- The crowns are much more bulbous than the permanent canines.
- When newly erupted the tip of the cusp is pointed, particularly in the upper canines.
- The mesial slope is longer than the distal slope in the maxillary and mandibular primary canine.

Primary molars (Figure 1.23b)

Identifying features of the maxillary first primary molar

Crown

- Outline of the crown trapezoid, the buccal surface is longer than the palatal surface and the mesiopalatal angle obtuse.
- Two cusps, buccal and palatal. Buccal cusp more like a ridge and is sometimes divided into two or three lobes.
- A fissure runs mesially–distally between the cusps is a fissure which bifurcates at each end.
- There is a pronounced bulge of enamel at the mesiobuccal corner of the crown near the cervical margin – Tubercle of Zuckerkandl.

Roots

- Three roots, two buccal and one palatal.
- The roots are widely divergent to accommodate the developing maxillary first permanent premolar.

Identifying features of the mandibular first primary molar

Crown

- The occlusal surface is elongated in the mesiodistal direction.
- It has four cusps, two lingual (mesiolingual, distolingual) and two buccal (mesiobuccal, distobuccal). The mesiolingual cusp is the largest.
- The mesiobuccal and the mesiolingual cusps are joined by a transverse ridge across the occlusal surface.
- On either side of this ridge is a fossa (mesial and distal fossae). The distal fossa is the largest.

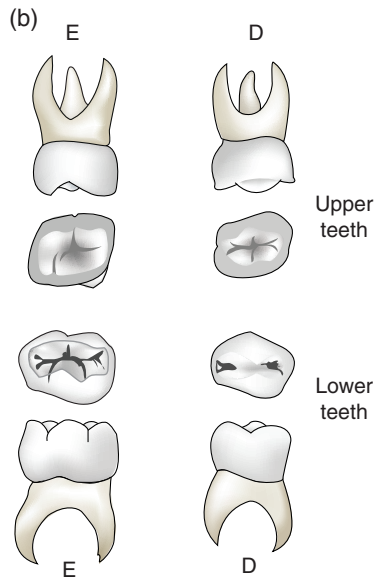


Figure 1.23b Upper and lower Primary Molars.

- Like the upper first primary molar, there is a pronounced bulge of enamel at the mesiolingual corner.

Roots

- Two roots, mesially and distally.
- Roots diverge to accommodate the developing lower first permanent premolar.

Identifying features of the maxillary second primary molar

Crown

- This tooth closely resembles the maxillary first permanent molar.
- There are four main cusps.
- Cusp of Carabelli may be present mesiopalatally.
- The oblique ridge is present, joining the mesiopalatal and distobuccal cusps.

Roots

- The roots resemble those of the maxillary first primary molars.
- They are larger and sometimes resemble the grab of a crane.
- They accommodate the developing maxillary second permanent premolar.

Identifying features of the mandibular second primary molar

Crown

- This tooth resembles the mandibular first permanent molar.
- It is smaller in size and has shallow fissures.

Roots

- Two roots, mesially and distally.
- Roots diverge to accommodate the developing mandibular second permanent premolar.

Further reading

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