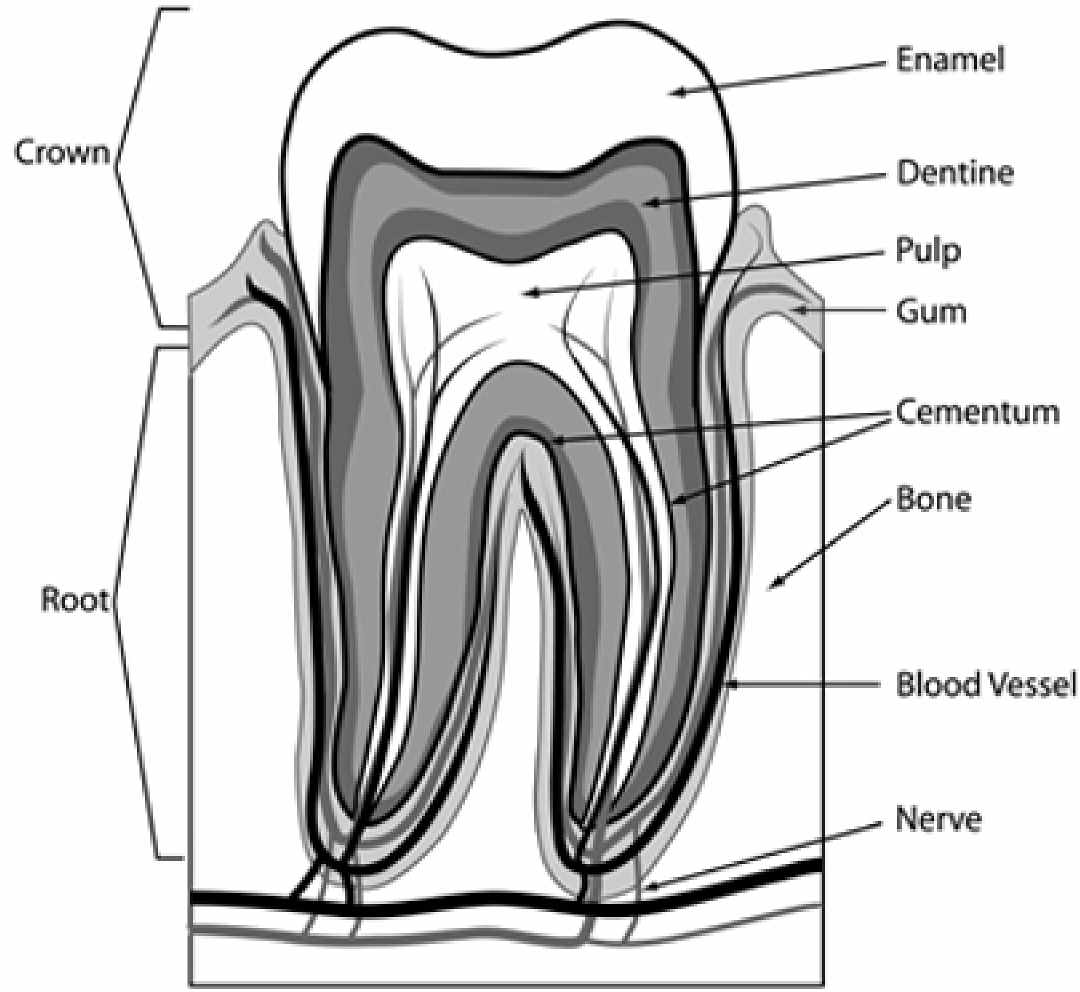
Dental Anatomy and Tooth Development



Rocio Franz

Adrienne Jordan

First Edition, 2012

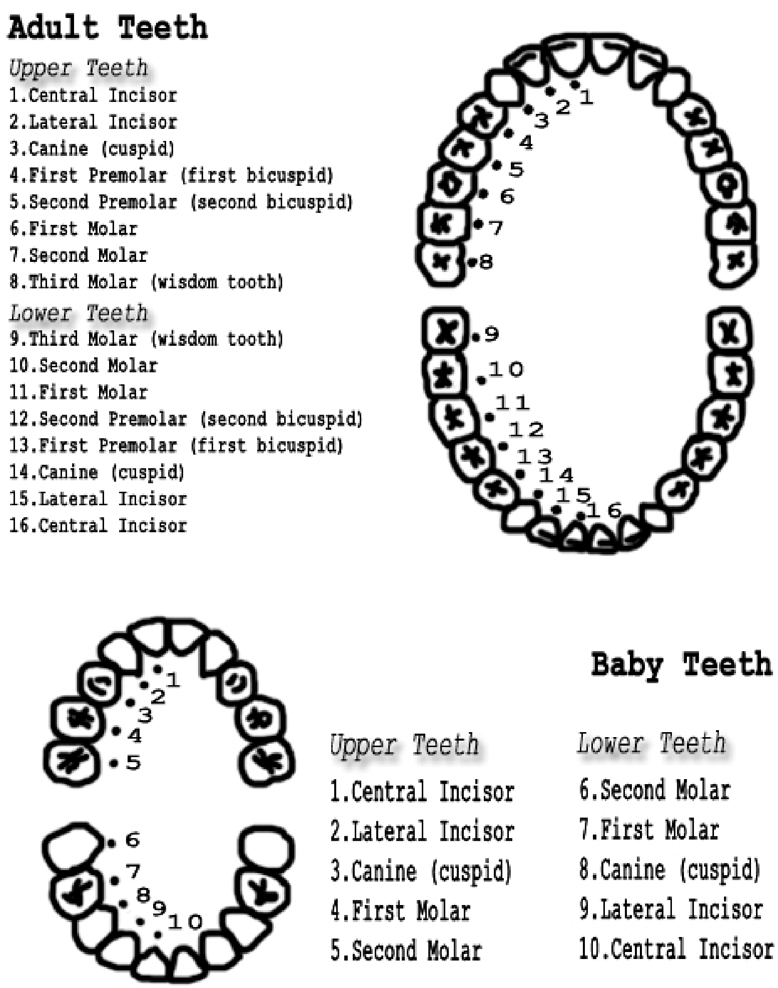
ISBN 978-81-323-1384-7

Published by:
College Publishing House
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

Table of Contents

Chapter 1

Dental Anatomy



Adult and "Baby" teeth diagram. Note the non-standard Dental notation (numbering)

Dental anatomy is a field of anatomy dedicated to the study of human tooth structures. The development, appearance, and classification of teeth fall within its purview. (The function of teeth as they contact one another falls elsewhere, under dental occlusion.) Tooth formation begins before birth, and teeth's eventual morphology is dictated during this time. Dental anatomy is also a taxonomical science: it is concerned with the naming of teeth and the structures of which they are made, this information serving a practical purpose in dental treatment.

Usually, there are 20 primary ("baby") teeth and 28 to 32 permanent teeth, the last four being third molars or "wisdom teeth", each of which may or may not grow in. Among primary teeth, 10 usually are found in the maxilla (upper jaw) and the other 10 in the mandible (lower jaw). Among permanent teeth, 16 are found in the maxilla and the other 16 in the mandible. Most of the teeth have distinguishing features.

Tooth development

Radiograph of lower right (from left to right) third, second, and first molars in different stages of development.

Panoramic x-ray radiography of the teeth of a 64 year-old male. Dental work performed mostly in UK/Europe in last half of 20th Century

Tooth development is the complex process by which teeth form from embryonic cells, grow, and erupt into the mouth. Although many diverse species have teeth, non-human tooth development is largely the same as in humans. For human teeth to have a healthy oral environment, enamel, dentin, cementum, and the periodontium must all develop during appropriate stages of fetal development. Primary (baby) teeth start to form between the sixth and eighth weeks in utero, and permanent teeth begin to form in the twentieth week in utero. If teeth do not start to develop at or near these times, they will not develop at all.

A significant amount of research has focused on determining the processes that initiate tooth development. It is widely accepted that there is a factor within the tissues of the first branchial arch that is necessary for the development of teeth. The tooth bud (sometimes called the tooth germ) is an aggregation of cells that eventually forms a tooth and is organized into three parts: the enamel organ, the dental papilla and the dental follicle.

The *enamel organ* is composed of the outer enamel epithelium, inner enamel epithelium, stellate reticulum and stratum intermedium. These cells give rise to ameloblasts, which produce enamel and the reduced enamel epithelium. The growth of cervical loop cells into the deeper tissues forms Hertwig's Epithelial Root Sheath, which determines the root shape of the tooth. The *dental papilla* contains cells that develop into odontoblasts, which are dentin-forming cells. Additionally, the junction between the dental papilla and inner enamel epithelium determines the crown shape of a tooth. The *dental follicle* gives rise to three important entities: cementoblasts, osteoblasts, and fibroblasts. Cementoblasts form the cementum of a tooth. Osteoblasts give rise to the alveolar bone around the roots of teeth. Fibroblasts develop the periodontal ligaments which connect teeth to the alveolar bone through cementum.

Tooth development is commonly divided into the following stages: the bud stage, the cap, the bell, and finally maturation. The staging of tooth development is an attempt to categorize changes that take place along a continuum; frequently it is difficult to decide what stage should be assigned to a particular developing tooth. This determination is further complicated by the varying appearance of different histologic sections of the same developing tooth, which can appear to be different stages.

Identification

Nomenclature

Teeth are named by their set, arch, class, type, and side. Teeth can belong to one of two sets of teeth: primary ("baby") teeth or permanent teeth. Often, "deciduous" may be used in place of "primary", and "adult" may be used for "permanent". "Succedaneous" refers to those teeth of the permanent dentition that replace primary teeth (incisors, canines, and premolars of the permanent dentition). Succedaneous dentition would refer to these teeth as a group. Further, the name depends upon which arch the tooth is found in. The term, "maxillary", is given to teeth in the upper jaw and "mandibular" to those in the lower jaw. There are four classes of teeth: incisors, canines, premolars, and molars. Premolars are found only in permanent teeth; there are no premolars in deciduous teeth. Within each class, teeth may be classified into different traits. Incisors are divided further into central and lateral incisors. Among premolars and molars, there are 1st and 2nd premolars, and 1st, 2nd, and 3rd molars. The side of the mouth in which a tooth is found may also be included in the name. For example, a specific name for a tooth may be "primary maxillary left lateral incisor."

Numbering systems

There are several different dental notation systems for associating information to a specific tooth. The three most commons systems are the FDI World Dental Federation notation, Universal numbering system (dental), and Palmer notation method. The FDI system is used worldwide, and the universal is used widely in the USA.

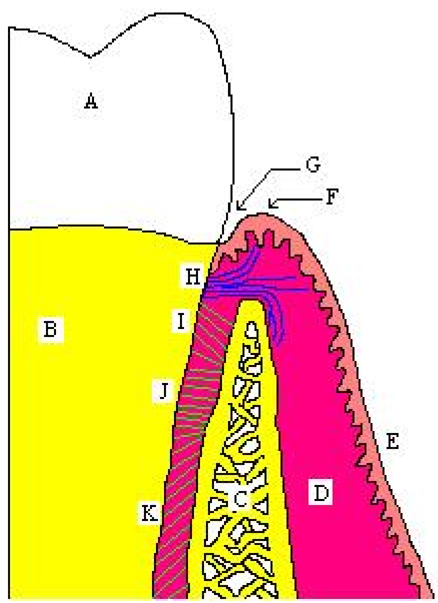
Although the Palmer notation was supposedly superseded by the FDI World Dental Federation notation, it overwhelmingly continues to be the preferred method used by dental students and practitioners in the United Kingdom. It was originally termed the "Zsigmondy system" after the Austrian dentist Adolf Zsigmondy who developed the idea in 1861, using a Zsigmondy cross to record quadrants of tooth positions.. The Palmer notation consists of a symbol (┘ └ ┐ ┌) designating in which quadrant the tooth is found and a number indicating the position from the midline. Permanent teeth are numbered 1 to 8, and primary teeth are indicated by a letter A to E. The universal numbering system uses a unique letter or number for each tooth. The uppercase letters A through T are used for primary teeth and the numbers 1 - 32 are used for permanent teeth. The tooth designated "1" is the right maxillary third molar and the count continues along the upper teeth to the left side. Then the count begins at the left mandibular third molar, designated number 17, and continues along the bottom teeth to the right side. The FDI system uses a two-digit numbering system in which the first number represents a tooth's quadrant and the second number represents the number of the tooth from the midline of the face. For permanent teeth, the upper right teeth begin with the number, "1". The upper left teeth begin with the number, "2". The lower left teeth begin with the number, "3". The lower right teeth begin with the number, "4". For primary teeth, the sequence of numbers goes 5, 6, 7, and 8 for the teeth in the upper right, upper left, lower left, and lower right respectively.

As a result, any given tooth has three different ways to identify it, depending on which notation system is used. The permanent right maxillary central incisor is identified by the number "8" in the universal system. In the FDI system, the same tooth is identified by the number "11". The palmer system uses the number and symbol, 1┘, to identify the tooth. Further confusion may result if a number is given on a tooth without assuming (or specifying) a common notation method. Since the number, "12", may signify the permanent left maxillary first premolar in the universal system or the permanent right maxillary lateral incisor in the FDI system, the notation being used must be clear to prevent confusion.

Victor Haderup of Denmark in 1891 devised a variant of eight tooth quadrant system in which plus(+) and minus(-) were used to differentiate between upper and lower quadrants, and betweenright and left quadrants(e.g.,+1=upper right central incisor;1-=lower left central incisor.).Primary teeth were numbered as upper right(05+ to 01+),lower left(-01 to -05).

Anatomic landmarks

Crown and root



The tooth is attached to the surrounding gingival tissue and alveolar bone *(C)* by fibrous attachments. The gingival fibers *(H)* run from the cementum *(B)* into the gingiva immediately apical to the junctional epithelial attachment and the periodontal ligament fibers *(I)*, *(J)* and *(K)* run from the cementum into the adjacent cortex of the alveolar bone.

The crown of a tooth can be used to describe two situations. The anatomic crown of a tooth is designated by the area above the cementoenamel junction (CEJ) and is consequently covered in enamel. Also, it is possible to describe the clinical crown of a tooth as any parts visible in the mouth, but frequently the anatomic crown is meant when the term is used. The majority of the crown is composed of dentin, with the pulp chamber found in the center. The crown is only found within bone before eruption into the mouth. Afterwards, it is almost always visible.

The anatomic root is found below the cementoenamel junction and is covered with cementum, whereas the clinical root is any part of a tooth not visible in the mouth. Similarly, the anatomic root is assumed in most circumstances. Dentin composes most of the root, which normally has pulp canals. The roots of teeth may be single in number (single-rooted teeth) or multiple. Canines and most premolars, except for maxillary first premolars, usually have one root. Maxillary first premolars and mandibular molars usually have two roots. Maxillary molars usually have three roots. The tooth is supported in bone by an attachment apparatus, known as the periodontium, which interacts with the root.

Surfaces

Surfaces that are nearest the cheeks or lips are referred to as facial, and those nearest the tongue are known as lingual. Facial surfaces can be subdivided into buccal (when found on posterior teeth nearest the cheeks) and labial (when found on anterior teeth nearest the lips). Lingual surfaces can also be described as palatal when found on maxillary teeth beside the hard palate.

Surfaces that aid in chewing are known as occlusal on posterior teeth and incisal on anterior teeth. Surfaces nearest the junction of the crown and root are referred to as cervical, and those closest to the apex of the root are referred to as apical. The words **mesial** and **distal** are also used as descriptions. "Mesial" signifies a surface closer to the median line of the face, which is located on a vertical axis between the eyes, down the nose, and between the contact of the central incisors. Surfaces further away from the median line are described as distal.

Cusp

A cusp is an elevation on an occlusal surface of posterior teeth and canines. It contributes to a significant portion of the tooth's surface. Canines have one cusp. Maxillary premolars and the mandibular first premolars usually have two cusps. Mandibular second premolars frequently have three cusps--- one buccal and two lingual. Maxillary molars have two buccal cusps and two lingual cusps. A fifth cusp that may form on the maxillary first molar is known as the cusp of Carabelli. Mandibular molars may have five or four cusps.

Cingulum

A cingulum is a convexity found on the lingual surface of anterior teeth. It is frequently identifiable as an inverted V-shaped ridge, and its appearance is comparable to a girdle. All anterior teeth are formed from four centers of development, referred to as lobes. Three are located on the facial side of the tooth, and one on the lingual side. The cingulum forms from this lingual lobe of development. The majority of a lingual surface's cervical third is made up of the cingulum. On lower incisors, a cingulum usually is poorly developed or absent. Maxillary canines have a large, well-developed cingulum, where as the cingulum of mandibular canines is smoother and rounded.

Ridges

Ridges are any linear, flat elevations on teeth, and they are named according to their location. The buccal ridge runs cervico-occlusally in approximately the center of the buccal surface of premolars. The labial ridge is one that runs cervico-incisally in approximately the center of the labial surface of canines. The lingual ridge extends from the cingulum to the cusp tip on the lingual surface of most canines. The cervical ridge runs mesiodistally on the cervical third of the buccal surface of the crown. These are found on all primary teeth but only on the permanent molars.

Cusp ridges are ridges that radiate from cusp tips. There are two marginal ridges, mesial and distal, present on all teeth. On anterior teeth, they are located on the mesial and distal borders of the lingual surface; on posterior teeth, they are located on the mesial and distal borders of the occlusal surface. Triangular ridges are those that project from the cusp tips of premolar and molars to the central groove. Transverse ridges are formed by the union of two triangular ridges on posterior teeth. The joining of buccal and lingual triangular ridges is usually named as an example. The oblique ridge is found on the occlusal surfaces of maxillary molars. It is formed by the union of the distal cusp ridge of the mesiolingual cusp and the triangular ridge of the distobuccal cusp. The oblique ridges usually forms the distal boundary of the central fossa.

Developmental groove

The teeth demonstrating the least number of developmental grooves are the mandibular central and lateral incisors. however the canines show the most prominent developmental grooves, because they have strong anchorage to the bone.

Embrasures

Embrasures are triangularly shaped spaces located between the proximal surfaces of adjacent teeth. The borders of embrasures are formed by the interdental papilla of the gingiva, the adjacent teeth, and the contact point where the two teeth meet. There are four embrasures for every contact area: facial (also called labial or buccal), lingual (or palatal), occlusal or incisal, and cervical or interproximal space. The cervical embrasure usually is filled by the interdental papilla from the gingiva.

Embrasures have three functions. They form spillways between teeth to direct food away from the gingiva. Also, they provide a mechanism for teeth to be more self cleansing. Lastly, they protect the gingiva from undue frictional trauma but also providing the proper degree of stimulation to the tissues.

Mammelons

Mammelons are usually found as three small bumps on the incisal edges of anterior teeth. They are the remnants of three lobes of formation of these teeth, the fourth lobe represented by the cingulum. Since this surface of the tooth is the first to wear away from attrition, mammelons may not be visible on teeth of older people. Instead, the best chance to see this characteristic is soon after eruption of the tooth into the mouth.

Distinguishing characteristics of teeth

Incisor

8 incisors are anterior teeth, 4 in the upper arch and 4 in the lower. Their function is for shearing or cutting food during chewing. There are no cusps on the teeth. Instead, the surface area of the tooth used in eating is called the incisal ridge or incisal edge. Though similar, there are some minor differences between the primary and permanent incisors.

Maxillary central incisor

The maxillary central incisor is usually the most visible tooth, since it is the top center two teeth in the front of a mouth, and it is located mesial to the maxillary lateral incisor.The overall length of the deciduous maxillary central incisor is 16 mm on average, with the crown being 6 mm and the root being 10 mm. In comparison to the permanent maxillary central incisor, the ratio of the root length to the crown length is greater in the deciduous tooth. The diameter of the crown mesiodistally is greater than the length cervicoincisally, which makes the tooth appear wider rather than taller from a labial viewpoint.

The permanent maxillary central incisor is the widest tooth mesiodistally in comparison to any other anterior tooth. It is larger than the neighboring lateral incisor and is usually not as convex on its labial surface. As a result, the central incisor appears to be more rectangular or square in shape. The mesial incisal angle is sharper than the distal incisal angle. When this tooth is newly erupted into the mouth, the incisal edges have three rounded features called mammelons. Mammelons disappear with time as the enamel wears away by friction.

Maxillary lateral incisor

The maxillary lateral incisor is the tooth located distally from both maxillary central incisors of the mouth and mesially from both maxillary canines.

Mandibular central incisor

The mandibular central incisor is the tooth located on the jaw, adjacent to the midline of the face. It is mesial from both mandibular lateral incisors.

Mandibular lateral incisor

The mandibular lateral incisor is the tooth located distally from both mandibular central incisors of the mouth and mesially from both manibular canines.

Canine

Both the maxillary and mandibular canines are called the "cornerstone" of the mouth because they are all located three teeth away from the midline, and separate the premolars from the incisors. The location of the canines reflect their dual function as they complement both the premolars and incisors during chewing. Nonetheless, the most common action of the canines is tearing of food. There is a single cusp on canines, and they resemble the prehensile teeth found in carnivorous animals. Though similar, there are some minor differences between the deciduous and permanent canines.

Maxillary canine

The maxillary canine is the tooth located laterally from both maxillary lateral incisors of the mouth but mesially from both maxillary first premolars. It is the longest tooth in total length, from root to the incisal edge, in the mouth.

Mandibular canine

The mandibular canine is the tooth located distally from both mandibular lateral incisors of the mouth but mesially from both mandibular first premolars.

Premolar

Premolars are found distal to canines and mesial to molars. They are divided into first and second premolars. The functions of premolars vary. There are no deciduous premolars. Instead, the teeth that precede the permanent premolars are the deciduous molars.

Maxillary first premolar

The maxillary first premolar is the tooth located laterally from both the maxillary canines of the mouth but mesially from both maxillary second premolars. The function of this premolar is similar to that of canines in regard to tearing being the principal action during chewing. There are two cusps on maxillary first premolars, and the buccal cusp is sharp enough to resemble the prehensile teeth found in carnivorous animals. There is a distinctive concavity on the cervical third of the crown extending onto the root.

Maxillary second premolar

The maxillary second premolar is the tooth located laterally from both the maxillary first premolars of the mouth but mesially from both maxillary first molars. The function of this premolar is similar to that of first molars in regard to grinding being the principle action during chewing. There are two cusps on maxillary second premolars, but both of them are less sharp than those of the maxillary first premolars.

Mandibular first premolar

The mandibular first premolar is the tooth located laterally from both the mandibular canines of the mouth but mesially from both mandibular second premolars. The function of this premolar is similar to that of canines in regard to tearing being the principle action during mastication. Mandibular first premolars have two cusps. The one large and sharp is located on the buccal side of the tooth. Since the lingual cusp is small and nonfunctional, which means it is not active in chewing, the mandibular first premolar resembles a small canine.

Mandibular second premolar

The mandibular second premolar is the tooth located distally from both the mandibular first premolars of the mouth but mesially from both mandibular first molars. The function of this premolar is to assist the mandibular first molar during mastication. Mandibular second premolars have three cusps. There is one large cusp on the buccal side of the tooth. The lingual cusps are well developed and functional, which means the cusps assist during chewing. Therefore, whereas the mandibular first premolar resembles a small canine, the mandibular second premolar is more like the first molar.

Molar

Molars are the most posterior teeth in the mouth. Their function is to grind food during chewing. The number of cusps, and thus the overall appearance, vary among the different molars and between people. There are great differences between the deciduous molars and those of the permanent molars, even though their functions are similar. Permanent maxillary molars are not considered to have any teeth that precede them. Despite being named "molars", the deciduous molars are followed by permanent premolars. The third molars are commonly called "wisdom teeth."

Maxillary first molar

The maxillary first molar is the tooth located laterally from both the maxillary second premolars of the mouth but mesially from both maxillary second molars. There are usually four cusps on maxillary molars, two on the buccal and two palatal.

Maxillary second molar

The maxillary second molar is the tooth located laterally from both the maxillary first molars of the mouth but mesially from both maxillary third molars. This is true only in permanent teeth. In deciduous teeth, the maxillary second molar is the last tooth in the mouth and does not have a third molar behind it. The deciduous maxillary second molar is also the most likely of the deciduous teeth to have an oblique ridge. There are usually four cusps on maxillary molars, two buccal and two palatal.

Maxillary third molar

The maxillary third molar is the tooth located laterally from both the maxillary second molars of the mouth with no tooth posterior to it in permanent teeth. In deciduous teeth, there is no maxillary third molar. There are usually four cusps on maxillary molars, two buccal and two palatal. Nonetheless, for this tooth, there are great variances among third molars, and a specific description of a third molar will not hold true in all cases.

Mandibular first molar

The mandibular first molar is the tooth located distally from both the mandibular second premolars of the mouth but mesially from both mandibular second molars. It is located on the mandibular arch of the mouth, and generally opposes the maxillary first molars and the maxillary 2nd premolar. This arrangement is known as Class I occlusion. There are usually five well-developed cusps on mandibular first molars: two on the buccal, two palatal, and one distal.

Mandibular second molar

The mandibular second molar is the tooth located distally from both the mandibular first molars of the mouth but mesially from both mandibular third molars. This is true only in permanent teeth. In deciduous teeth, the mandibular second molar is the last tooth in the mouth and does not have a third molar behind it. Though there is more variation between individuals to that of the first mandibular molar, there are usually four cusps on mandibular second molars: two buccal and two palatal.

Mandibular third molar

The mandibular third molar is the tooth located distally from both the mandibular second molars of the mouth with no tooth posterior to it in permanent teeth. In deciduous teeth, there is no mandibular third molar. For this tooth, there are great variances among third molars, and a specific description of a third molar will not hold true in all cases.

Chapter 2

Tooth

Teeth (singular **tooth**) are small, calcified, whitish structures found in the jaws (or mouths) of many vertebrates that are used to break down food. Some animals, particularly carnivores, also use teeth for hunting or for defensive purposes. The roots of teeth are covered by gums. Teeth are not made of bone, but rather of multiple tissues of varying density and hardness.

Teeth are among the most distinctive (and long-lasting) features of mammal species. Paleontologists use teeth to identify fossil species and determine their relationships. The shape of the animal's teeth are related to its diet. For example, plant matter is hard to digest, so herbivores have many molars for chewing and grinding. Carnivores, on the other hand, need canines to kill prey and to tear meat.

Mammals are diphyodont, meaning that they develop two sets of teeth. In humans, the first set (the "baby," "milk," "primary" or "deciduous" set) normally starts to appear at about six months of age, although some babies are born with one or more visible teeth, known as neonatal teeth. Normal tooth eruption at about six months is known as teething and can be painful.

Some animals develop only one set of teeth (monophyodont) while others develop many sets (polyphyodont). Sharks, for example, grow a new set of teeth every two weeks to replace worn teeth. Rodent incisors grow and wear away continually through gnawing, which helps maintain relatively constant length. The industry of the beaver is due in part to this qualification. Many rodents such as voles (but not mice) and guinea pigs, as well as rabbits, have continuously growing molars in addition to incisors.

Mammals

Aardvark

In Aardvarks, teeth lack enamel and have many pulp tubules, hence the name of the order Tubulidentata.

Cetaceans

Toothed whales is a suborder of the cetaceans characterized by having teeth. The teeth differ considerably between the species. They may be numerous, with some dolphins bearing over 100 teeth in their jaws. On the other hand, the narwhals have a giant unicorn-like tusk, which is a tooth containing millions of sensory pathways and used for sensing during feeding, navigation and mating. It is the most neurologically complex tooth known. Beaked whales are almost toothless, with only bizarre teeth found in males. These teeth may be used for feeding but also for demonstrating aggression and showmanship.

Primates

Horse

An adult horse has between 36 and 44 teeth. All horses have twelve premolars, twelve molars, and twelve incisors. Generally, all male equines also have four canine teeth (called tushes) between the molars and incisors. However, few female horses (less than 28%) have canines, and those that do usually have only one or two, which many times are only partially erupted. A few horses have one to four wolf teeth, which are vestigial premolars, with most of those having only one or two. They are equally common in male and female horses and much more likely to be on the upper jaw. If present these can cause problems as they can interfere with the horse's bit contact. Therefore, wolf teeth are commonly removed.

Horse teeth can be used to estimate the animal's age. Between birth and five years, age can be closely estimated by observing the eruption pattern on milk teeth and then permanent teeth. By age five, all permanent teeth have usually erupted. The horse is then said to have a "full" mouth. After the age of five, age can only be conjectured by study of the wear patterns on the incisors, shape, the angle at which the incisors meet, and other factors. The wear of teeth may also be affected by diet, natural abnormalities, and cribbing. Two horses of the same age may have different wear patterns.

A horse's incisors, premolars, and molars, once fully developed, continue to erupt as the grinding surface is worn down through chewing. A young adult horse will have teeth which are 4.5-5 inches long, with the majority of the crown remaining below the gumline in the dental socket. The rest of the tooth will slowly emerge from the jaw, erupting about 1/8" each year, as the horse ages. When the animal reaches old age, the crowns of the teeth are very short and the teeth are often lost altogether. Very old horses, if lacking molars, may need to have their fodder ground up and soaked in water to create a soft mush for them to eat in order to obtain adequate nutrition.

Proboscideans

Section through the ivory tusk of a mammoth

Elephants' tusks are specialized incisors for digging food up and fighting. Some of elephant teeth are similar to those in manatees, and it is notable that elephants are believed to have undergone an aquatic phase in their evolution.

Elephants have four molars, one on each side of the upper and lower jaw. Until age 40, these are replaced by larger molars. The new molars shift forward from the back of the jaw as the old wear down. The final set of molars last for about twenty years.

Rabbit

Rabbits and other Lagomorphs usually shed their deciduous teeth before (or very shortly after) their birth, and are usually born with their permanent teeth. The teeth of rabbits complement their diet, which consist of a wide range of vegetation. Since many of the foods are abrasive enough to cause attrition, rabbit teeth grow continuously throughout life. Rabbits have a total of 6 incisors, three upper premolars, three upper molars, two lower premolars, and two lower molars on each side. There are no canines. Three to four millimeters of tooth is worn away by incisors every week, whereas the posterior teeth require a month to wear away the same amount. Anatomy of rabbit teeth

The incisors and cheek teeth of rabbits are called aradicular hypsodont teeth. This is sometimes referred to as an elodent dentition. These teeth grow or erupt continuously. The growth or eruption is held in balance by dental abrasion from chewing a diet high in fiber.

Rodent

Rodents' incisors grow continuously throughout their lives, a process known as aradicular. Unlike humans whose ameloblasts die after tooth development, rodents continually produce enamel and must wear down their teeth by gnawing on various materials. These teeth are used for cutting wood, biting through the skin of fruit, or for defense. The teeth have enamel on the outside and exposed dentin on the inside, so they self-sharpen during gnawing. On the other hand, continually growing molars are found in some rodent species, such as the sibling vole and the guinea pig. There is variation in the dentition of the rodents, but generally, rodents lack canines and premolars, and have a space between their incisors and molars, called the diastema region.

Manatees

Mandibular molars of manatees develop separately from the jaw and are encased in a bony shell separated by soft tissue.

Walrus

Walrus tusks are canine teeth that grow continuously throughout life.

Dogs

In dogs, the teeth are less likely than humans to form dental cavities because of the very high pH of dog saliva, which prevents enamel from demineralizing.

Fish

Fish, such as sharks, may go through many teeth in their lifetime. The multiple replacement of teeth is known as polyphydontia.

Reptiles

The teeth of reptiles are replaced constantly during their life. Juvenile crocodilians replace teeth with larger ones at a rate as high as 1 new tooth per socket every month. Once adult, tooth replacement rates can slow to two years and even longer. Over all, crocodilians may use 3,000 teeth from birth to death. New teeth are created within old teeth.

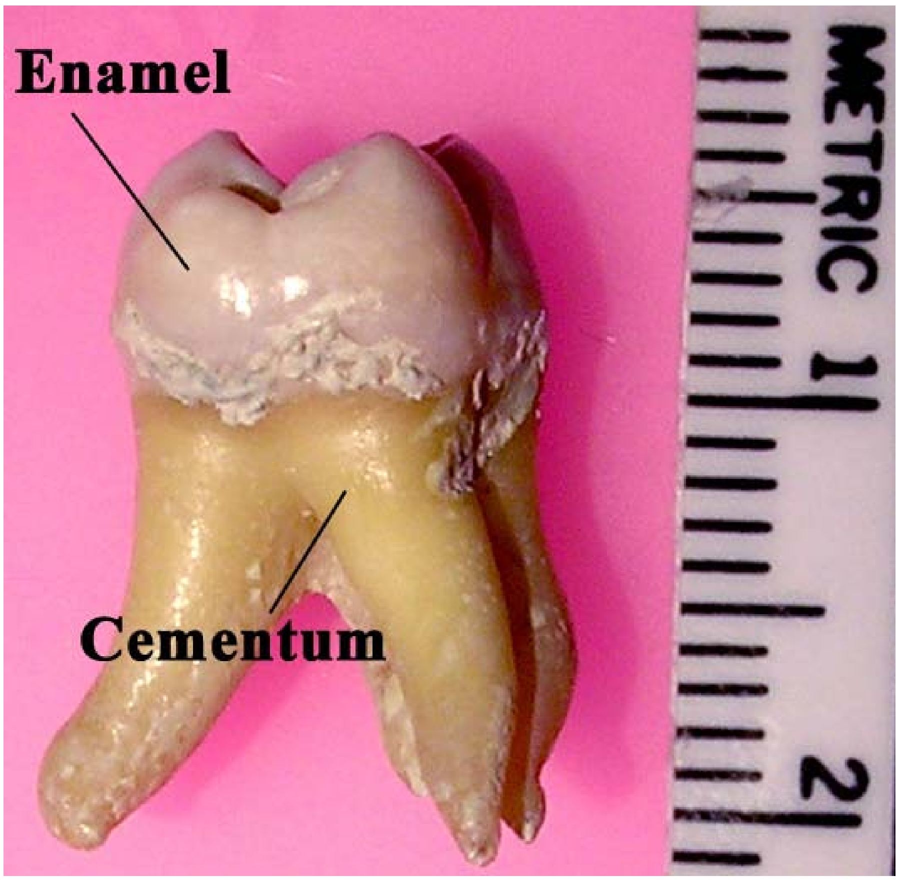
Fossilization and taphonomy

Because teeth are very resistant, often preserved when bones are not, and reflect the diet of the host organism, they are very valuable to archaeologists and palaeontologists. Early fish such as the thelodonts had teeth for scales, suggesting that the origin of teeth was scales which were retained in the mouth. Fish as early as the late Cambrian had dentine in their exoskeleton, which may have functioned in defense or for sensing their environment. Dentine can be as hard as the rest of teeth, and is composed of collagen fibres, reinforced with hydroxyapatite.

Decalcification removes the enamel from teeth and leaves only the organic interior intact, which comprises dentine and cementine. Enamel is quickly decalcified in acids, perhaps by dissolution by plant acids or via diagenetic solutions, or in the stomachs of vertebrate predators. Enamel can be lost by abrasion or spalling, and is lost before dentine or bone are destroyed by the fossilisation process. In such a case, the 'skeleton' of the teeth would consist of the dentine, with a hollow pulp cavity. The organic part of dentine, conversely, is destroyed by alkalis.

Chapter 3

Tooth Enamel



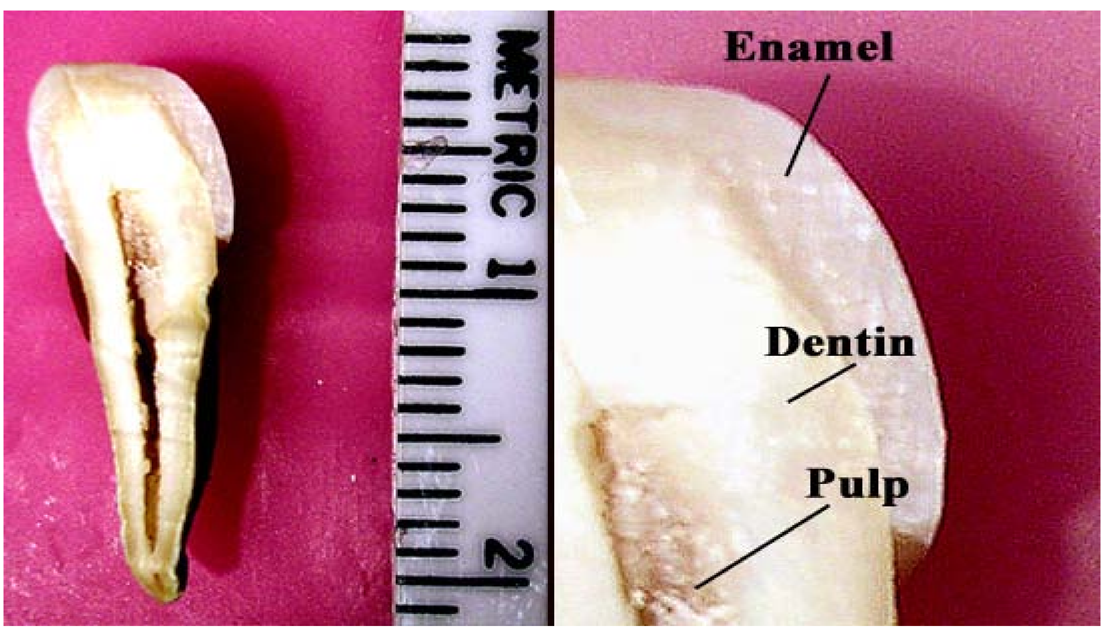
Tooth enamel along with dentin, cementum, and dental pulp is one of the four major tissues which make up the tooth in vertebrates. It is the hardest and most highly mineralized substance in the human body. Tooth enamel is also found in the dermal denticles of sharks. It is the normally visible dental tissue of a tooth because it covers the anatomical crown and must be supported by underlying dentin. Ninety-six percent of enamel consists of mineral, with water and organic material composing the rest. In humans, enamel varies in thickness over the surface of the tooth, often thickest at the cusp, up to 2.5 mm, and thinnest at its border with the cementum at the cementoenamel junction (CEJ).

The normal color of enamel varies from light yellow to grayish white. At the edges of teeth where there is no dentin underlying the enamel, the color sometimes has a slightly blue tone. Since enamel is semitranslucent, the color of dentin and any material underneath the enamel strongly affects the appearance of a tooth. The enamel on primary teeth has a more opaque crystalline form and thus appears whiter than on permanent teeth.

Enamel's primary mineral is hydroxylapatite, which is a crystalline calcium phosphate. The large amount of minerals in enamel accounts not only for its strength but also for its brittleness. Tooth enamel ranks 5 on Mohs hardness scale and a Young's modulus of 83 GPa. Dentin, less mineralized and less brittle, 3–4 in hardness, compensates for enamel and is necessary as a support. On radiographs, the differences in the mineralization of different portions of the tooth and surrounding periodontium can be noted; enamel appears more radiopaque (or lighter) than either dentin and pulp since it is denser than both, both of which appear more radiolucent (or darker).

Enamel does not contain collagen, as found in other hard tissues such as dentin and bone, but it does contain two unique classes of proteins - amelogenins and enamelins. While the role of these proteins is not fully understood, it is believed that they aid in the development of enamel by serving as a framework for minerals to form on, among other functions. Once it is mature, enamel is almost totally absent of the softer organic matter. Enamel is avascular and has no nerve supply within it and is not renewed, however, it is not a static tissue as it can undergo mineralization changes.

Structure



The basic unit of enamel is called an enamel rod. Measuring 4–8 μm in diameter an enamel rod, formerly called an enamel prism, is a tightly packed mass of hydroxyapatite crystals in an organized pattern. In cross section, it is best compared to a keyhole, with the top, or head, oriented toward the crown of the tooth, and the bottom, or tail, oriented toward the root of the tooth.

The arrangement of the crystals within each enamel rod is highly complex. Both ameloblasts (the cells which initiate enamel formation) and Tomes' processes affect the crystals' pattern. Enamel crystals in the head of the enamel rod are oriented parallel to the long axis of the rod. When found in the tail of the enamel rod, the crystals' orientation diverges slightly(65 degrees) from the long axis.

The arrangement of enamel rods is understood more clearly than their internal structure. Enamel rods are found in rows along the tooth, and within each row, the long axis of the enamel rod is generally perpendicular to the underlying dentin. In permanent teeth, the enamel rods near the cementoenamel junction (CEJ) tilt slightly toward the root of the tooth. Understanding enamel orientation is very important in restorative dentistry, because enamel unsupported by underlying dentin is prone to fracture.

The area around the enamel rod is known as interrod enamel. Interrod enamel has the same composition as enamel rod, however a histologic distinction is made between the two because crystal orientation is different in each. The border where the crystals of enamel rods and crystals of interrod enamel meet is called the rod sheath.

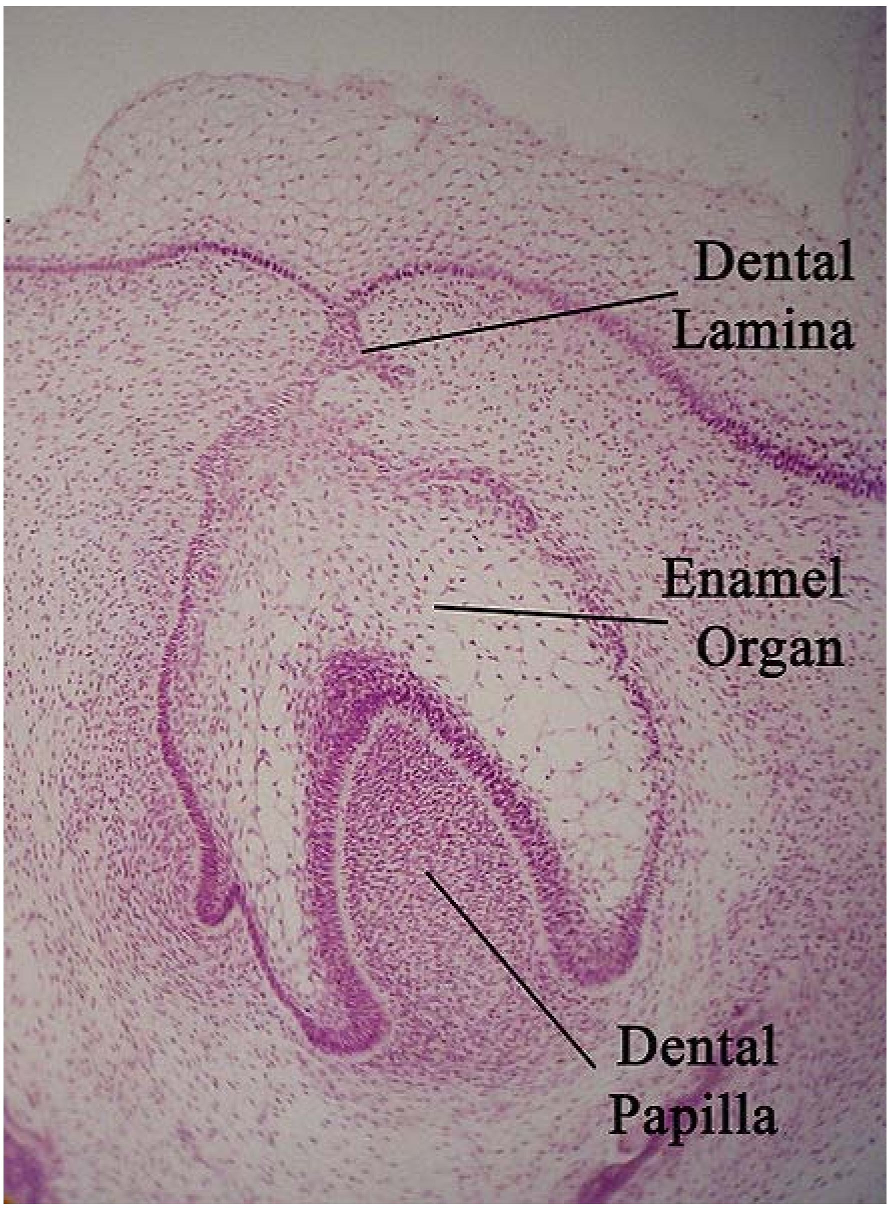
Striae of Retzius are incremental lines that appear brown in a stained section of mature enamel. These lines are composed of bands or cross striations on the enamel rods that, when combined in longitudinal sections, seem to traverse the enamel rods. Formed from changes in diameter of Tomes’ processes, these incremental lines demonstrate the growth of enamel, similar to the annual rings on a tree on transverse sections of enamel. The exact mechanism that produces these lines is still being debated. Some researchers hypothesize that the lines are a result of the diurnal, or 24 hour, metabolic rhythm of the ameloblasts producing the enamel matrix, which consists of an active secretory work period followed by an inactive rest period during tooth development. Thus, each band on the enamel rod demonstrates the work/rest pattern of the ameloblasts that generally occurs over a span of a week. Perikymata which are associated with the Striae are shallow grooves noted clinically on the nonmasticatory surfaces of some teeth in the oral cavity. Perikymata are usually lost through tooth wear, except on the protected cervical regions of some teeth, especially the permanent maxillary central incisors, canines, and first premolars, and may be confused as dental calculus. Darker than the other incremental lines, the neonatal line is a incremental line that separates enamel formed before and after birth. The neonatal line marks the stress or trauma experienced by the ameloblasts during birth, again illustrating the sensitivity of the ameloblasts as they form enamel matrix. As one would expect, the neonatal line is found in all primary teeth and in the larger cusps of the permanent first molars. They contain irregular structures of enamel prisms with disordered crystal arrangements basically formed by the abrupt bending of the prisms towards the root; usually, the prisms gradually bent back again to regain their previous orientation.

Gnarled enamel is found at the cusps of teeth. Its twisted appearance results from the orientation of enamel rods and the rows in which they lie.

Enamel is covered by various structures in relation to the development of tooth:

Nasmyth's membrane or enamel cuticle, structure of embryological origin is composed of keratin which gives rise to the enamel organ.
Acquired pellicle, structure acquired after tooth eruption is composed of food debris, calculus, dental plaque (organic film).

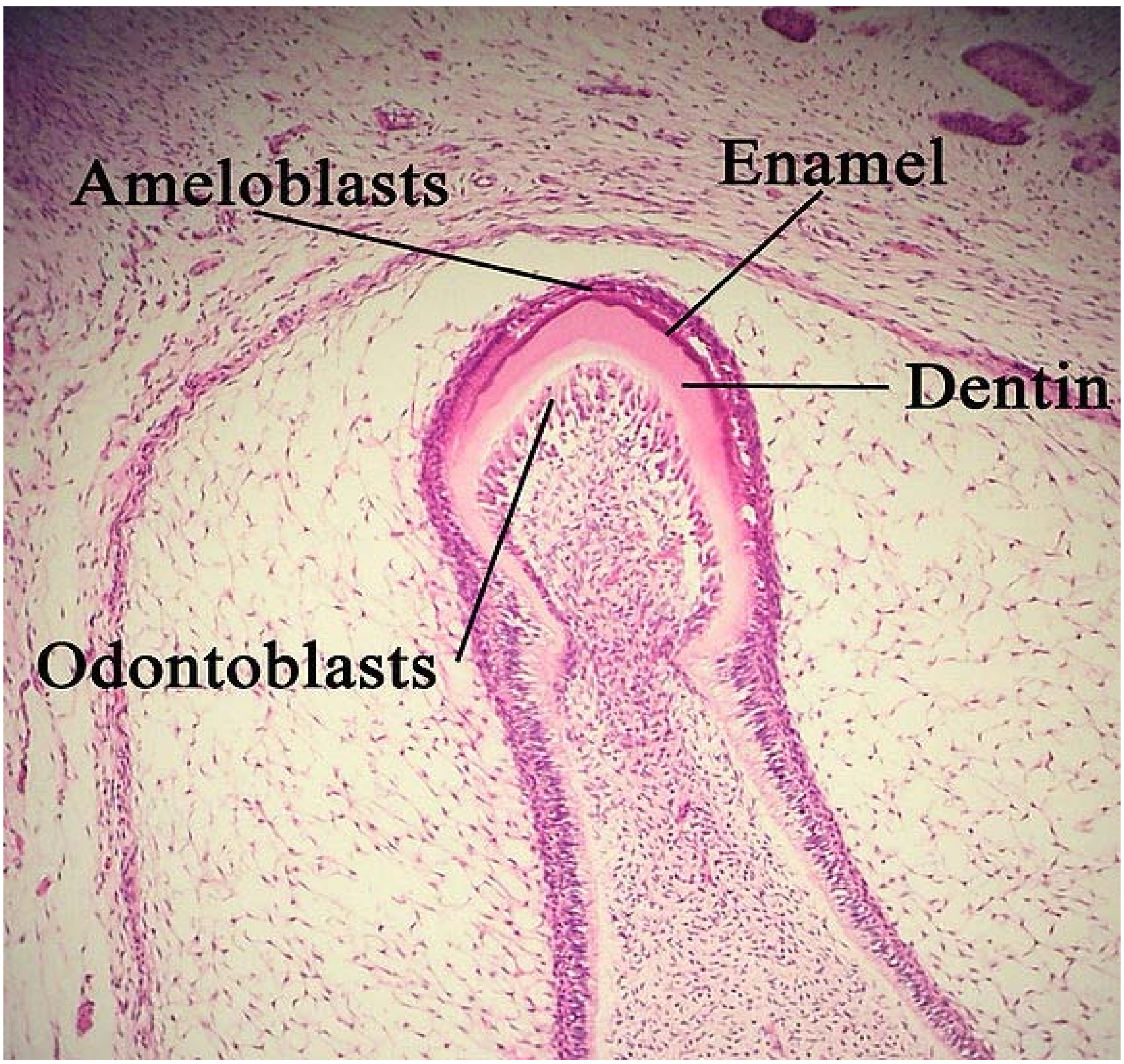
Development



Histologic slide showing a developing tooth. The mouth would be in the area of space at the top of the picture.

Enamel formation is part of the overall process of tooth development. When the tissues of the developing tooth are seen under a microscope, different cellular aggregations can be identified, including structures known as the enamel organ, dental lamina, and dental papilla. The generally recognized stages of tooth development are the bud stage, cap stage, bell stage, and crown, or calcification, stage. Enamel formation is first seen in the crown stage.

Amelogenesis, or enamel formation, occurs after the first establishment of dentin, via cells known as ameloblasts. Human enamel forms at a rate of around 4 μm per day, beginning at the future location of cusps, around the third or fourth month of pregnancy. As in all human processes, the creation of enamel is complex, but can generally be divided into two stages. The first stage, called the secretory stage, involves proteins and an organic matrix forming a partially mineralized enamel. The second stage, called the maturation stage, completes enamel mineralization.



Histologic slide showing enamel formation

In the secretory stage, ameloblasts are polarized columnar cells. In the rough endoplasmic reticulum of these cells, enamel proteins are released into the surrounding area and contribute to what is known as the enamel matrix, which is then partially mineralized by the enzyme alkaline phosphatase. When this first layer is formed, the ameloblasts move away from the dentin, allowing for the development of Tomes' processes at the apical pole of the cell. Enamel formation continues around the adjoining ameloblasts, resulting in a walled area, or pit, that houses a Tomes' process, and also around the end of each Tomes' process, resulting in a deposition of enamel matrix inside of each pit. The matrix within the pit will eventually become an enamel rod, and the walls will eventually become interrod enamel. The only distinguishing factor between the two is the orientation of the calcium phosphate crystals.

In the maturation stage, the ameloblasts transport substances used in the formation of enamel. Histologically, the most notable aspect of this phase is that these cells become striated, or have a ruffled border. These signs demonstrate that the ameloblasts have changed their function from production, as in the secretory stage, to transportation. Proteins used for the final mineralization process compose most of the transported material. The noteworthy proteins involved are amelogenins, ameloblastins, enamelins, and tuftelins. During this process, amelogenins and ameloblastins are removed after use, leaving enamelins and tuftelin in the enamel. By the end of this stage, the enamel has completed its mineralization.

At some point before the tooth erupts into the mouth, but after the maturation stage, the ameloblasts are broken down. Consequently, enamel, unlike many other tissues of the body, has no way to regenerate itself. After destruction of enamel from decay or injury, neither the body nor a dentist can restore the enamel tissue. Enamel can be affected further by non-pathologic processes.

The discoloration of teeth over time can result from exposure to substances such as tobacco, coffee, and tea. The staining occurs in the interprismatic region internally on the enamel, which causes the tooth to appear darker or more yellow overall. In a perfect state, enamel is colorless, but it does reflect underlying tooth structure with its stains since light reflection properties of the tooth are low.

Progress of enamel formation for primary teeth

		Amount of enamel formed at birth	**Enamel mineralization completed**
Primary maxillary tooth	Central incisor	5/6	1.5 months after birth
	Lateral incisor	2/3	2.5 months after birth
	Canine	1/3	9 months after birth
	1st molar	Cusps united; occlusal completely calcified	6 months after birth

		and 1/2 to 3/4 crown height	
	2nd molar	Cusps united; occlusal incompletely calcified; calcified tissue covers 1/5 to 1⁄4 crown height	11 months after birth
Primary mandibular tooth	Central incisor	3/5	2.5 months after birth
	Lateral incisor	3/5	3 months after birth
	Canine	1/3	9 months after birth
	1st molar	Cusps united; occlusal completely calcified	5.5 months after birth
	2nd molar	Cusps united; occlusal incompletely calcified	10 months after birth

Destruction

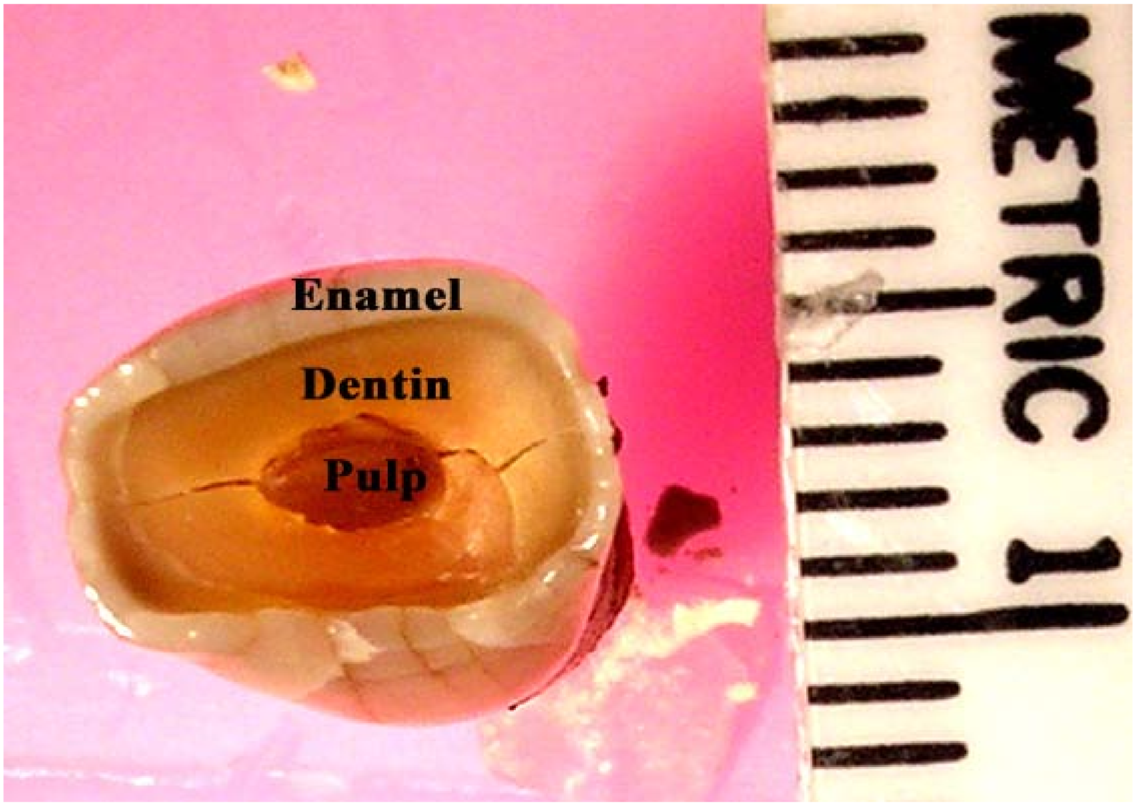
Destruction of enamel by cervical decay from dental caries

The high mineral content of enamel, which makes this tissue the hardest in the human body, also makes it susceptible to a demineralization process which often occurs as dental caries, otherwise known as cavities. Demineralization occurs for several reasons, but the most important cause of tooth decay is the ingestion of sugars. Tooth cavities are caused when acids dissolve tooth enamel:

$$Ca_{10}(PO_4)_6(OH)_2(s) + 8H^+(aq) \rightarrow 10Ca^{2+}(aq) + 6HPO_4^{2-}(aq) + 2H_2O(l)$$

Sugars from candies, soft drinks, and even fruit juices play a significant role in tooth decay, and consequently in enamel destruction. The mouth contains a great number and variety of bacteria, and when sucrose, the most common of sugars, coats the surface of the mouth, some intraoral bacteria interact with it and form lactic acid, which decreases the pH in the mouth. Then, the hydroxylapatite crystals of enamel demineralize, allowing for greater bacterial invasion deeper into the tooth. The most important bacterium involved with tooth decay is *Streptococcus mutans*, but the number and type of bacteria varies with the progress of tooth destruction.

Furthermore, tooth morphology dictates that the most common site for the initiation of dental caries is in the deep grooves, pits, and fissures of enamel. This is expected because these locations are impossible to reach with a toothbrush and allow for bacteria to reside there. When demineralization of enamel occurs, a dentist can use a sharp instrument, such as a dental explorer, and "feel a stick" at the location of the decay. As enamel continues to become less mineralized and is unable to prevent the encroachment of bacteria, the underlying dentin becomes affected as well. When dentin, which normally supports enamel, is destroyed by a physiologic condition or by decay, enamel is unable to compensate for its brittleness and breaks away from the tooth easily.



The effects of bruxism on an anterior tooth, revealing the dentin and pulp which are normally hidden by enamel

The extent to which tooth decay is likely, known as cariogenicity, depends on factors such as how long the sugar remains in the mouth. Contrary to common belief, it is not the amount of sugar ingested but the frequency of sugar ingestion that is the most important factor in the causation of tooth decay. When the pH in the mouth initially decreases from the ingestion of sugars, the enamel is demineralized and left vulnerable for about 30 minutes. Eating a greater quantity of sugar in one sitting does not increase the time of demineralization. Similarly, eating a lesser quantity of sugar in one sitting does not decrease the time of demineralization. Thus, eating a great quantity of sugar at one time in the day is less detrimental than is a very small quantity ingested in many intervals throughout the day. For example, in terms of oral health, it is better to eat a single dessert at dinner time than to snack on a bag of candy throughout the day.

In addition to bacterial invasion, enamel is also susceptible to other destructive forces. Bruxism, also known as clenching of or grinding on teeth, destroys enamel very quickly. The wear rate of enamel, called attrition, is 8 micrometers a year from normal factors. A common misconception is that enamel wears away mostly from chewing, but actually teeth rarely touch during chewing. Furthermore, normal tooth contact is compensated physiologically by the periodontal ligaments (pdl) and the arrangement of dental occlusion. The truly destructive forces are the parafunctional movements, as found in bruxism, which can cause irreversible damage to the enamel.

Other nonbacterial processes of enamel destruction include abrasion (involving foreign elements, such as toothbrushes), erosion (involving chemical processes, such as lemon juice), and possibly abfraction (involving compressive and tensile forces).

Though enamel is described as tough, it has a similar brittleness to glass making it unlike other natural crack-resistant laminate structures such as shell and nacre potentially vulnerable to fracture. In spite of this it can withstand the bite forces as high as 1,000 N many times a day during chewing. This resistance is due in part to the microstructure of enamel which contains processes, enamel tufts, that stabilize the growth of such fractures at the dentinoenamel junction. The configuration of the tooth also acts to reduce the tensile stresses that cause fractures during biting.

Oral hygiene and fluoride

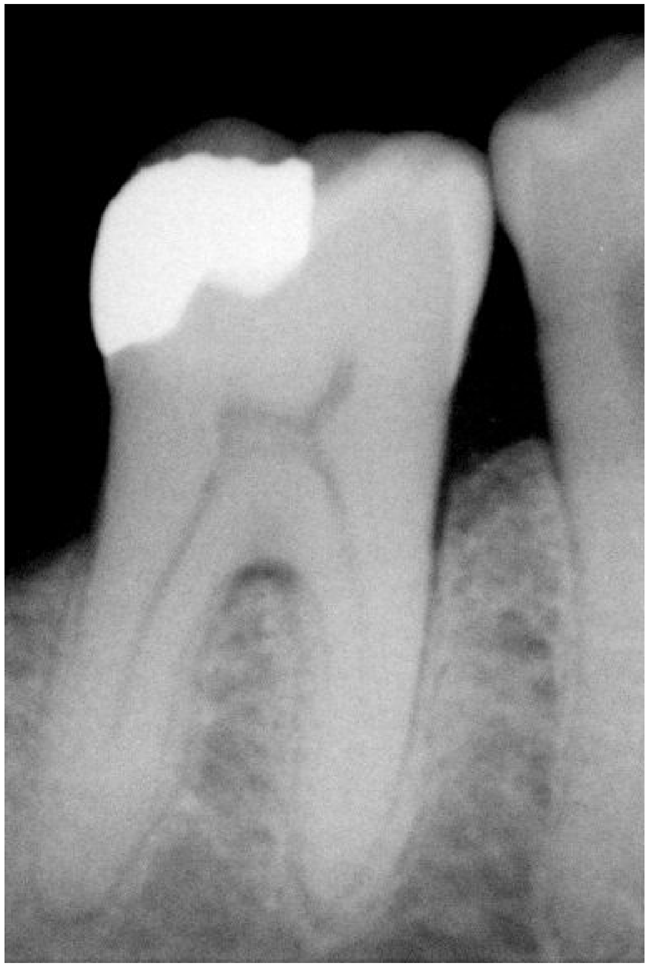
Considering the vulnerability of enamel to demineralization and the daily menace of sugar ingestion, prevention of tooth decay is the best way to maintain the health of teeth. Most countries have wide use of toothbrushes, which can reduce the number of bacteria and food particles on enamel. Some isolated societies do not have access to toothbrushes, but it is common for those people to use other objects, such as sticks, to clean their teeth. In between two adjacent teeth, floss is used to wipe the enamel surfaces free of plaque and food particles to discourage bacterial growth. Although neither floss nor toothbrushes can penetrate the deep grooves and pits of enamel, good general oral health habits can usually prevent enough bacterial growth to keep tooth decay from starting.

Common dentistry trays filled with fluoride foam

These methods of oral hygiene have been helped greatly by the use of fluoride. Fluoride can be found in many locations naturally, such as the ocean and other water sources. Naturally occurring calcium fluoride is not the same as sodium fluoride, a byproduct of the fertilizer industry and the fluoride that is added to drinking water. The recommended dosage of fluoride in drinking water depends on air temperature; in the U.S. it ranges from 0.7 to 1.2 mg/L (milligrams per liter). Fluoride catalyzes the diffusion of calcium and phosphate into the tooth surface, which in turn remineralizes the crystalline structures in a dental cavity. The remineralized tooth surfaces contain fluoridated hydroxyapatite and fluorapatite, which resist acid attack much better than the original tooth did. Fluoride therapy is used to help prevent dental decay.

Many groups of people have spoken out against fluoridated drinking water. One example used by these advocates is the damage fluoride can do as fluorosis. Fluorosis is a condition resulting from the overexposure to fluoride, especially between the ages of 6 months to 5 years, and appears as mottled enamel. Consequently the teeth look unsightly, although the incidence of dental decay in those teeth is very small. It is important, however, to note that all substances, even beneficial ones, are detrimental when taken in extreme doses. Where fluoride is found naturally in high concentrations, filters are often used to decrease the amount of fluoride in water. For this reason, codes have been developed by dental professionals to limit the amount of fluoride a person should take. These codes are supported by the American Dental Association and the American Academy of Pediatric Dentistry. The acute toxic dose of fluoride is ~5 mg/kg of body weight. Furthermore, whereas topical fluoride, found in toothpaste and mouthwashes, does not cause fluorosis, its effects are also less pervasive and not as long-lasting as those of systemic fluoride, such as when drinking fluorinated water. For instance, all of a tooth's enamel gains the benefits of fluoride when it is ingested systemically, through fluoridated water or salt fluoridation (a common alternative in Europe). Only some of the outer surfaces of enamel can be reached by topical fluoride. Thus, despite fluoridation's detractors, most dental health care professionals and organizations agree that the inclusion of fluoride in public water has been one of the most effective methods of decreasing the prevalence of tooth decay.

Effects of dental procedures



An X-ray showing enamel and dentin replaced by an amalgam restoration

Dental restorations

Most dental restorations involve the removal of enamel. Frequently, the purpose of removal is to gain access to the underlying decay in the dentin or inflammation in the pulp. This is typically the case in amalgam restorations and endodontic treatment.

Nonetheless, enamel can sometimes be removed before there is any decay present. The most popular example is the dental sealant. The process of placing dental sealants in the past involved removing enamel in the deep fissures and grooves of a tooth and replacing it with a restorative material. Presently, it is more common to only remove decayed enamel if present. In spite of this, there are still cases where deep fissures and grooves in enamel are removed in order to prevent decay, and a sealant may or may not be placed depending on the situation. Sealants are unique in that they are preventative restorations for protection from future decay and have shown to reduce the risk of decay by 55% over 7 years.

Aesthetics is another reason for the removal of enamel. Removing enamel is necessary when placing crowns and veneers to enhance the appearance of teeth. In both of these instances, it is important to keep in mind the orientation of enamel rods because it is possible to leave enamel unsupported by underlying dentin, leaving that portion of the prepared teeth more vulnerable to fracture.

Acid-etching techniques

Invented in 1955, acid-etching employs dental etchants and is used frequently when bonding dental restoration to teeth. This is important for long-term use of some materials, such as composites and sealants. By dissolving minerals in enamel, etchants remove the outer 10 micrometers on the enamel surface and make a porous layer 5–50 micrometers deep. This roughens the enamel microscopically and results in a greater surface area on which to bond.

The effects of acid-etching on enamel can vary. Important variables are the amount of time the etchant is applied, the type of etchant used, and the current condition of the enamel.

There are three types of patterns formed by acid-etching. Type 1 is a pattern where predominantly the enamel rods are dissolved; type 2 is a pattern where predominantly the area around the enamel rods are dissolved; and type 3 is a pattern where there is no evidence left of any enamel rods. Besides concluding that type 1 is the most favorable pattern and type 3 the least, the explanation for these different patterns is not known for certain but is most commonly attributed to different crystal orientation in the enamel.

Tooth whitening

Tooth whitening or tooth bleaching procedures attempt to lighten a tooth's color in either of two ways: by chemical or mechanical action. Working chemically, a bleaching agent is used to carry out an oxidation reaction in the enamel and dentin. The agents most commonly used to intrinsically change the color of teeth are hydrogen peroxide and carbamide peroxide. Oxygen radicals from the peroxide in the whitening agents contact the stains in the interprismatic spaces within the enamel layer. When this occurs, stains will be bleached and the teeth now appear lighter in color. Teeth not only appear whiter but also reflect light in increased amounts, which makes the teeth appear brighter as well. Studies show that whitening does not produce any ultrastructural or microhardness changes in the dental tissues. Studies show that patients who have whitened their teeth take better care of them. However, a tooth whitening product with an overall low pH can put enamel at risk for decay or destruction by demineralization. Consequently, care should be taken and risk evaluated when choosing a product which is very acidic. Tooth whiteners in toothpastes work through a mechanical action. They have mild abrasives which aid in the removal of stains on enamel. Although this can be an effective method, it does not alter the intrinsic color of teeth.

Microabrasion techniques employ both methods. An acid is used first to weaken the outer 22–27 micrometers of enamel in order to weaken it enough for the subsequent abrasive force. This allows for removal of superficial stains in the enamel. If the discoloration is deeper or in the dentin, this method of tooth whitening will not be successful.

Systemic conditions affecting enamel

There are many different types of amelogenesis imperfecta. The hypocalcification type, which is the most common, is an autosomal dominant condition that results in enamel that is not completely mineralized. Consequently, enamel easily flakes off the teeth, which appear yellow because of the revealed dentin. The hypoplastic type is X-linked and results in normal enamel that appears in too little quantity, having the same effect as the most common type.

Gastroesophageal reflux disease can also lead to enamel loss, as acid refluxes up the esophagus and into the mouth, occurring most during overnight sleep.

Chronic bilirubin encephalopathy, which can result from erythroblastosis fetalis, is a disease which has numerous effects on an infant, but it can also cause enamel hypoplasia and green staining of enamel.

Enamel hypoplasia is broadly defined to encompass all deviations from normal enamel in its various degrees of absence. The missing enamel could be localized, forming a small pit, or it could be completely absent.

Erythropoietic porphyria is a genetic disease resulting in the deposition of porphyrins throughout the body. These deposits also occur in enamel and leave an appearance described as red in color and fluorescent.

Fluorosis leads to mottled enamel and occurs from overexposure to fluoride.

Tetracycline staining leads to brown bands on the areas of developing enamel. Children up to age 8 can develop mottled enamel from taking tetracycline. As a result, tetracycline is contraindicated in pregnant women.

Celiac disease, a disorder characterized by an auto-immune response to gluten, also commonly results in demineralization of the enamel.

In other mammals

For the most part, research has shown that formation in animals is almost identical to formation in humans. The enamel organ, including the dental papilla, and ameloblasts function similarly. The variations of enamel that are present are infrequent but sometimes important. Differences exist, certainly, in the morphology, number, and types of teeth among animals.

Teeth of a rottweiler

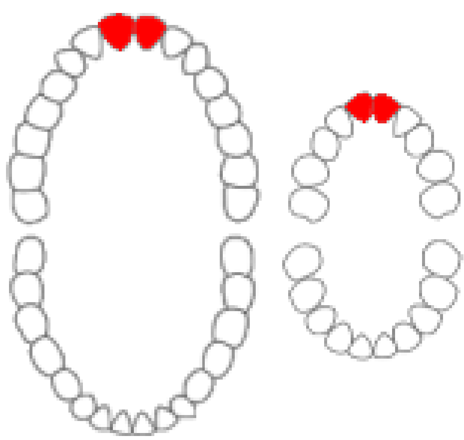
Dogs are less likely than humans to have tooth decay due to the high pH of dog saliva, which prevents an acidic environment from forming and the subsequent demineralization of enamel which would occur. In the event that tooth decay does occur (usually from trauma), dogs can receive dental fillings just as humans do. Similar to human teeth, the enamel of dogs is vulnerable to tetracycline staining. Consequently, this risk must be accounted for when tetracycline antibiotic therapy is administered to young dogs. Enamel hypoplasia may also occur in dogs.

The mineral distribution in rodent enamel is different from that of monkeys, dogs, pigs, and humans. In horse teeth, the enamel and dentin layers are intertwined with each other, which increases the strength and decreases the wear rate of those teeth.

Chapter 4

Maxillary Central Incisor

Maxillary central incisor



Maxillary central incisors of permanent and primary teeth marked in red.

The **maxillary central incisor** is a human tooth in the front upper jaw, or maxilla, and is usually the most visible of all teeth in the mouth. It is located mesial (closer to the midline of the face) to the maxillary lateral incisor. As with all incisors, their function is for shearing or cutting food during mastication (chewing). There are no cusps on the teeth. Instead, the surface area of the tooth used in eating is called an incisal ridge or incisal edge. Formation of these teeth begin at 14 weeks in utero for the deciduous (baby) set and 3–4 months of age for the permanent set.

There are some minor differences between the deciduous maxillary central incisor and that of the permanent maxillary central incisor. The deciduous tooth appears in the mouth at 3–18 months of age, with 6 months being the average and is replaced by the permanent tooth around 7–8 years of age. The permanent tooth is larger and is longer than it is wide. The maxillary central incisors contact each other at the midline of the face. The mandibular central incisors are the only other type of teeth to do so. The position of these teeth may determine the existence of an open bite or diastema. As with all teeth, variations of size, shape, and color exist among people. Systemic disease, such as syphilis, may affect the appearance of teeth.

Notation

Dentistry has several systems of notation to identify teeth. In the universal system of notation, the deciduous maxillary central incisors are designated by a letter written in uppercase. The right deciduous maxillary central incisor is known as "E", and the left one is known as "F". The permanent maxillary central incisors are designated by a number. The right permanent maxillary central incisor is known as "8", and the left one is known as "9".

In the Palmer notation, a letter is used in conjunction with a symbol designating in which quadrant the tooth is found. For the deciduous teeth, the left and right central incisor would have the same letter, "A", but the right one would have the symbol, "┘", underneath it, while the left one would have, " └". For the permanent teeth, the left and right central incisor would have the same number, "1", but the right one would have the symbol, "┘", underneath it, while the left one would have, " └".

The FDI World Dental Federation notation has a different system of numbering system than the previous two. Thus, the right deciduous maxillary central incisor is known as "51", and the left one is known as "61". For the permanent maxillary central incisor, the right one is known as "11", and the left one is known as "21".

Development

The aggregate of cells which eventually form a tooth are derived from the ectoderm of the first branchial arch and the ectomesenchyme of the neural crest. As in all cases of tooth development, the first hard tissue to begin forming is dentin, with enamel appearing immediately afterwards.

The deciduous maxillary central incisor begins to undergo mineralization 14 weeks in utero, and at birth 5/6ths of the enamel is formed. The crown of the tooth is completed 1.5 months after birth and erupts into the mouth at around 10 months of age, making these teeth usually the second type of teeth to appear. The root completes its formation when the child is 1.5 years old.

The permanent maxillary central incisor begins to undergo mineralization when a child is 3–4 months of age. The crown of the tooth is completed at around 4–5 years of age and erupts into the mouth at 7–8 years of age. The root completes its formation when the child is 10 years old.

Deciduous dentition

The overall length of the deciduous maxillary central incisor is 16 mm on average, with the crown being 6 mm and the root being 10 mm. In comparison to the permanent maxillary central incisor, the ratio of the root length to the crown length is greater in the deciduous tooth. The diameter of the crown mesiodistally is greater than the length cervicoincisally, which makes the tooth appear wider rather than taller from a labial viewpoint.

The marginal ridges and the cingulum of the tooth are well-developed. The cingulum reaches incisally a great length and is large enough to create small fossa on either side of it. Depicted by the cementoenamel junction, the cervical line is the border between the root and crown of a tooth. On the mesial and distal surfaces, the cervical line curves incisally, which is also seen in the permanent maxillary central incisor.

The root of this tooth is cone-shaped with a rounded apex. Most of the surfaces are smooth, but the mesial surface of the root may have a developmental groove or a concavity.

Permanent dentition

The permanent maxillary central incisor is the widest tooth mesiodistally in comparison to any other anterior tooth. It is larger than the neighboring lateral incisor and is usually not as convex on its labial surface. As a result, the central incisor appears to be more rectangular or square in shape. The mesial incisal angle is sharper than the distal incisal angle. When this tooth is newly erupted into the mouth, the incisal edges have three rounded features called mammelons. Mammelons disappear with time as the enamel wears away by friction.

Generally, there are gender differences in the appearance of this tooth. In males, the size of the maxillary central incisor is larger usually than in females. Gender differences in enamel thicknes and dentin width are low. Age differences in the gingival-incisal length of maxillary central incisors are seen and are attributed to normal attrition occurring throughout life. Thus, younger individuals have a greater gingival incisal length of the teeth than older individuals.

Labial view

Labial view

The labial view of this tooth considers the portion of the tooth visible from the side where the lips would be. The mesial outline of the tooth is straight or slightly convex, whereas the distal outline is much more convex. Consequently, the height of curvature (the point furthest away from the central axis of the tooth) is closer to the mesioincisal angle on the mesial side while more apical on the distal side. the distal outline of the crown is more convex than the mesial outline, and the distoincisal angle is not as sharp as the mesoincisal angle. After the mammelons are worn away, the incisal edge of the maxillary central incisor is straight mesiodistally. The center of the incisal edge curves slightly downward in the center of the tooth. The cervical line, which is seen as the border between the crown and the root of the tooth, is closer to the apex of the root in the center of the tooth. This makes the cervical line appear as a semicircle in shape.

From this view, the root is blunt and cone-shaped. Although there is a large amount of variation between people, the length of the root is usually 2–3 mm longer than the length of the crown. Large curvatures of the root are usually not seen in this tooth.

Lingual view

Lingual view

The lingual view of this tooth considers the portion of the tooth visible from the side where the tongue would be. The lingual side of the maxillary central incisor has a small convexity, called a cingulum near the cervical line and has a large concavity, called the lingual fossa. Along the mesial and distal sides are slightly raised portions called marginal ridges. The lingual incisal edge is also raised slightly to the level of the marginal ridges. The lingual fossa is bordered incisally by the lingual incisal edge, mesially by the mesial marginal ridge, distally by the distal marginal ridge, and cervically by the cingulum. Developmental grooves are found on the cingulum and lying into the lingual fossa.

This side of the tooth tapers in size from the labial side of the tooth. As a result, the mesial and distal sides of the tooth are further away on the labial side than on the lingual side. Furthermore, a cross-section of the tooth at the cervical line would show a general triangle appearance. One of the triangle's sides would be the facial surface, and the other two sides would be the mesial side and the slightly shorter distal side.

Mesial view

Mesial view

The mesial view of this tooth considers the portion of the tooth visible from the side closest to where the middle line of the face would be. The mesial side of the maxillary central incisor shows the crown of the tooth as a triangle with the point at the incisal edge and the base at the cervix. The root appears cone shaped with a blunt apex. Unlike most other teeth, a line drawn through the center of the incisal edge will also cross through the center of the root apex. This also occurs in maxillary lateral incisors.

The crest of curvature for the palatal and labial surfaces is located directly incisally to the cervical line. The labial surface of the crown is convex from the crest of curvature to the incisal edge. The lingual surface of the crown is convex near the cingulum and near the incisal edge, but for the most part is concave along the surface between those two areas.

More than any other tooth in the mouth, the cervical line from this view curves tremendously toward the incisal. In an average crown length of 10.5 to 11 mm, the curvature of the cervical line in a maxillary central incisor is 3 to 4 mm.

Distal view

Distal view

The distal view of this tooth considers the portion of the tooth visible from the side furthest from where the middle line of the face would be. This side of the tooth is very similar to the mesial side. A greater portion of the tooth surface facing the lips is visible from this view compared to the mesial view because the labial surface tilts distally and lingually. Also, the cervical line curves less in comparison to the mesial view.

Incisal view

The incisal view of this tooth considers the portion of the tooth visible from the side where the incisal edge is located. From this angle, only the crown of the tooth is visible, and overall the tooth looks bilateral. The labial surface appears broad and flat. The lingual surface tapers toward the cingulum. The distance between the mesioincisal angle to the cingulum is slightly longer than the distance between the distoincisal angle to the cingulum.

Pulp anatomy

The pulp is the location of the nerve and blood supply of a tooth. In the deciduous maxillary central incisor, endodontic treatment is less frequent. In the permanent maxillary central incisor, root canal treatment can be effective. There frequently are three pulp horns in this tooth. In nearly all maxillary central incisors, there is one canal with one apex. During root canal therapy, access into the pulp is frequently located centrally on the lingual surface between the incisal edge and the cingulum. At the level of the cervical line, the shape of the canal is triangular but becomes circular at the middle level of the root. Although the root is generally straight, the most common points of curvature is near the apex, and their direction is more common toward the distal and lingual.

Surrounding teeth

Interproximal contacts

Contact with adjacent teeth in the same arch is referred to as interproximal contacts. The maxillary central incisors are one of only two types of teeth which has an interproximal contact with itself. The other type of teeth is the mandibular central incisors. In usually preferred and healthy states, the central incisors touch in the incisal third of the teeth. On the other hand, the contact between the central incisor and the lateral incisor is nearer the gingiva at the location between the incisal and middle thirds of the tooth's crown.

Occlusion

As with all maxillary anterior teeth, the central incisors are usually located facially to the mandibular teeth when the mouth is closed. In instances when the maxillary anterior teeth are lingual to the mandibular teeth, the condition is referred to as an anterior crossbite. In some cases, this arrangement of teeth may indicate a displacement of the mandible relative to the maxilla and is called Class III or Pseudo-Class III malocclusion. Normal occlusion is Class I occlusion.

When the teeth are biting down, the maxillary central incisors occlude with the mandibular central and lateral incisors. The contact point of the mandibular teeth is in the lingual fossa of the maxillary central incisor about 4 mm gingivally from the incisal edge. In this position, the maxillary incisors cover nearly half of the mandibular incisors' crowns. When the maxillary and mandibular incisors do not contact even when the mouth is fully closed, an anterior open bite occurs. This misalignment of teeth may result from some habits, such as thumb-sucking. On the other hand, when the contact of the mandibular incisors to the maxillary incisors is near or completely on the gingiva, a deep bite occurs.

Variation

Considered to be a relatively unique genetic variation occurring virtually exclusively only in East Asian populations, possibly a trait retained from an indigenous East Asian archaic human ancestor Homo Erectus Pekinensis, shovel-shaped incisors derive their name from the deeper-than-normal lingual fossa and prominent marginal ridges of the teeth. When seen from lingual view, the tooth is said to resemble a shovel. It is also common to see signs of attrition, which is wear over time from other tooth contact. The lingual of maxillary incisors and the facial of mandibular incisors are the most common places for attrition to occur.

When space exists between the contacts of the maxillary central incisors, the condition is referred to as a diastema or "gap tooth." One frequent cause of the space is the presence of a large labial frenum from the upper lip extending near the teeth. Treatment depends upon the cause and extent of the gap. Periodontal surgery may be required to reduce the frenum. A small space may be corrected with a filling, veneer, or crown. Larger spaces may require orthodontics.

The maxillary incisors, both the central and lateral, are the most likely teeth to have a talon cusp, which is an extra cusp on the lingual surface. Talon cusps have been found in to range in less than 1% to 6% of the population, and 33% of cases occur on the permanent maxillary central incisor. Deciduous teeth are unlikely to have talon cusps. Also, the permanent maxillary incisors are the most likely teeth to have a dilaceration, which is a sharp curve on a tooth.

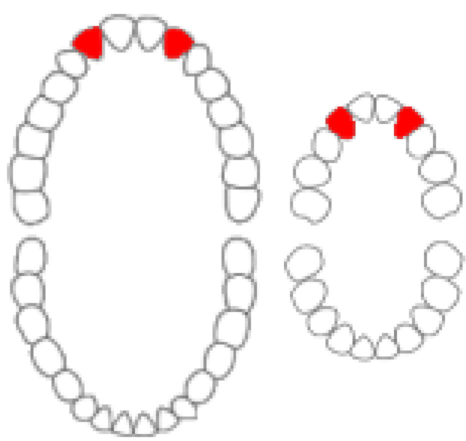
All incisors have the potential to be affected by a case of congentital syphilis, which can cause a notch to form on the incisal edges of these teeth. These teeth, sometimes described as screwdriver-shaped, are called "Hutchinson's incisors." They serve as part of Hutchinson's triad, which also includes interstitial keratitis and eighth nerve deafness.

Chapter 5

Maxillary Lateral Incisor and Mandibular Central Incisor

Maxillary lateral incisor

Maxillary lateral incisor



Maxillary lateral incisors of permanent and primary teeth marked in red.

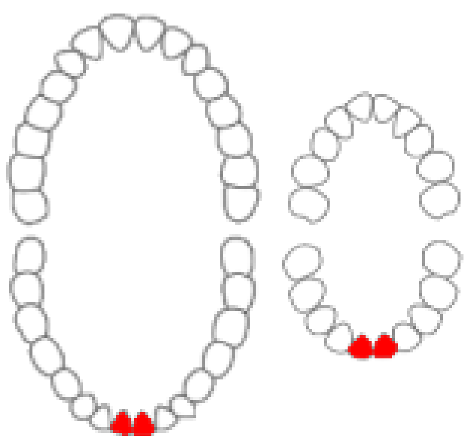
The **Maxillary lateral incisor** is a tooth that is located distally (away from the midline of the face) from both maxillary central incisors of the mouth and mesially (toward the midline of the face) from both maxillary canines. As with all incisors, their function is for shearing or cutting food during mastication, commonly known as chewing. There are no cusps on the teeth. Instead, the surface area of the tooth used in eating is called an incisal ridge or incisal edge. Though relatively the same, there are some minor differences between the deciduous (baby) maxillary lateral incisor and that of the permanent maxillary lateral incisor.

In the universal system of notation, the deciduous maxillary lateral incisors are designated by a letter written in uppercase. The right deciduous maxillary lateral incisor is known as "D", and the left one is known as "G". The international notation has a different system of notation. Thus, the right deciduous maxillary lateral incisor known as "52", and the left one is known as "62".

In the universal system of notation, the permanent maxillary lateral incisors are designated by a number. The right permanent maxillary lateral incisor is known as "7", and the left one is known as "10". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right lateral incisors would have the same number, "2", but the right one would have the symbol, "┘", underneath it, while the left one would have, " └". The international notation has a different numbering system than the previous two, and the right permanent maxillary lateral incisor is known as "12", and the left one is known as "22".

Mandibular central incisor

Mandibular central incisor



Mandibular central incisors of permanent and primary teeth marked in red.

The **mandibular central incisor** is the tooth located on the jaw, adjacent to the midline of the face. It is mesial (toward the midline of the face) from both mandibular lateral incisors. As with all incisors, its function includes shearing or cutting food during mastication, commonly known as chewing. There are no cusps on the tooth. Instead, the surface area of the tooth used in eating is called an incisal ridge or incisal edge. Though the two are similar, there are some minor differences between the deciduous (baby) mandibular central incisor and that of the permanent mandibular central incisor.

Notation

In the universal system of notation, the deciduous mandibular central incisors are designated by a letter written in uppercase. The right deciduous mandibular central incisor is known as "P", and the left one is known as "O". The international notation has a different system of notation. Thus, the right deciduous mandibular central incisor is known as "81", and the left one is known as "71".

In the universal system of notation, the permanent mandibular central incisors are designated by a number. The right permanent mandibular central incisor is known as "25", and the left one is known as "24". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right central incisors would have the same number, "1", but the right one would have the symbol, "┐", over it, while the left one would have, "┌". The international notation has a different numbering system than the previous two, and the right permanent mandibular central incisor is known as "41", and the left one is known as "31".

Anatomy

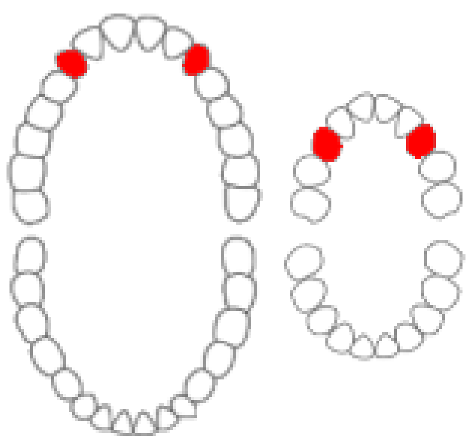
The central incisors have fossa on their lingual surfaces.

Chapter 6

Maxillary Canine and Mandibular Canine

Maxillary canine

Maxillary canine



Maxillary canines of permanent and primary teeth marked in red.

The **maxillary canine** is the tooth located laterally (away from the midline of the face) from both maxillary lateral incisors of the mouth but mesial (toward the midline of the face) from both maxillary first premolars. Both the maxillary and mandibular canines are called the "cornerstone" of the mouth because they are all located three teeth away from the midline, and separate the premolars from the incisors. The location of the canines reflect their dual function as they complement both the premolars and incisors during mastication, commonly known as chewing. Nonetheless, the most common action of the canines is tearing of food. The canine teeth are able to withstand the tremendous lateral pressure caused by chewing. There is a single cusp on canines, and they resemble the prehensile teeth found in carnivorous animals. Though relatively the same, there are some minor differences between the deciduous (baby) maxillary canine and that of the permanent maxillary canine.

It is the longest tooth in total length (from the root to the incisal edge) in the mouth. Canines are also the only anterior teeth with a cusp.

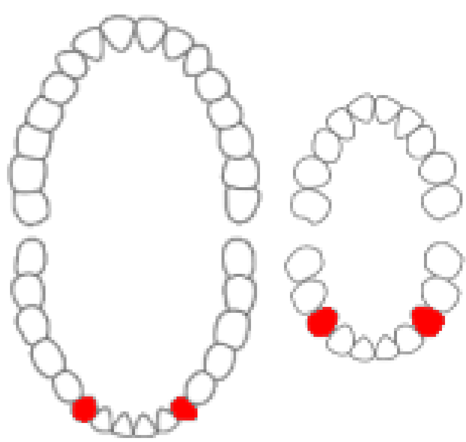
Maxillary canines begin to calcify by 4 months of age. The enamel of the tooth is completely formed by around 6 to 7 years of age and the permanent maxillary canines erupt at around 11 to 12 years of age. The root is completely formed by 13 to 15 years of age. The maxillary canine teeth are slightly wider than the mandibular canine teeth. The maxillary canines have one root, usually the longest root of any tooth in the mouth.

In the *universal system of notation*, the deciduous maxillary canines are designated by a letter written in uppercase. The right deciduous maxillary canine is known as "C" and the left one "H". In *international notation*, the right deciduous maxillary canine is known as "53" and the left one "63".

In the universal system of notation, the permanent maxillary canines are referred to by numbers. The right permanent maxillary canine is known as "6" and the left "11". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right canines would have the same number, "3", but the right is designated with the symbol "┘" under the number, and the left one likewise with "└". The international notation has a different numbering system from the other two, and the right permanent maxillary canine is known as "13" and the left "23".

Mandibular canine

Mandibular canine



Mandibular canines of permanent and primary teeth marked in red.

The **mandibular canine** is the tooth located distally (away from the midline of the face) from both mandibular lateral incisors of the mouth but mesially (toward the midline of the face) from both mandibular first premolars. Both the maxillary and mandibular canines are called the "cornerstone" of the mouth because they are all located three teeth away from the midline, and separate the premolars from the incisors. The location of the canines reflect their dual function as they complement both the premolars and incisors during mastication, commonly known as chewing. Nonetheless, the most common action of the canines is tearing of food. The canine teeth are able to withstand the tremendous lateral pressures from chewing. There is a single cusp on canines, and they resemble the prehensile teeth found in carnivorous animals. Though relatively the same, there are some minor differences between the deciduous (baby) mandibular canine and that of the permanent mandibular canine.

The mandibular canines begin to show calcification at age 4 months and the enamel of the crown is completely formed by age 7 years. The permanent mandibular canines erupt at around 9 to 10 years of age. The mandibular and maxillary canines are the longest teeth in the mouth. The root of the mandibular canine, which is fully formed by age 13, is the longest in the mandibular arch. The mandibular canines are slightly narrower than the maxillary canines but its crown is as long and sometimes is longer. The mandibular canines usually have only one root, but sometimes the root may be bifurcated, or have two roots. When it does, one root faces the tongue (lingual side) and one will face the lip (labial side).

In the universal system of notation, the deciduous mandibular canines are designated by a letter written in uppercase. The right deciduous mandibular canine is known as "R", and the left one is known as "M". The international notation has a different system of notation. Thus, the right deciduous mandibular canine is known as "83", and the left one is known as "73".

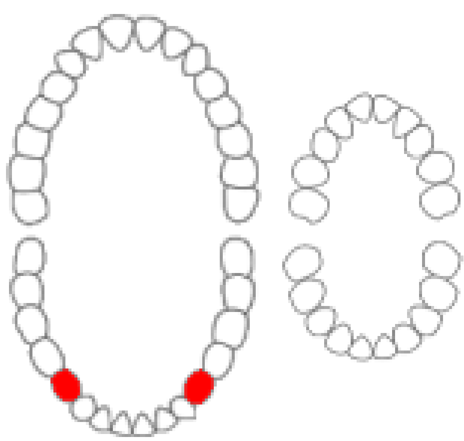
In the universal system of notation, the permanent mandibular canines are designated by a number. The right permanent mandibular canine known as "27", and the left one is known as "22". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right canines would have the same number, "3", but the right one would have the symbol, "┐", over it, while the left one would have, "┌". The international notation has a different numbering system than the previous two, and the right permanent mandibular canine is known as "43", and the left one is known as "33".

Chapter 7

Mandibular First Premolar and Mandibular Second Premolar

Mandibular first premolar

Mandibular first premolar



Mandibular first premolars of permanent teeth marked in red. There are no premolars in primary teeth.

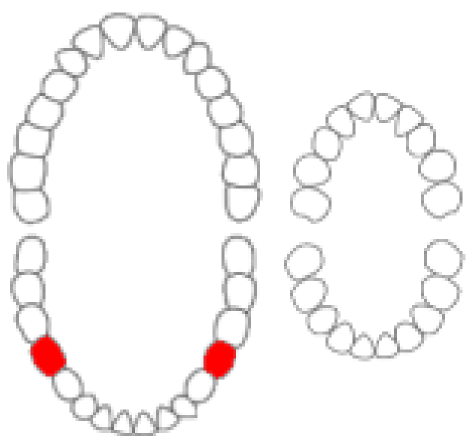
The **mandibular first premolar** is the tooth located laterally (away from the midline of the face) from both the mandibular canines of the mouth but mesial (toward the midline of the face) from both mandibular second premolars. The function of this premolar is similar to that of canines in regard to tearing being the principal action during mastication, commonly known as chewing. Mandibular first premolars have two cusps. The one large and sharp is located on the buccal side (closest to the cheek) of the tooth. Since the lingual cusp (located nearer the tongue) is small and nonfunctional (which refers to a cusp not active in chewing), the mandibular first premolar resembles a small canine. There are no deciduous (baby) mandibular premolars. Instead, the teeth that precede the permanent mandibular premolars are the deciduous mandibular molars.

Sometimes, premolars are referred to as **bicuspids**. Even though the terms are synonymous, "bicuspid" refers to having two functional cusps, and the mandibular first premolar is an example of a premolar with only one functional cusp. Thus, "biscupid" is technically not as accurate as "premolar".

In the universal system of notation, the permanent mandibular premolars are designated by a number. The right permanent mandibular first premolar is known as "28", and the left one is known as "21". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right first premolars would have the same number, "4", but the right one would have the symbol, "┐", over it, while the left one would have, "┌". The international notation has a different numbering system than the previous two, and the right permanent mandibular first premolar is known as "44", and the left one is known as "34".

Mandibular second premolar

Mandibular second premolar



Mandibular second premolars of permanent teeth marked in red. There are no premolars in primary teeth.

The **mandibular second premolar** is the tooth located distally (away from the midline of the face) from both the mandibular first premolars of the mouth but mesial (toward the midline of the face) from both mandibular first molars. The function of this premolar is assist the mandibular first molar during mastication, commonly known as chewing. Mandibular second premolars have three cusps. There is one large cusp on the buccal side (closest to the cheek) of the tooth. The lingual cusps (located nearer the tongue) are well developed and functional (which refers to cusps assisting during chewing). Therefore, whereas the mandibular first premolar resembles a small canine, the mandibular second premolar is more alike to the first molar. There are no deciduous (baby) mandibular premolars. Instead, the teeth that precede the permanent mandibular premolars are the deciduous mandibular molars.

Anatomy: The mandibular second premolar most commonly has three cusps but can have two as well. The three cusp variety has one large cusp on the buccal with two smaller lingual cusps. The mesiolingual cusp is twice the size of the disolingual cusp. Viewed from the occlusal (looking down onto the biting surface of the tooth) the tooth is rather square in outline, particularly on the lingual. The occlusal table (the area bounded by the cusps, cusp ridges, and marginal ridges) is rectangular. The groove pattern is shaped like a “Y” with the tail pointed to the lingual and placed between the distolingual and mesiolingual cusps one third of the distance form the distal to the mesial. The contacts with the adjacent teeth are positioned buccal to the midpoint. Viewed from the buccal the buccal cusp tip is centered mesiodistally. The buccal cusp ridges exhibit slight concavities that extend over the buccal surfaces as developmental grooves into the gingival embrasure. The contacts with adjacent teeth are in the occlusal third of the tooth with the distal height of contour slightly closer to the gingival than the mesial height of contour. The root is generally straight with slight curvature to the distal in the apical third. Viewed from the mesial or distal the buccal height of contour is in the gingival third of the tooth. The lingual height of contour is in the middle third of the tooth (not the middle third of the lingual cusp). When divided into thirds from the buccal height of contour to the lingual height of contour, the buccal cusp is at the contact between the buccal and middle thirds and the central groove is at the contact of the middle and lingual thirds. The two cusp variety generally has a groove pattern shaped like a “U” or “H”. Viewed from the occlusal it is more rounded in general and its lingual cusp is positioned slightly to the mesial, while the occlusal table remains squared. Viewed from the buccal the buccal cusp is centered over the root as in the three cusp variety. Viewed from the mesial or distal its heights of contour are similar to the three cusp variety.

Sometimes, premolars are referred to as **bicuspids**. Even though the terms are synonymous, "bicuspid" refers to having two functional cusps, and the mandibular second premolar is an example of a premolar with three functional cusps. Thus, "biscupid" is technically not as accurate as "premolar".

In the universal system of notation, the permanent mandibular premolars are designated by a number. The right permanent mandibular second premolar is known as "29", and the left one is known as "20". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right second premolars would have the same number, "5", but the right one would have the symbol, "┐", over it, while the left one would have, " ┌". The international notation has a different numbering system than the previous two, and the right permanent mandibular second premolar is known as "45", and the left one is known as "35".

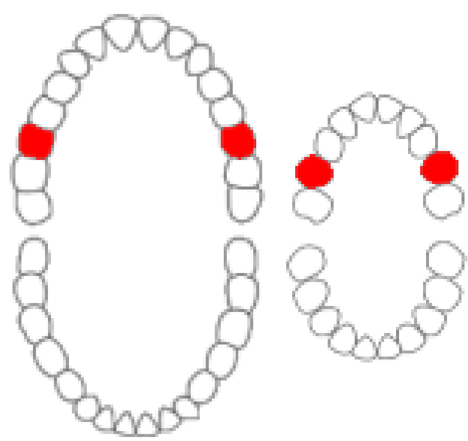
It is a very common condition in orthodontics for a patient to have one or both mandibular second premolars congenitally absent.

Chapter 8

Maxillary First Molar, Maxillary Second Molar and Maxillary Third Molar

Maxillary first molar

Maxillary first molar



Maxillary first molars of permanent and primary teeth marked in red.

The **maxillary first molar** is the tooth located laterally (away from the midline of the face) from both the maxillary second premolars of the mouth but mesial (toward the midline of the face) from both maxillary second molars.

The function of this molar is similar to that of all molars in regard to grinding being the principle action during mastication, commonly known as chewing.

There are usually four cusps on maxillary molars, two on the buccal (side nearest the cheek) and two palatal (side nearest the palate). There may also be a fifth smaller cusp on the palatal side known as the Cusp of Carabelli.

Normally, maxillary molars have four lobes, two buccal and two lingual, which are named in the same manner as the cusps that represent them (mesiobuccal, distobuccal, mesiolineual, and distolingual lobes). Unlike the anterior teeth and premolars, molars do not exhibit facial developmental depressions. Evidence of lobe separation can be found in the central groove, which divides buccal from lingual lobes. The two lingual lobes are separated by the distolingual groove, and the two buccal lobes are divided by the buccal groove.

There are great differences between the deciduous (baby) maxillary molars and those of the permanent maxillary molars, even though their function are similar. The permanent maxillary molars are not considered to have any teeth that precede it. Despite being named molars, the deciduous molars are followed by permanent premolars.

Notation

Permanent Maxillary 1st Molar Notation

In the Universal Numbering System, one number is used to identify the tooth. The right permanent maxillary first molar is known as tooth "3", and the left permanent maxillary first molar is known as tooth "14".

In the Palmer Notation, a number and symbol are used to identify the tooth. The number identifies the tooth position relative to the midline, and the symbol identifies the quadrant of the mouth. Both Maxillary First Molars have the same number; 6. However, the right molar has the symbol "┘ " underneath it. The left molar has " └" underneath it.

In the International System of Notation two numbers are used to identify the tooth. The first number identifies the quadrant of the mouth. The second number identifies the tooth relative to the midline of the arch. The right permanent maxillary first molar is known as "16". The left permanent maxillary first molar is known as "26".

Deciduous Maxillary 1st Molar Notation

In the Universal Numbering System, an uppercase letter is used to identify the tooth. The right deciduous maxillary first molar is known as "B", and the left one is known as "I".

In the International System of Notation two numbers are used to identify the tooth. The Right Deciduous Maxillary First Molar is known as "54", and the left one is known as "64".

External Root Morphology

The maxillary first molar normally has three roots.

1. The **Mesiobuccal Root** is broad buccolingually and has prominent depressions or flutings on its mesial and distal surfaces. The internal canal morphology is highly variable, but the majority of the mesiobuccal roots contain two canals.
2. The **Distobuccal Root** is generally rounded or ovoid in cross section and usually contains a single canal.
3. The **Palatal Root** is more broad mesiodistally than buccolingually and ovoidal in shape but normally contains only a single canal. Although the palatal root generally appears straight on radiographs, there is usually a buccal curvature in the apical third. Depressions on the buccal and palatal surfaces of the palatal root can be present but are generally shallow.

There are prominent depressions found on the distal aspect of the mesiobuccal roots. Depressions can also be found on the furcal side of the distobuccal and palatal roots.

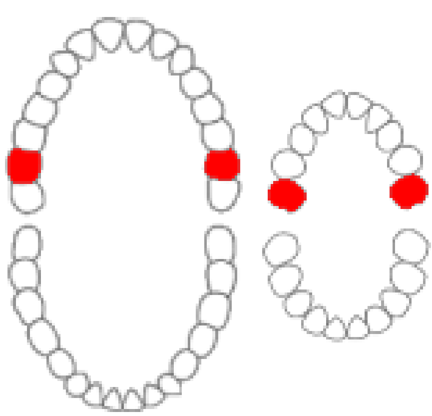
The overall average length of the maxillary first molar is 20.5 mm with an average crown length of 7.5 mm and an average root length of 13 mm.

Pathologies

The maxillary first molars are the second most common carious teeth and the second most common teeth to undergo endodontic treatment or extraction (with mandibular first molars the most common diseased teeth). Up to 21% of all extracted teeth are maxillary first molars.

Maxillary second molar

Maxillary second molar



Maxillary second molars of permanent and primary teeth marked in red.

The **maxillary second molar** is the tooth located distally (away from the midline of the face) from both the maxillary first molars of the mouth but mesial (toward the midline of the face) from both maxillary third molars. This is true only in permanent teeth. In deciduous (baby) teeth, the maxillary second molar is the last tooth in the mouth and does not have a third molar behind it. The function of this molar is similar to that of all molars in regard to grinding being the principle action during mastication, commonly known as chewing. There are usually four cusps on maxillary molars, two on the buccal (side nearest the cheek) and two palatal (side nearest the palate).

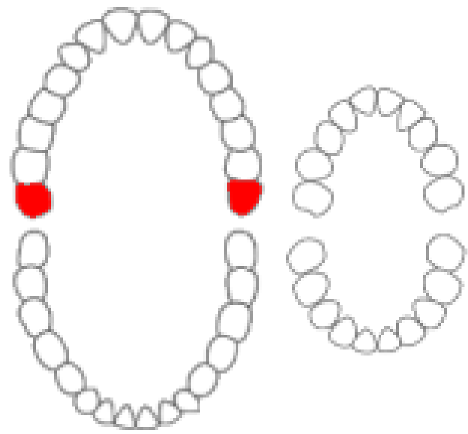
There are great differences between the deciduous (baby) maxillary molars and those of the permanent maxillary molars, even though their function are similar. The permanent maxillary molars are not considered to have any teeth that precede it. Despite being named molars, the deciduous molars are followed by permanent premolars. The deciduous maxillary second molar is the most likely deciduous tooth to have an oblique ridge.

In the universal system of notation, the deciduous maxillary second molars are designated by a letter written in uppercase. The right deciduous maxillary second molar is known as "A", and the left one is known as "J". The international notation has a different system of notation. Thus, the right deciduous maxillary second molar is known as "55", and the left one is known as "65".

In the universal system of notation, the permanent maxillary second molars are designated by a number. The right permanent maxillary second molar is known as "2", and the left one is known as "15". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right second molars would have the same number, "7", but the right one would have the symbol, "┘ ", underneath it, while the left one would have, " └". The international notation has a different numbering system than the previous two, and the right permanent maxillary second molar is known as "17", and the left one is known as "27".

Maxillary third molar

Maxillary third molar



Maxillary third molars of permanent teeth marked in red. There are no third molars in primary teeth.

The **maxillary third molar** is the third molar (commonly known as wisdom teeth) located laterally (away from the midline of the face) from both the maxillary (upper) second molars of the mouth with no tooth posterior to it in permanent teeth. In deciduous (baby) teeth, there is no maxillary third molar. The function of this molar is similar to that of all molars in regard to grinding being the principal action during mastication, commonly known as chewing. There are usually four cusps on maxillary molars, two on the buccal (side nearest the cheek) and two palatal (side nearest the palate). Nonetheless, for this tooth, there are great variances among third molars, and a specific description of a third molar will not hold true in all cases. The permanent maxillary molars are not considered to have any teeth that precede it.

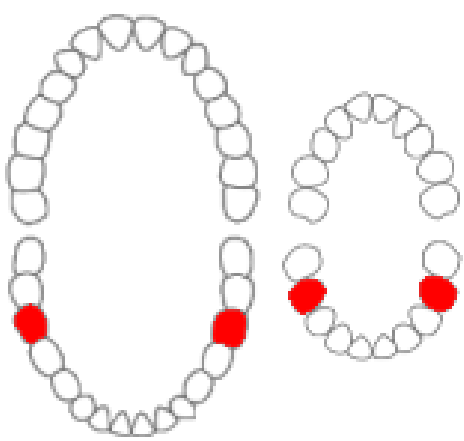
In the universal system of notation, the permanent maxillary third molars are designated by a number. The right permanent maxillary third molar is known as "1", and the left one is known as "16". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right third molars would have the same number, "8", but the right one would have the symbol, "┘", underneath it, while the left one would have, " └". The international notation has a different numbering system than the previous two, and the right permanent maxillary third molar is known as "18", and the left one is known as "28".

Chapter 9

Mandibular First Molar and Mandibular Second Molar

Mandibular first molar

Mandibular first molar



Mandibular first molars of permanent and primary teeth marked in red.

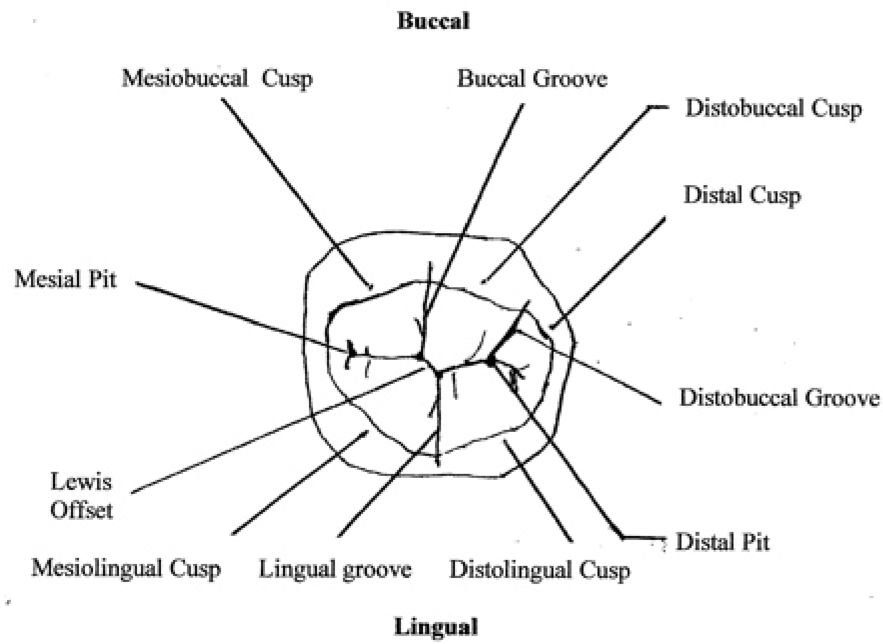
The **mandibular first molar** or **six-year molar** is the tooth located distally (away from the midline of the face) from both the mandibular second premolars of the mouth but mesial (toward the midline of the face) from both mandibular second molars. It is located on the mandibular (lower) arch of the mouth, and generally opposes the maxillary (upper) first molars and the maxillary 2nd premolar in normal class I occlusion. The function of this molar is similar to that of all molars in regard to grinding being the principal action during mastication, commonly known as chewing. There are usually five well-developed cusps on mandibular first molars: two on the buccal (side nearest the cheek), two lingual (side nearest the tongue), and one distal. There are great differences between the deciduous (baby) mandibular molars and those of the permanent mandibular molars, even though their function are similar. The permanent mandibular molars are not considered to have any teeth that precede it. Despite being named molars, the deciduous molars are followed by permanent premolars.

In the universal system of notation, the deciduous mandibular first molars are designated by a letter written in uppercase. The right deciduous mandibular first molar is known as "S", and the left one is known as "L". The international notation has a different system of notation. Thus, the right deciduous mandibular first molar is known as "84", and the left one is known as "74".

In the universal system of notation, the permanent mandibular first molars are designated by a number. The right permanent mandibular first molar is known as "30", and the left one is known as "19". The Palmer notation uses a number in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right first molars would have the same number, "6", but the right one would have the symbol, "┐", over it, while the left one would have, "┌". The international notation has a different numbering system than the previous two, and the right permanent mandibular first molar is known as "46", and the left one is known as "36". Mandibular primary first molars usually have four pulp horns.

The first molar is usually the first permanent tooth to erupt and has adult undertones.

Anatomy: The mandibular first molar has five cusps: the mesiobuccal (MB, toward midline and cheek), mesiolingual (ML, toward midline and tongue), distolingual (DL, away from midline and toward tongue), distobuccal (DB, away from midline and toward cheek), and distal (D, away from midline), listed in order of decreasing size. Listed in order of decreasing height they are: ML, DL, DF, MF, and D. Viewed from the top of the tooth (occlusal view), the mandibular first molar is pentagonal (five sided) in shape and tapers toward the lingual, with the sides being the buccal surface, the mesial surface, the lingual surface, distal surface, and the distobuccal surface. The occlusal surface has four grooves. The central groove is not straight but runs down the center of the tooth mesially to distally and contains four pits (mesial, central, central, and distal). The distobuccal groove runs from the distal pit in the central groove distobuccally separating the distal and distobuccal cusps. The lingual groove runs from the more distal of the central pits in the central groove toward the lingual surface between the mesiolingual and distolingual cusps. The buccal groove runs from the more mesial of the central pits in the central groove toward the buccal surface between the mesiobuccal and distobuccal cusps ending in the buccal pit. The portion of the central groove between the central pits is termed the Lewis offset and is mandatory to account for the locations of the buccal and lingual grooves (buccal groove being more mesial than the lingual groove while they are parallel). From the buccal (buccal view), two roots are present. The distal root is generally straighter, although both often have a slight distal curvature. The heights of contour on the mesial and distal contact the adjacent teeth and are located at the junction of the occlusal and middle thirds of the crown. The mesial view shows a slight tipping of the crown to the lingual. Both roots have flutings but they are more prominent on the mesial root. The mesial root is broader buccolingually and its apex is more blunted. The height of contour on the buccal is in the gingival third and the occlusal two thirds of the surface is flat. The lingual height of contour is in the middle third of the tooth and the lingual surface is evenly convex. The sharpness of the mesiolingual cusp can also be noted from this view.

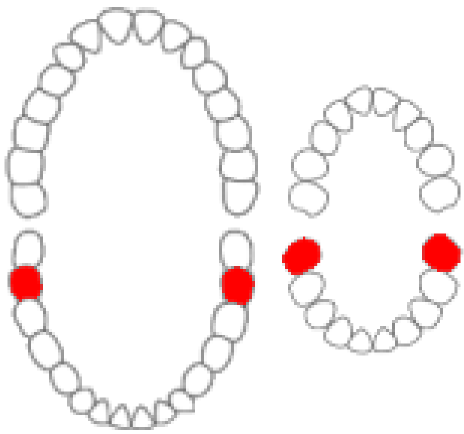


Pathologies

The mandibular first molars are the most common carious teeth and the most common teeth to undergo endodontic treatment or extraction. Up to 45% of all extracted teeth are mandibular first molars.

Mandibular second molar

Mandibular second molar



The **mandibular second molar** is the tooth located distally (away from the midline of the face) from both the mandibular first molars of the mouth but mesial (toward the midline of the face) from both mandibular third molars. This is true only in permanent teeth. In deciduous (baby) teeth, the mandibular second molar is the last tooth in the mouth and does not have a third molar behind it. The function of this molar is similar to that of all molars in regard to grinding being the principal action during mastication, commonly known as chewing. Though there is more variation between individuals to that of the first mandibular molar, there are usually four cusps on mandibular second molars: two on the buccal (side nearest the cheek) and two palatal (side nearest the palate). There are great differences between the deciduous (baby) mandibular molars and those of the permanent mandibular molars, even though their function are similar. The permanent mandibular molars are not considered to have any teeth that precede it. Despite being named molars, the deciduous molars are followed by permanent premolars.

In the universal system of notation, the deciduous mandibular second molars are designated by a letter written in uppercase. The right deciduous mandibular second molar is known as "T", and the left one is known as "K". The international notation has a different system of notation. Thus, the right deciduous mandibular second molar is known as "85", and the left one is known as "75".

In the universal system of notation, the permanent mandibular second molars are designated by a number. The right permanent mandibular second molar is known as "31", and the left one is known as "18". In the Palmer notation, a number is used in conjunction with a symbol designating in which quadrant the tooth is found. For this tooth, the left and right second molars would have the same number, "7", but the right one would have the symbol, "┐", underneath it, while the left one would have, "┌". The international notation has a different numbering system from the previous two, and the right permanent mandibular second molar is known as "47", and the left one is known as "37".

Chapter 10

Wisdom Tooth

A **wisdom tooth**, in humans, is any of the usually four **third molars**, including mandibular third molar and maxillary third molar. Wisdom teeth usually appear between the ages of 17 and 25. Most adults have four wisdom teeth, but it is possible to have more, in which case they are called supernumerary teeth. Wisdom teeth commonly affect other teeth as they develop, becoming impacted or "coming in sideways". They are often extracted when this occurs. About 35% of the population does not develop wisdom teeth at all.

Impaction

The upper left (picture right) and upper right (picture left) wisdom tooth are distoangularly impacted. The lower left wisdom tooth is horizontally impacted. The lower right wisdom tooth is vertically impacted (unidentifiable in orthopantomogram).

Impacted wisdom teeth fall into one of several categories:

- *Mesioangular impaction* is the most common form (44%), and means the tooth is angled forward, towards the front of the mouth.
- *Vertical impaction* (38%) occurs when the formed tooth does not erupt fully through the gum line.
- *Distoangular impaction* (6%) means the tooth is angled backward, towards the rear of the mouth.

- *Horizontal impaction* (3%) is the least common form, which occurs when the tooth is angled fully ninety degrees sideways, growing into the roots of the second molar.

Typically mesioangular impactions are the most difficult to extract in the maxilla and easiest to extract in the mandible, while distoangular impactions are the easiest to extract in the maxilla and most difficult to extract in the mandible. Frequently, a fully erupted upper wisdom tooth requires bone removal if the tooth does not yield easily to forceps or elevators. Failure to remove distal or buccal bone while removing one of these teeth can cause the entire maxillary tuberosity to be fractured off, thereby tearing out the floor of the maxillary sinus.

Impacted wisdom teeth may also be categorized on whether they are still completely encased in the jawbone. If it is completely encased in the jawbone, it is a *bony impaction*. If the wisdom tooth has erupted out of the jawbone but not through the gumline, it is called a *soft tissue impaction*.

In a small portion of patients, cysts and tumors occur around impacted wisdom teeth, requiring surgical extraction. Estimates of the incidence of cysts around impacted teeth vary from 0.001% to 11%, with a higher incidence in older patients, suggesting that the chance of a cyst or tumor increases the longer an impaction exists. Only 1-2% of impactions result in malignant tumors.

The oldest known impacted wisdom tooth belonged to a European woman of the Magdalenian period (18,000 - 10,000 BC).

Partial eruption

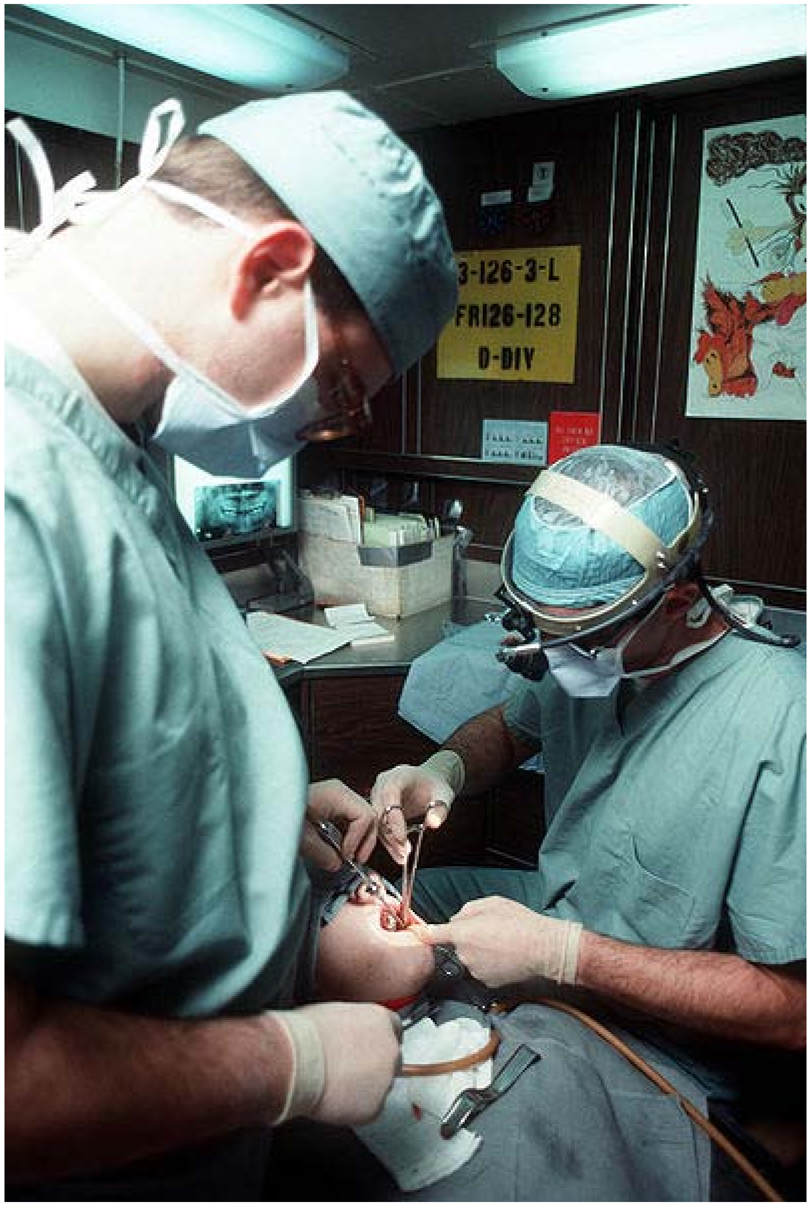
Sometimes the wisdom tooth fails to erupt completely through the gum bed and the gum at the back of the wisdom tooth extends over the biting surface, forming a soft tissue flap or lid around the tooth called an operculum. Teeth covered by an operculum can be difficult to clean with a toothbrush. Additional cleaning techniques can include using a needle-less plastic syringe to vigorously wash the tooth with moderately pressured water or to softly wash it with hydrogen peroxide.

However, debris and bacteria can easily accumulate under an operculum, which may cause pericoronitis, a common infection problem in young adults with partial impactions that is often exacerbated by occlusion with opposing third or second molars. Common symptoms include a swelling and redness of the gum around the eruption site, difficulty in opening the mouth, a bad odor or taste in the mouth, and pain in the general area which may also run down the entire lower jaw or possibly the neck. Untreated pericoronitis can progress to a much more severe infection.

If the operculum does not disappear, recommended treatment is extraction of the wisdom tooth. An alternative treatment involving removal of the operculum, called operculectomy, has been advocated. There is a high risk of permanent or temporary numbness of the tongue due to damage of the nerve with this treatment and it is no longer recommended as a standard treatment in oral surgery.

Extraction

A wisdom tooth protrudes outwards from the gumline at the back of the lower teeth



A dental officer and his assistant remove the mandibular third molar of a patient

An extracted mandibular third molar that was horizontally impacted

An upper and lower right wisdom tooth extracted during the same session under local anesthetics.

Wisdom teeth are extracted for two general reasons: either the wisdom teeth have already become impacted, or the wisdom teeth could potentially become problematic if not extracted. Potential problems caused by the presence of properly grown-in wisdom teeth include infections caused by food particles easily trapped in the jaw area behind the wisdom teeth where regular brushing and flossing is difficult and ineffective. Such infections may be frequent, and cause considerable pain and medical danger. Other reasons wisdom teeth are removed include misalignment which rubs up against the tongue or cheek causing pain, potential crowding or malocclusion of the remaining teeth (a result of there being not enough room on the jaw or in the mouth), as well as orthodontics.

Post-extraction problems

There are several problems that might occur after the extraction(s) have been completed. Some of these problems are unavoidable and natural, while others are under the control of the patient. The suggestions contained in the sections below are general guidelines that a patient will be expected to abide by, but the patient should follow all directions that are given by the surgeon in addition to the following guidelines. Above all, the patient must not disregard the given instructions; doing so is extremely dangerous and could result in any number of problems ranging in severity from being merely inconvenient (dry socket) to potentially life-threatening (serious infection of the extraction sites).

Cyst around right lower wisdom tooth

Bleeding and oozing

Bleeding and oozing is inevitable and should be expected to last up to three days (although by day three it should be less noticeable). Rinsing the mouth during this period is counter-productive, as the bleeding stops when the blood forms clots at the extraction sites, and rinsing out the mouth will most likely dislodge the clots. The end result will be a delay in healing time and a prolonged period of bleeding. Gauze pads should be placed at the extraction sites, and then should be bitten down on with firm and even pressure. This will help to stop the bleeding, but should not be overdone as it is possible to irritate the extraction sites and prolong the bleeding or remove the clot. The bleeding should decrease gradually and noticeably upon changing the gauze. If the bleeding lasts for more than a day without decreasing despite having followed the surgeon's directions, the surgeon should be contacted as soon as possible. This is not supposed to happen under normal circumstances and signals that a serious problem is present. A wet tea bag can replace the gauze pads. Tannin contained in tea can help reduce the bleeding.

Due to the blood clots that form in the exposed sockets as well as the abundant bacterial flora in the mouth, an offensive smell may be noticeable a short time after surgery. The persistent odor often is accompanied by an equally rancid-tasting fluid seeping from the wounds. These symptoms will diminish over an indeterminate amount of time, although one to two weeks is normal. While not a cause for great concern, a post-operative appointment with one's surgeon seven to ten days after surgery is highly recommended to make sure that the healing process has no complications and that the wounds are relatively clean. If infection does enter the socket, a qualified dental professional can gently plunge a plastic syringe (without the hypodermic needle) full of a mixture of equal parts hydrogen peroxide and water or chlorohexidine gluconate, which also comes in the form of a mouth wash, into the sockets to remove any food or bacteria that may collect in the back of the mouth. This is less likely if the person has his/her wisdom teeth removed at an early age.

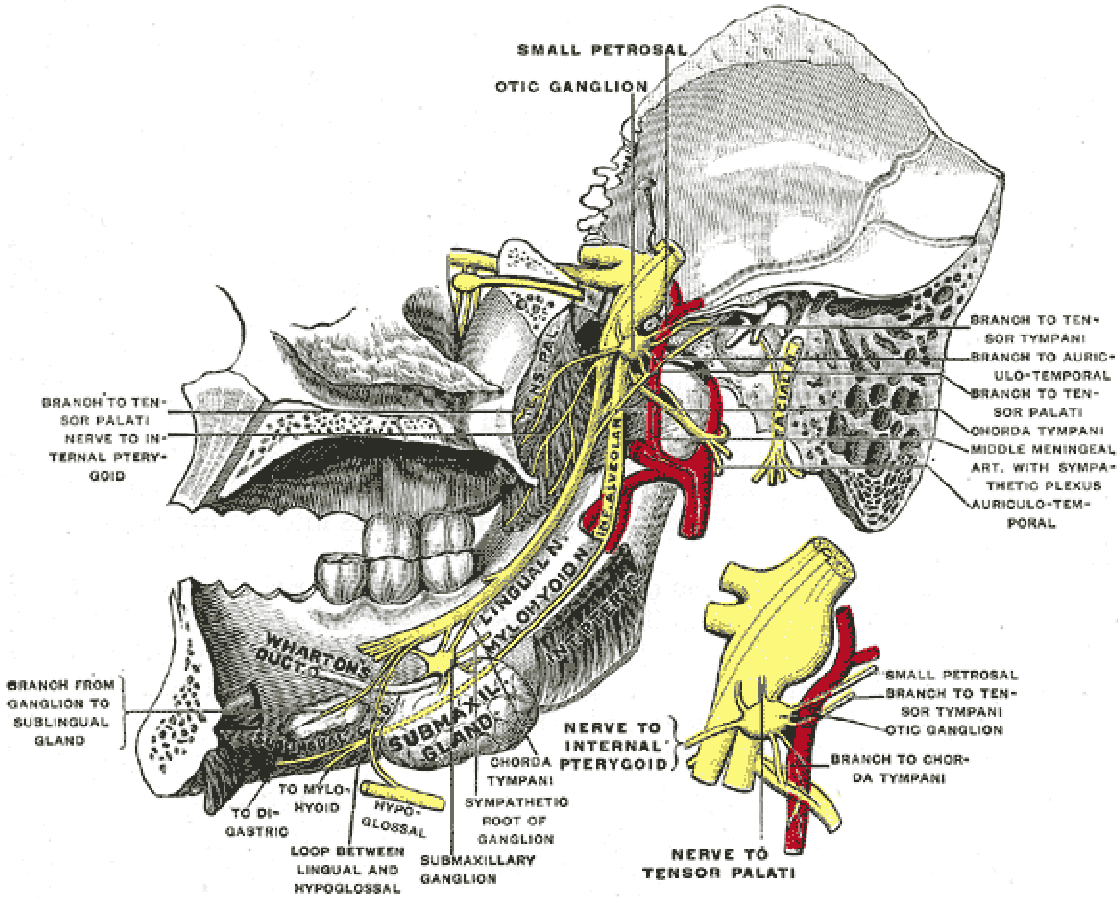
Dry socket

A dry socket is a painful inflammation of the alveolar bone (not an infection); it occurs when the blood clots at an extraction site are dislodged, fall out prematurely, or fail to form. It is still not known how they form or why they form. In some cases, this is beyond the control of the patient. However, in other cases this happens because the patient has disregarded the instructions given by the surgeon. Smoking, blowing one's nose, spitting, or drinking with a straw in disregard to the surgeon's instructions can cause this, along with other activities that change the pressure inside of the mouth, such as sneezing or playing a musical instrument. The risk of developing a dry socket is greater in smokers, in diabetics, if the patient has had a previous dry socket, in the lower jaw, and following complicated extractions. The extraction site will become irritated and painful, due to inflammation of the bone lining the tooth socket (osteitis). The symptoms are made worse when food debris is trapped in the tooth socket. The patient should contact their surgeon if they suspect that they have a case of dry socket. The surgeon may elect to clean the socket under local anesthetic to cause another blood clot to form or prescribe medication in topical form (e.g. Alvogel) to apply to the affected site. A non-steroidal anti-inflammatory drug (NSAID) such as ibuprofen may be prescribed by the surgeon for pain relief. Generally dry sockets are self limiting and heal in a couple of weeks without treatment.

Swelling

Swelling should not be confused with dry socket, although painful swelling should be expected and is a sign that the healing process is progressing normally. There is no general duration for this problem; the severity and duration of the swelling vary from case to case. The surgeon will tell the patient how long they should expect swelling to last, including when to expect the swelling to peak and when the swelling will start to subside. If the swelling does not begin to subside when it is supposed to, the patient should contact his or her surgeon immediately. While the swelling will generally not disappear completely for several days after it peaks, swelling that does not begin to subside or gets worse may be an indication of infection. Swelling that re-appears after a few weeks is an indication of infection caused by a bone or tooth fragment still in the wound and should be treated immediately.

Nerve injury



Mandibular division of trigeminal nerve, seen from the middle line

Nerve injury is primarily an issue with extraction of third molars, but can occur with the extraction of any tooth should the nerve be near the surgical site. Two nerves are typically of concern and are found in duplicate (on the left and right side):

- The inferior alveolar nerve, which enters the mandible at the mandibular foramen and exits the mandible at the sides of the chin from the mental foramen. This nerve supplies sensation to the lower teeth on the right or left half of the dental arch, as well as sense of touch to the right or left half of the chin and lower lip.
- The lingual nerve, which branches off the mandibular branches of the trigeminal nerve and courses just inside the jaw bone, entering the tongue and supplying sense of touch and taste to the right and left half of the anterior 2/3 of the tongue as well as the lingual gingiva (i.e. the gums on the inside surface of the dental arch).

Such injuries can occur while lifting teeth (typically the inferior alveolar) but are most commonly caused by inadvertent damage with a surgical drill. Such injuries are rare and are usually temporary. Depending on the type of injury (i.e. Seddon classification:

neuropraxia, axonotmesis, and neurotmesis) they can be prolonged or permanent. In rare cases it is also possible for bleeding into the nerve canal to also cause an injury to the nerve due to the increased pressure of the blood build up.

Treatment controversy

Preventive removal of the third molars is a common practice in developed countries and is usually recommended by dentists. According to *Pediatric Dentistry: Infancy Through Adolescence, 4th Edition*:

Evaluation of third molars is usually completed during mid- to late adolescence. Parents commonly ask about treating these teeth. The reasons for extraction of third molars include impaction or failure to erupt; potential or existing pathosis such as cysts or ameloblastoma; decay; posteruption malposition; nonfunction as a result of an absent opposing tooth; difficulty with hygiene; and recurrent pericoronitis. If any of these are considerations, third molars should be removed during adolescence.... The evaluation of developing third molars in adolescent athletes is of particular importance. Not only can an athletic season suddenly be interrupted by the annoying and often painful eruption of third molars with associated acute pericoronitis, but mandibular fractures in the gonial angle region of developing third molars can also occur in adolescent athletes.

Several dental textbooks encourage the removal of third molars. From *Contemporary Oral and Maxillofacial Surgery*, 5th Edition:

As a general rule, all impacted teeth should be removed unless removal is contraindicated. Extraction should be performed as soon as the dentist determines that the tooth is impacted. Removal of impacted teeth becomes more difficult with advancing age. The dentist should typically not recommend that impacted teeth be left in place until they cause difficulty. If the tooth is left in place until problems arise, the patient may experience an increased incidence of local tissue morbidity, loss of or damage to adjacent teeth and bone, and potential injury to adjacent vital structures. Additionally, if removal of impacted teeth is deferred until they cause problems later in life, surgery is more likely to be complicated and hazardous because the patient may have compromising systemic diseases and the surrounding bone becomes more dense. A fundamental precept of the philosophy of dentistry is that problems should be prevented. Preventive dentistry dictates that impacted teeth are to be removed before complications arise unless removal will cause more serious problems.

The rationale of prophetically removing third molars prior to their complete root formation is that the likelihood of nerve damage or other complications is extremely low. This is not the case however with symptomatic removal of a third molar after root formation is complete and more intimate with the inferior alveolar nerve and as the mandible becomes more dense with age.

However, studies have shown that dentists graduated from different countries—or even from different dental schools in the same country—may have different clinical decisions regarding third molar removal for the same clinical condition. For example, dentists graduated from Israeli dental schools may recommend more often for the removal of asymptomatic impacted third molar than dentists graduated from Latin-American or Eastern European dental schools.

Scientific trials

In 2006, the Cochrane Collaboration published a systematic review of randomized controlled trials in order to evaluate the effect of preventive removal of asymptomatic wisdom teeth. The authors found no evidence to either support or refute this practice. There was reliable evidence showing that preventative removal did not reduce or prevent late incisor crowding. The authors of the review suggested that the number of surgical procedures could be reduced by 60% or more. Likewise, *ClinicalEvidence* published a summary largely based on the Cochrane review that concluded prophylactic extraction is "likely to be ineffective or harmful." It advised against extracting asymptomatic, disease-free wisdom teeth because of the risk of damage to the inferior alveolar nerve.

Some evidence not from randomized trials suggests that the extraction of the asymptomatic tooth may be beneficial if caries are present in the adjacent second molar, or if periodontal pockets are present distal to the second molar.

It may be argued, however, that these meta-analyses are inappropriate in that the lack of randomized control trials is likely the result of the expense and impracticality of studying diseases already strongly linked to third molar tissues. For example odontogenic cysts arising from the third molar follicle and odontogenic tumors from the third molar epithelium are relatively rare and can take decades to develop, making controlled trials extremely expensive and challenging (especially high loss to follow up).

The American Association of Oral and Maxillofacial Surgeons has published an extensive White Paper on Third Molar Data summarizing the most current research into the subject of third molar extraction. It states that, "The presence of visible third molars is associated with elevated levels of periodontitis . . . which involves adjacent teeth and is progressive and only partially responsive to therapy." In developed countries, the presence of wisdom teeth is associated with substandard dental care, leading to an increased likelihood of periodontitis, which may be caused by a lack of dental care rather than the presence of wisdom teeth. Periodontal bacteria causes gum disease, and may travel through the blood stream, resulting in systemic infections associated with the heart, kidneys and other organs. Further, studies have found such bacteria in amniotic fluid and is considered a factor in low birth weight infants.

Recommendations

In the U.K., the National Institute for Health and Clinical Excellence, which appraises the cost-effectiveness of treatments for the National Health Service, has argued that there is no evidence that removing disease-free impacted wisdom teeth is beneficial, and recommends against removal to avoid the various risks and discomforts of the procedure.

The American Association of Oral and Maxillofacial Surgeons recommends that third molars be removed in patients who, in the opinion of their family dentists, suffer from periodontal infections where the probing depth exceeds 3 mm. It argues that it is advisable to have the third molars of such patients removed in young adulthood to avoid the complications that may occur when third molars have grown to maturity. In these cases, there is a greater likelihood of nerve damage and other potential concerns.

The American Public Health Association recommends against prophylactic removal of asymptomatic, non-pathological wisdom teeth, including wisdom teeth that are impacted, on the basis that the removal of third molars (wisdom teeth), like the removal of any teeth, should be based on evidence of diagnosed pathology or demonstrable need, rather than anticipated future pathology. The APHA's position is based on scientific research that documents the risks of injury to the nerves of the jaw that can cause permanent numbness of the lip and tongue, damage to the temporomandibular (jaw) joint and adjacent teeth.

Vestigiality and variation

Wisdom teeth are vestigial third molars that human ancestors used to help in grinding down plant tissue. The common postulation is that the skulls of human ancestors had larger jaws with more teeth, which were possibly used to help chew down foliage to compensate for a lack of ability to efficiently digest the cellulose that makes up a plant cell wall. As human diets changed, smaller jaws gradually evolved, yet the third molars, or "wisdom teeth", still commonly develop in human mouths.

Agenesis of wisdom teeth in human populations ranges from practically zero in Tasmanians to nearly 100% in indigenous Mexicans. The difference is related to the PAX9 gene (and perhaps other genes).

Potential uses for extracted teeth

In August 2008, it was revealed that scientists in Japan were able to successfully harvest stem cells from wisdom teeth. This discovery is of great clinical importance, as wisdom tooth extractions are a relatively common type of oral surgery. Patients who have their wisdom teeth removed are currently able to opt to have stem cells from those teeth isolated and saved, in case they should ever need the cells.

Etymology

They are generally thought to be called wisdom teeth because they appear so late – much later than the other teeth, at an age where people are presumably "wiser" than as a child, when the other teeth erupt.

Different terms in other languages

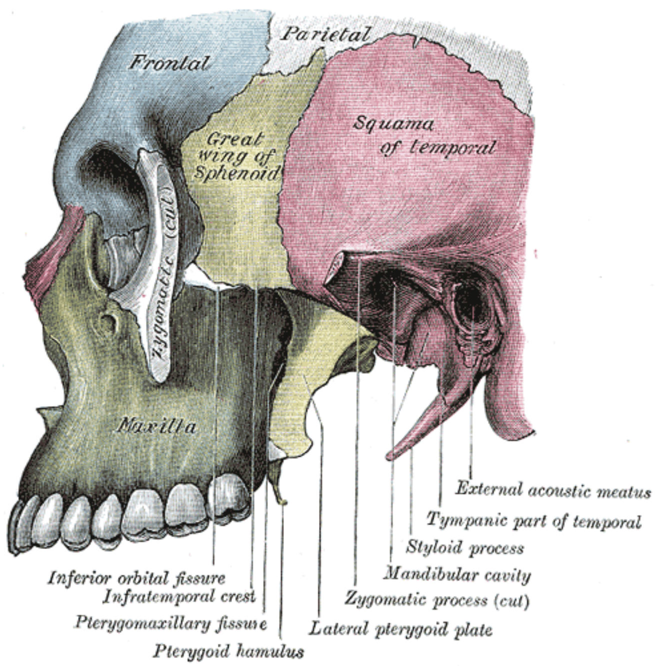
Some languages use a different term for the same teeth, for example:

- In Arabic, it is called (Dors el Aql) or (ضرس العقل) meaning "tooth of maturity" or "the adulthood tooth".
- In Dutch, the name is "verstandskies", a literal translation to English would be wisdomtooth, but "verstands" could also mean "standing far away", referring to the fact that wisdom teeth are at the most distant position in one's mouth. The English word "wisdom tooth" may thus be based on a mistranslation of the Dutch word "verstandskies".
- Turkish refers directly to the age at which wisdom teeth appear and calls it *20 yaş dişi* (20th year tooth).
- In Korean, its name is *Sa-rang-nee* (사랑니, love teeth) referring to the young age and the pain of the first love.
- In Japanese, its name is *Oyashirazu* (親知らず), literally meaning "unknown to the parents," from the idea that they erupt after a child has moved away.
- The Indonesian term *gigi bungsu* for the last teeth a person cuts refers to *bungsu*, meaning "youngest child", because the teeth erupt so much later than the others, implying that the teeth are "younger" than the rest.
- In Thailand, the wisdom tooth is described *fun-khut* (ฟันคุด) "huddling tooth" due to its shortage of space.
- In Italian, Portuguese and Spanish, respectively, their name is "Denti del Giudizio", "Dente do Juízo" and "Muelas del Juicio", close equivalents to wisdom teeth: ("Giudizio", "Juízo" and "Juicio" meaning: good judgment, reason, sense).
- In India, in its Hindi speaking states, they are called "Akkal daant" ("akkal" means wisdom and "daant" means tooth) which refers to the tooth erupting at an age when a person is wiser. Alternately it may also refer to the wisdom of sexual awareness of a person when the tooth erupts in the late teens and thus is also linked with a person starting to develop sexual feelings.
- In Kannada its known as Daudi Halla("Daudi" means end of the jaw line, "Halla" means tooth - literally meaning "The last tooth")

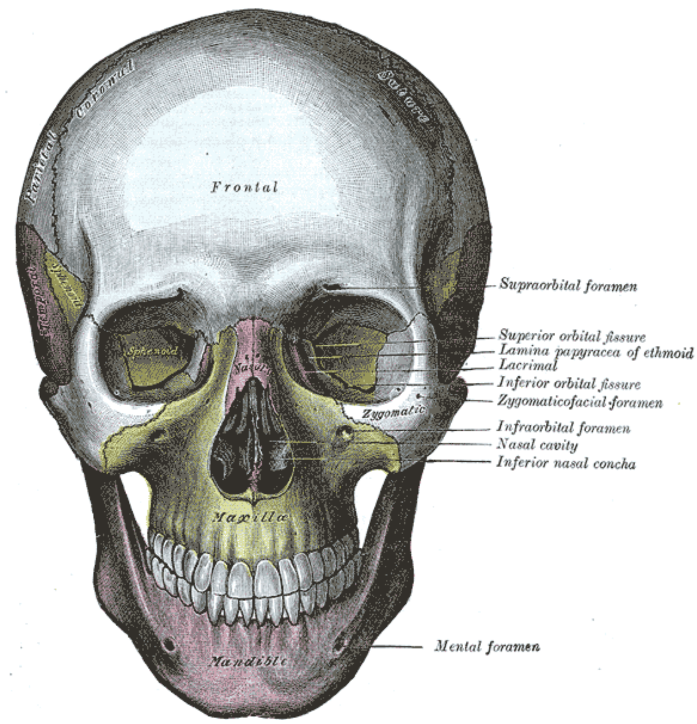
Chapter 11

Maxilla

Bone: Maxilla



Side view. Maxilla visible at bottom left, in green.



Front view. Maxilla visible at center, in yellow.

Gray's	*subject #38 157*
Precursor	1st branchial arch
MeSH	*Maxilla*
Dorlands / Elsevier	*Maxilla*

The **maxilla** (plural: maxillae), also known as the mustache bone, is a fusion of two bones along the palatal fissure that form the upper jaw. This is similar to the mandible (lower jaw), which is also a fusion of two halves at the mental symphysis. Sometimes (e.g. in bony fish), the maxilla is sometimes called **"upper maxilla,"** with the mandible being the **"lower maxilla."** Conversely, in birds the upper jaw is often called **"upper mandible."**

Function

The alveolar process of the maxilla holds the upper teeth, and is referred to as the maxillary arch. The maxilla attaches laterally to the zygomatic bones (cheek bones).

The maxilla assists in forming the boundaries of three cavities:

- the roof of the mouth
- the floor and lateral wall of the nasal antrum

- the wall of the orbit

The maxilla also enters into the formation of two fossae: the infratemporal and pterygopalatine, and two fissures, the inferior orbital and pterygomaxillary.

Components

Each half of the fused maxilla consists of:

- The body of the maxilla
- Four processes
    - The zygomatic process
    - The frontal process of maxilla
    - The alveolar process
    - The palatine process
- Infraorbital foramen
- The maxillary sinus

Articulations

The maxilla articulates with nine bones:

- two of the cranium: the frontal and ethmoid
- seven of the face: the nasal, zygomatic, lacrimal, inferior nasal concha, palatine, vomer, and the adjacent fused maxillary bone.

Sometimes it articulates with the orbital surface, and sometimes with the lateral pterygoid plate of the sphenoid.

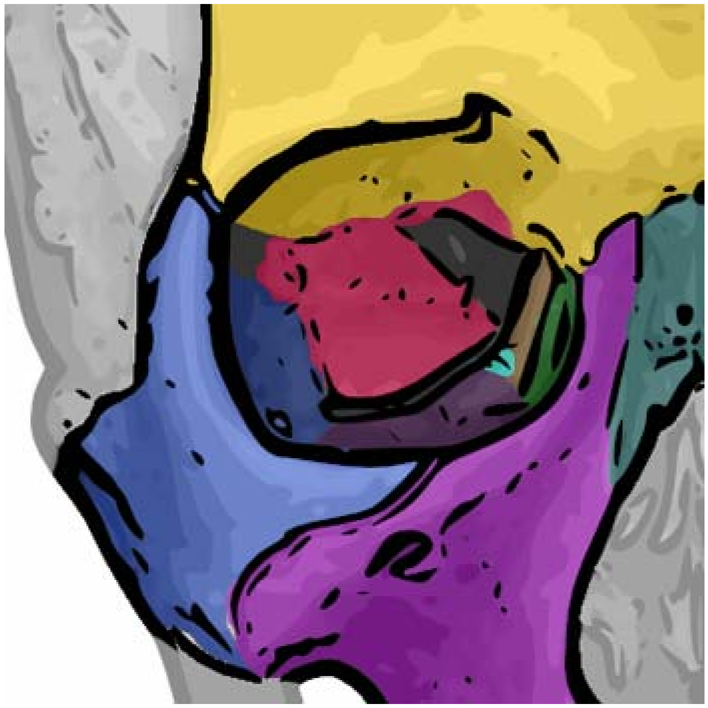
In other animals

In most vertebrates, the foremost part of the upper jaw, to which the incisors are attached in mammals consists of a separate pair of bones, the premaxillae. These fuse with the maxilla proper to form the bone found in humans, and some other mammals. In bony fish, amphibians, and reptiles, both maxilla and premaxilla are relatively plate-like bones, forming only the sides of the upper jaw, and part of the face, with the premaxilla also forming the lower boundary of the nostrils. However, in mammals, the bones have curved inward, creating the palatine process and thereby also forming part of the roof of the mouth.

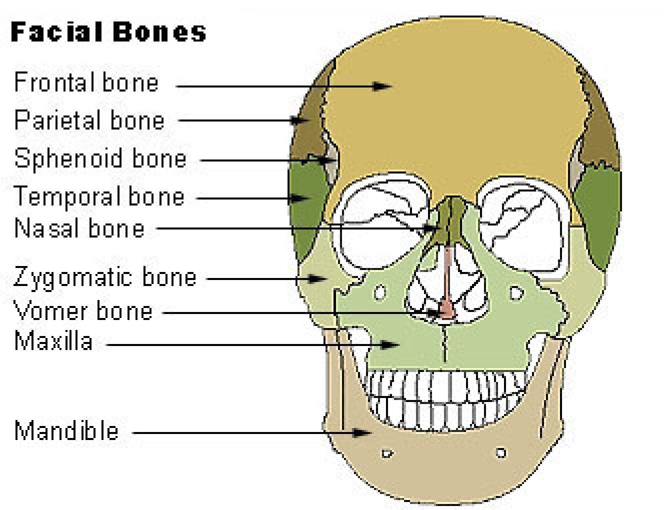
Birds do not have a maxilla in the strict sense; the corresponding part of their beaks (mainly consisting of the premaxilla) is called "upper mandible."

Cartilagenous fish, such as sharks also lack a true maxilla. Their upper jaw is instead formed from a cartilagenous bar that is not homologous with the bone found in other vertebrates.

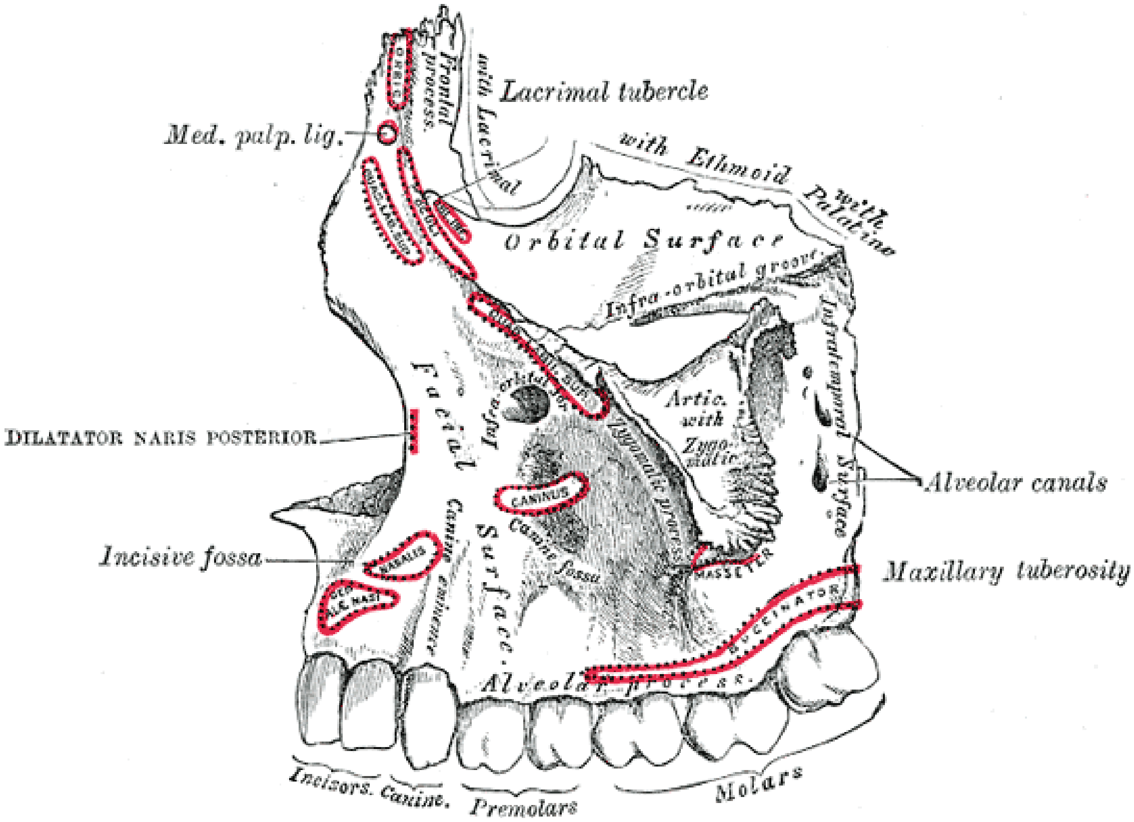
Additional images



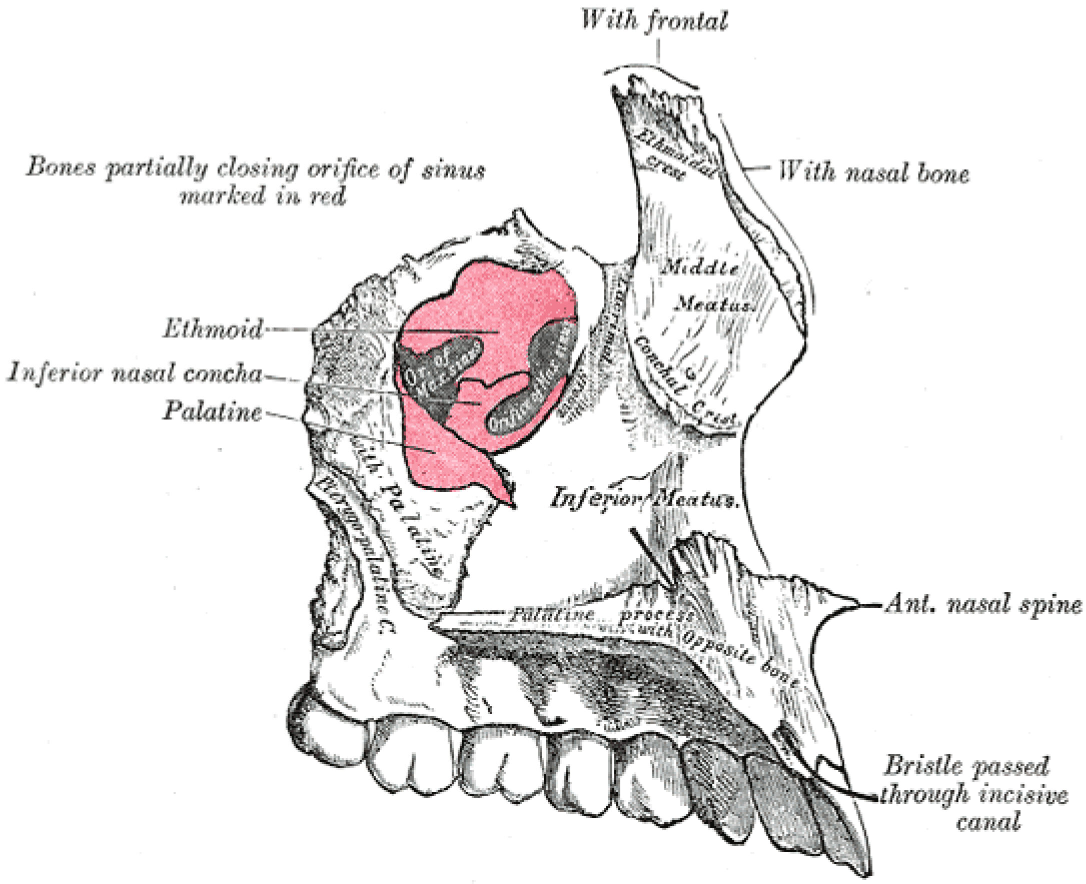
The seven bones which articulate to form the orbit



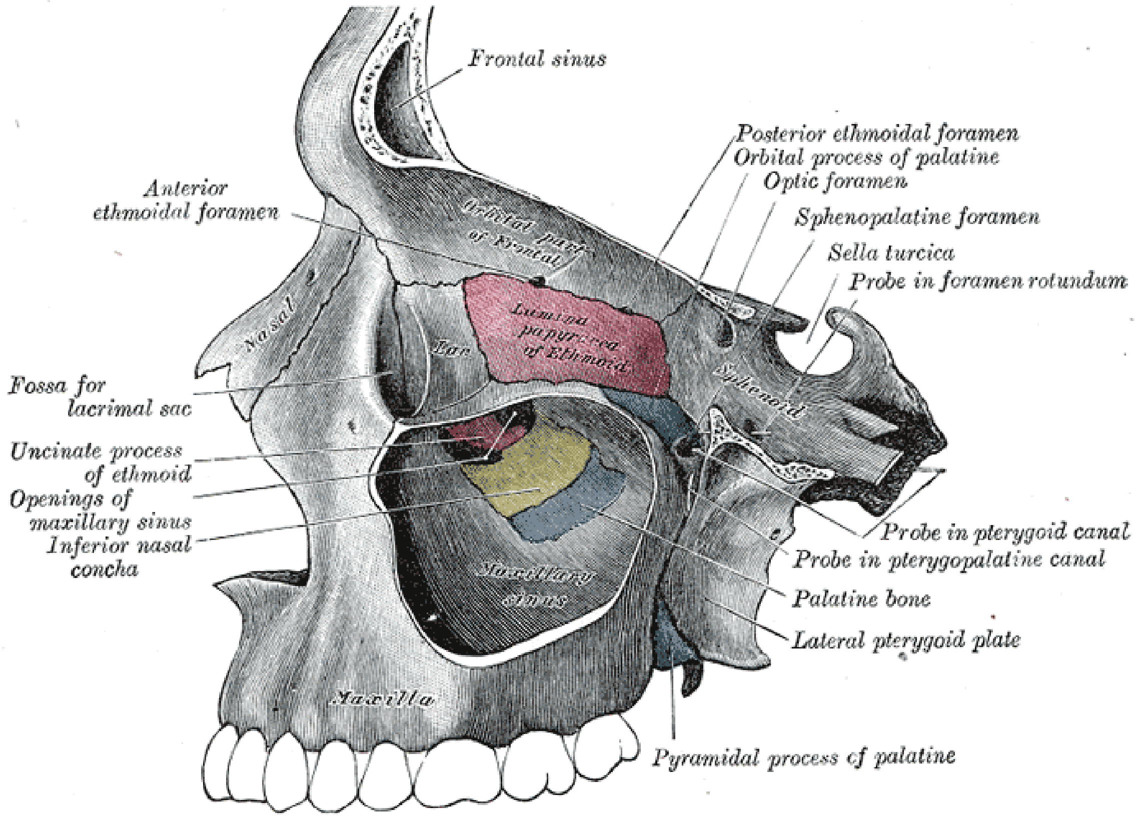
Facial bones



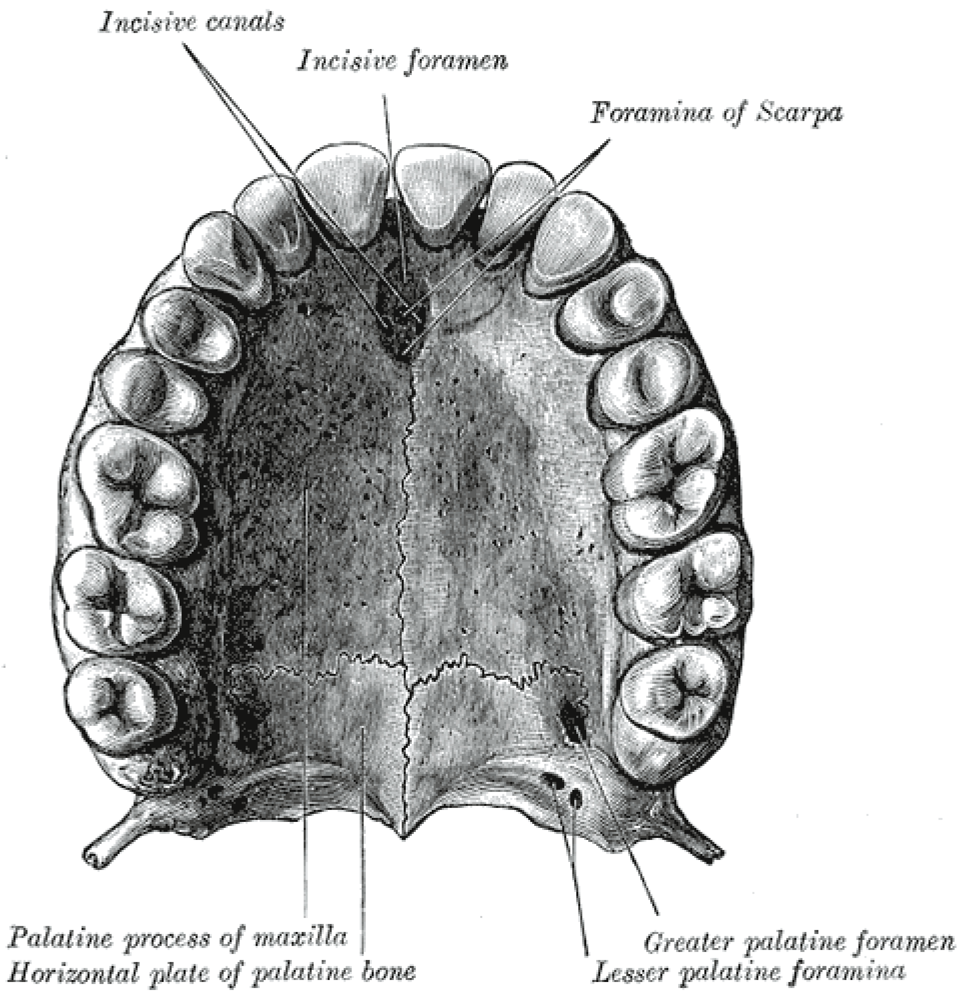
Left maxilla. Outer surface.



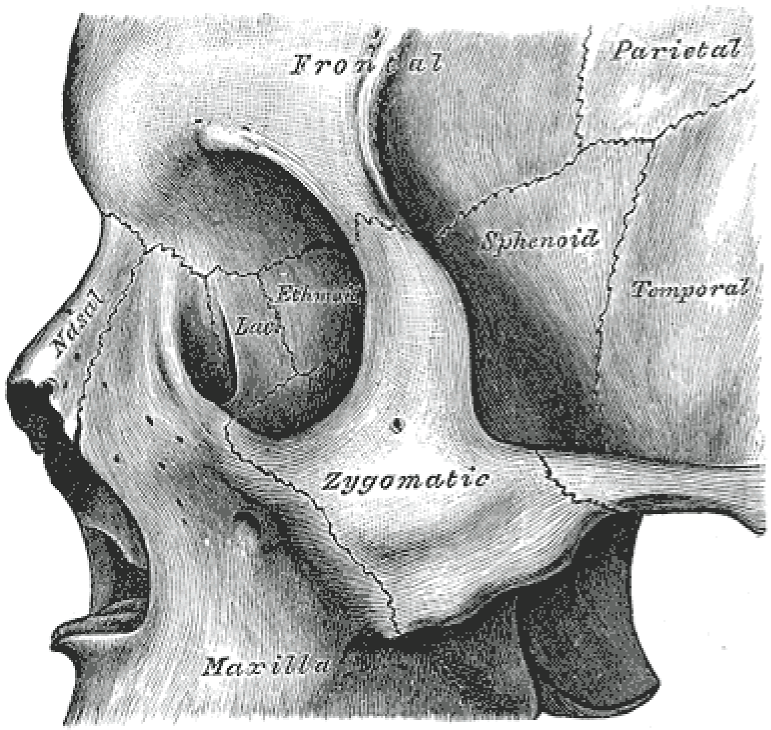
Left maxilla. Nasal surface.



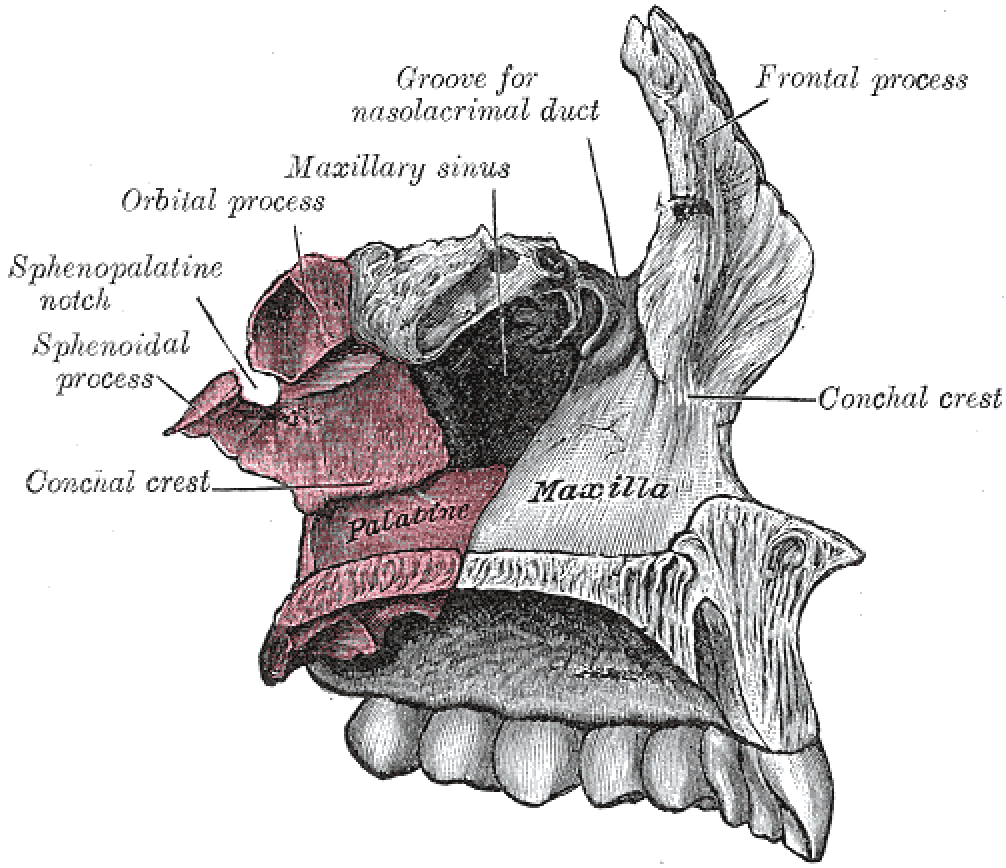
Left maxillary sinus opened from the exterior



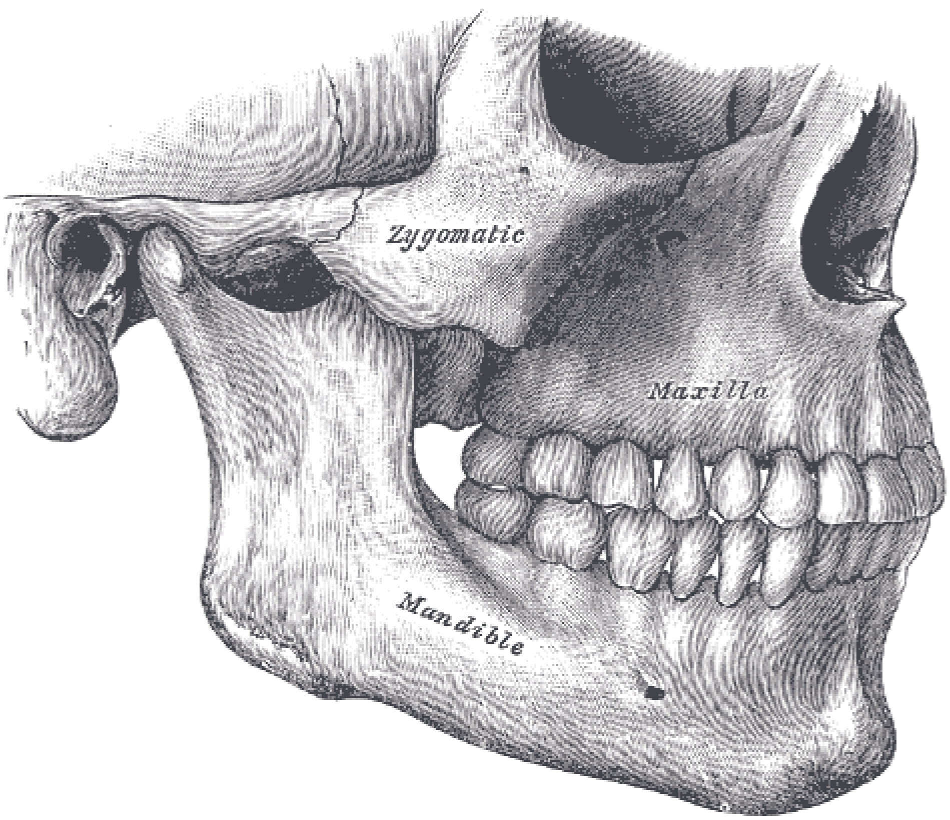
The bony palate and alveolar arch



Sphenoid bone visible center right



Articulation of left palatine bone with maxilla



Side view of the teeth and jaws

Chapter 12

Tooth Development

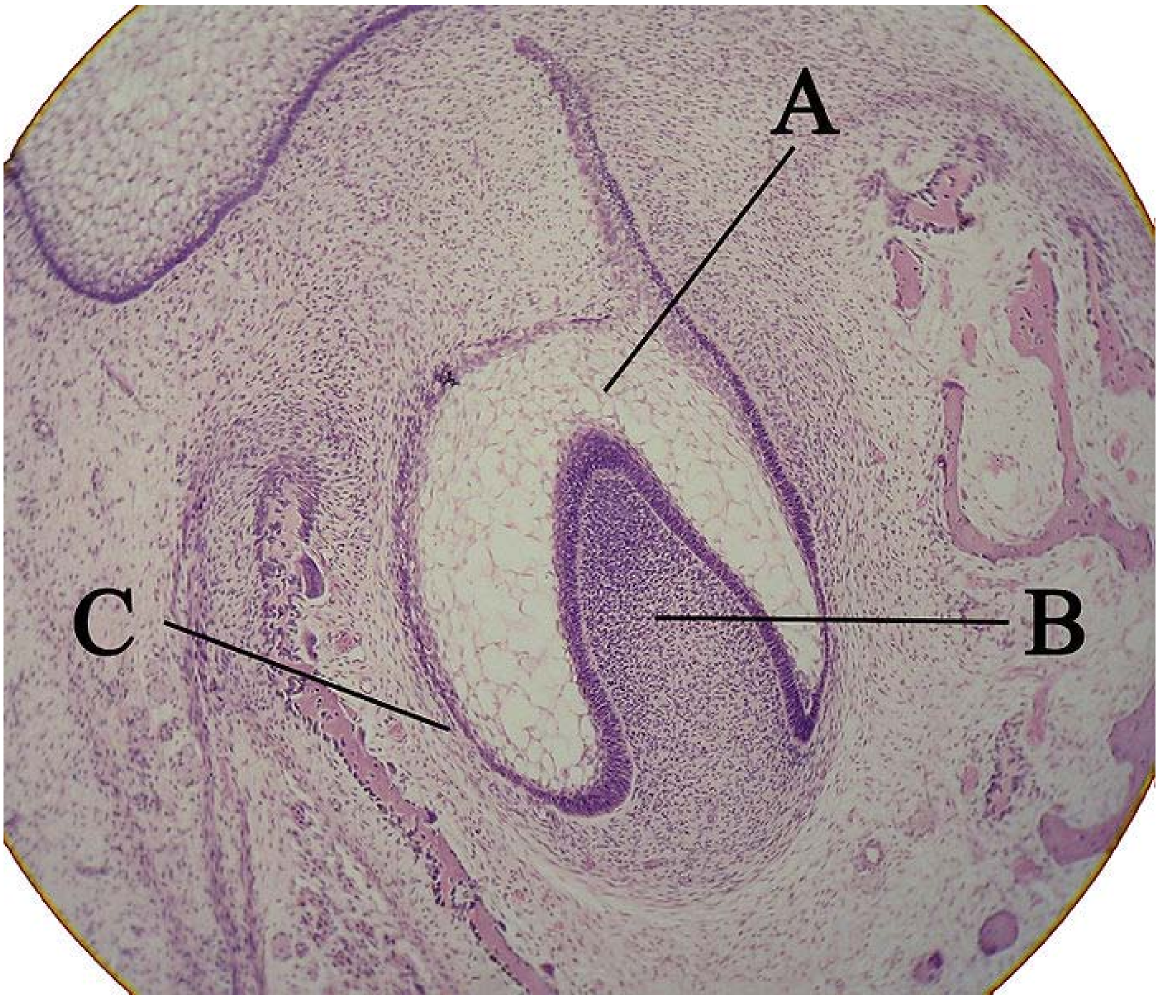
Radiograph of lower right (from left to right) third, second, and first molars in different stages of development.

Tooth development or **odontogenesis** is the complex process by which teeth form from embryonic cells, grow, and erupt into the mouth. Although many diverse species have teeth, non-human tooth development is largely the same as in humans. For human teeth to have a healthy oral environment, enamel, dentin, cementum, and the periodontium must all develop during appropriate stages of fetal development. Primary (baby) teeth start to form between the sixth and eighth weeks, and permanent teeth begin to form in the twentieth week. If teeth do not start to develop at or near these times, they will not develop at all.

A significant amount of research has focused on determining the processes that initiate tooth development. It is widely accepted that there is a factor within the tissues of the first branchial arch that is necessary for the development of teeth.

In vertebrates several specializations of epithelial tissue ('phanères') generate after thickening specific structures: keratinized structure (hair, nails) or exoskeletons structure (scales, teeth). Placoids scales and teeth of sharks are considered homologous organs.

Overview



Histologic slide showing a tooth bud.
A: enamel organ
B: dental papilla
C: dental follicle

The tooth bud (sometimes called the tooth germ) is an aggregation of cells that eventually forms a tooth. These cells are derived from the ectoderm of the first branchial arch and the ectomesenchyme of the neural crest. The tooth bud is organized into three parts: the enamel organ, the dental papilla and the dental follicle.

The *enamel organ* is composed of the outer enamel epithelium, inner enamel epithelium, stellate reticulum and stratum intermedium. These cells give rise to ameloblasts, which produce enamel and the reduced enamel epithelium. The location where the outer enamel epithelium and inner enamel epithelium join is called the cervical loop. The growth of cervical loop cells into the deeper tissues forms Hertwig's Epithelial Root Sheath, which determines the root shape of the tooth.

The *dental papilla* contains cells that develop into odontoblasts, which are dentin-forming cells. Additionally, the junction between the dental papilla and inner enamel epithelium determines the crown shape of a tooth. Mesenchymal cells within the dental papilla are responsible for formation of tooth pulp.

The *dental follicle* gives rise to three important entities: cementoblasts, osteoblasts, and fibroblasts. Cementoblasts form the cementum of a tooth. Osteoblasts give rise to the alveolar bone around the roots of teeth. Fibroblasts develop the periodontal ligaments which connect teeth to the alveolar bone through cementum.

Human tooth development timeline

The following tables present the development timeline of human teeth. Times for the initial calcification of primary teeth are for weeks *in utero*. Abbreviations: wk = weeks; mo = months; yr = years.

	Maxillary (upper) teeth				
Primary teeth	**Central incisor**	**Lateral incisor**	**Canine**	**First molar**	**Second molar**
Initial calcification	14 wk I.U.	16 wk I.U.	17 wk I.U.	15.5 wk I.U.	19 wk I.U.
Crown completed	1.5 mo	2.5 mo	9 mo	6 mo	11 mo
Root completed	1.5 yr	2 yr	3.25 yr	2.5 yr	3 yr
	Mandibular (lower) teeth				
Initial calcification	14 wk I.U.	16 wk I.U.	17 wk I.U.	15.5 wk I.U.	18 wk I.U.
Crown completed	2.5 mo	3 mo	9 mo	5.5 mo	10 mo
Root completed	1.5 yr	1.5 yr	3.25 yr	2.5 yr	3 yr

	Maxillary (upper) teeth							
Permanent teeth	**Central incisor**	**Lateral incisor**	**Canine**	**First premolar**	**Second premolar**	**First molar**	**Second molar**	**Third molar**
Initial calcification	3–4 mo	10–12 mo	4–5 mo	1.5–1.75 yr	2–2.25 yr	at birth	2.5–3 yr	7–9 yr
Crown completed	4–5 yr	4–5 yr	6–7 yr	5–6 yr	6–7 yr	2.5–3 yr	7–8 yr	12–16 yr

Root completed	10 yr	11 yr	13–15 yr	12–13 yr	12–14 yr	9–10 yr	14–16 yr	18–25 yr
	Mandibular (lower) teeth							
Initial calcification	3–4 mo	3–4 mo	4–5 mo	1.5–2 yr	2.25–2.5 yr	at birth	2.5–3 yr	8–10 yr
Crown completed	4–5 yr	4–5 yr	6–7 yr	5–6 yr	6–7 yr	2.5–3 yr	7–8 yr	12–16 yr
Root completed	9 yr	10 yr	12–14 yr	12–13 yr	13–14 yr	9–10 yr	14–15 yr	18–25 yr

The developing tooth bud

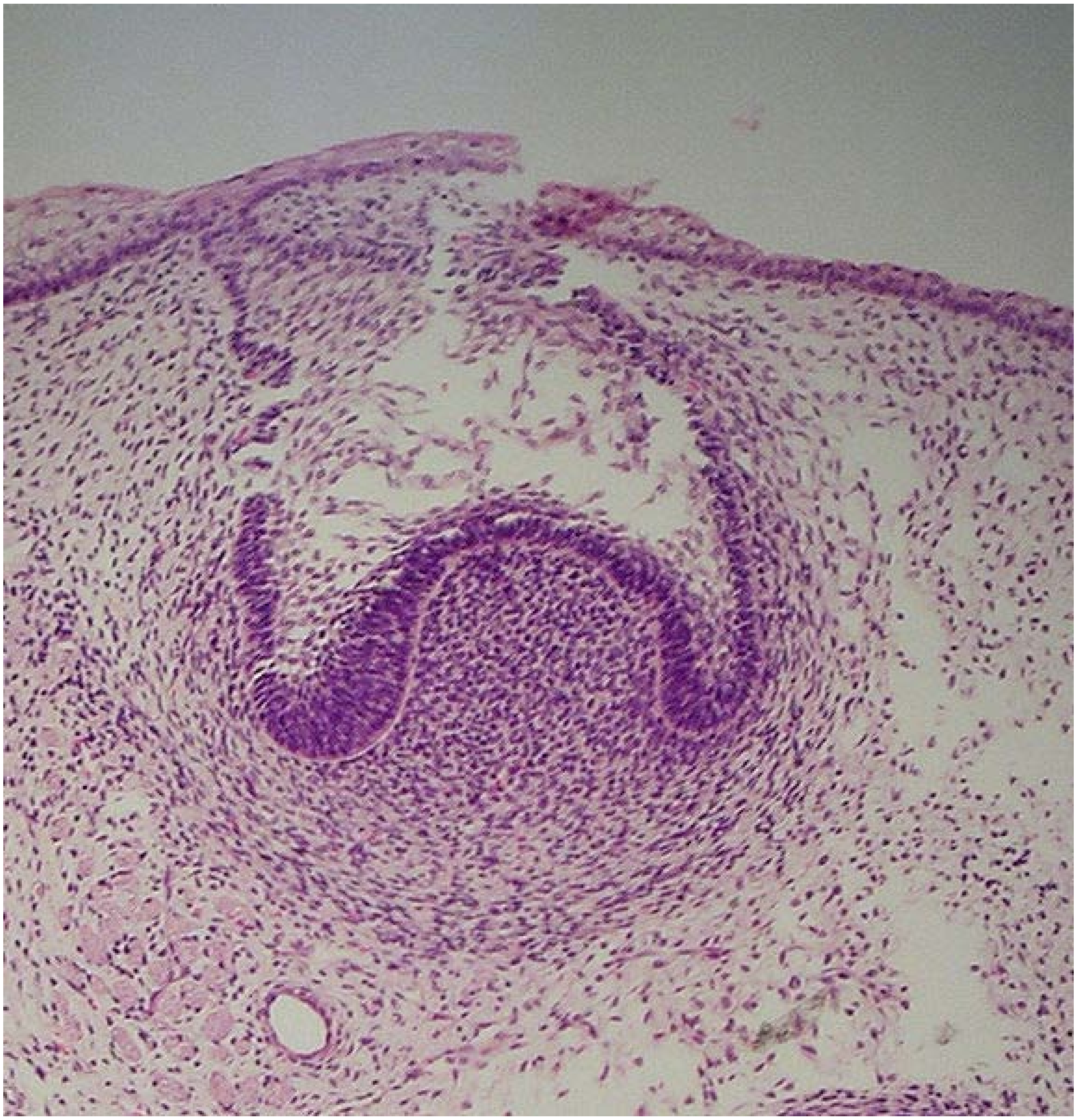
One of the earliest steps in the formation of a tooth that can be seen microscopically is the distinction between the vestibular lamina and the dental lamina. The dental lamina connects the developing tooth bud to the epithelial layer of the mouth for a significant time.

Tooth development is commonly divided into the following stages: the bud stage, the cap, the bell, and finally maturation. The staging of tooth development is an attempt to categorize changes that take place along a continuum; frequently it is difficult to decide what stage should be assigned to a particular developing tooth. This determination is further complicated by the varying appearance of different histologic sections of the same developing tooth, which can appear to be different stages.

Bud stage

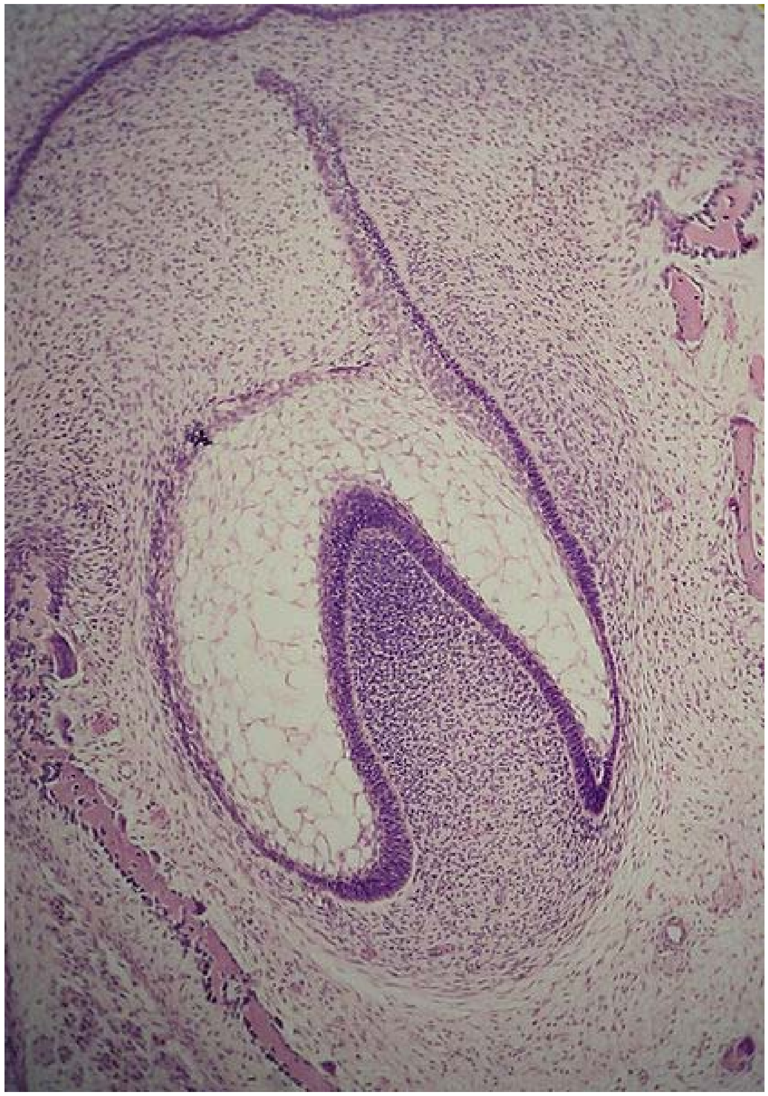
The bud stage is characterized by the appearance of a tooth bud without a clear arrangement of cells. The stage technically begins once epithelial cells proliferate into the ectomesenchyme of the jaw. Typically, this occurs when the fetus is around 6 weeks old. The tooth bud itself is the group of cells at the end of the dental lamina.

Cap stage



Histologic slide of tooth in cap stage

The first signs of an arrangement of cells in the tooth bud occur in the cap stage. A small group of ectomesenchymal cells stops producing extracellular substances, which results in an aggregation of these cells called the dental papilla. At this point, the tooth bud grows around the ectomesenchymal aggregation, taking on the appearance of a cap, and becomes the enamel (or dental) organ. A condensation of ectomesenchymal cells called the dental follicle surrounds the enamel organ and limits the dental papilla. Eventually, the enamel organ will produce enamel, the dental papilla will produce dentin and pulp, and the dental follicle will produce all the supporting structures of a tooth.



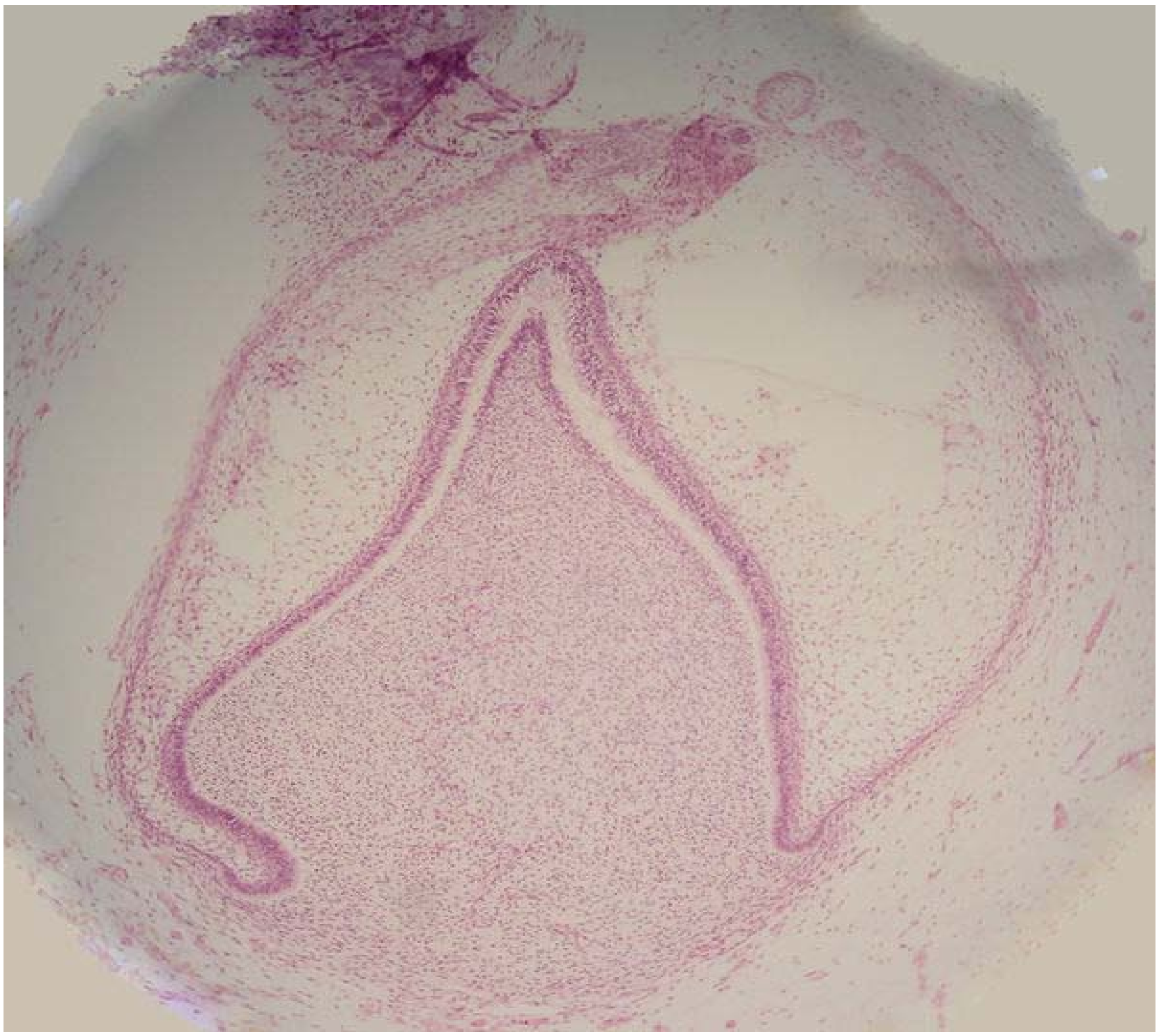
Histologic slide of tooth in early bell stage. Note cell organization.

Bell stage

The bell stage is known for the histodifferentiation and morphodifferentiation that takes place. The dental organ is bell-shaped during this stage, and the majority of its cells are called stellate reticulum because of their star-shaped appearance. Cells on the periphery of the enamel organ separate into three important layers. Cuboidal cells on the periphery of the dental organ are known as outer enamel epithelium. The columnar cells of the enamel organ adjacent to the dental papilla are known as inner enamel epithelium. The cells between the inner enamel epithelium and the stellate reticulum form a layer known as the stratum intermedium. The rim of the dental organ where the outer and inner enamel epithelium join is called the *cervical loop*. In summary, the layers in order of innermost to outermost consist of dentine, enamel (formed by inner enamel epithelium, or 'ameloblasts', as they move outwards/upwards), inner enamel epithelium and stratum intermedium (specialised stratified cells that support the synthetic activity of the Inner

Enamel Epithelium) What follows is part of the initial 'enamel organ', the middle of which is made up of stellate reticulum cells. This is all encased by the outer enamel epithelium layer.

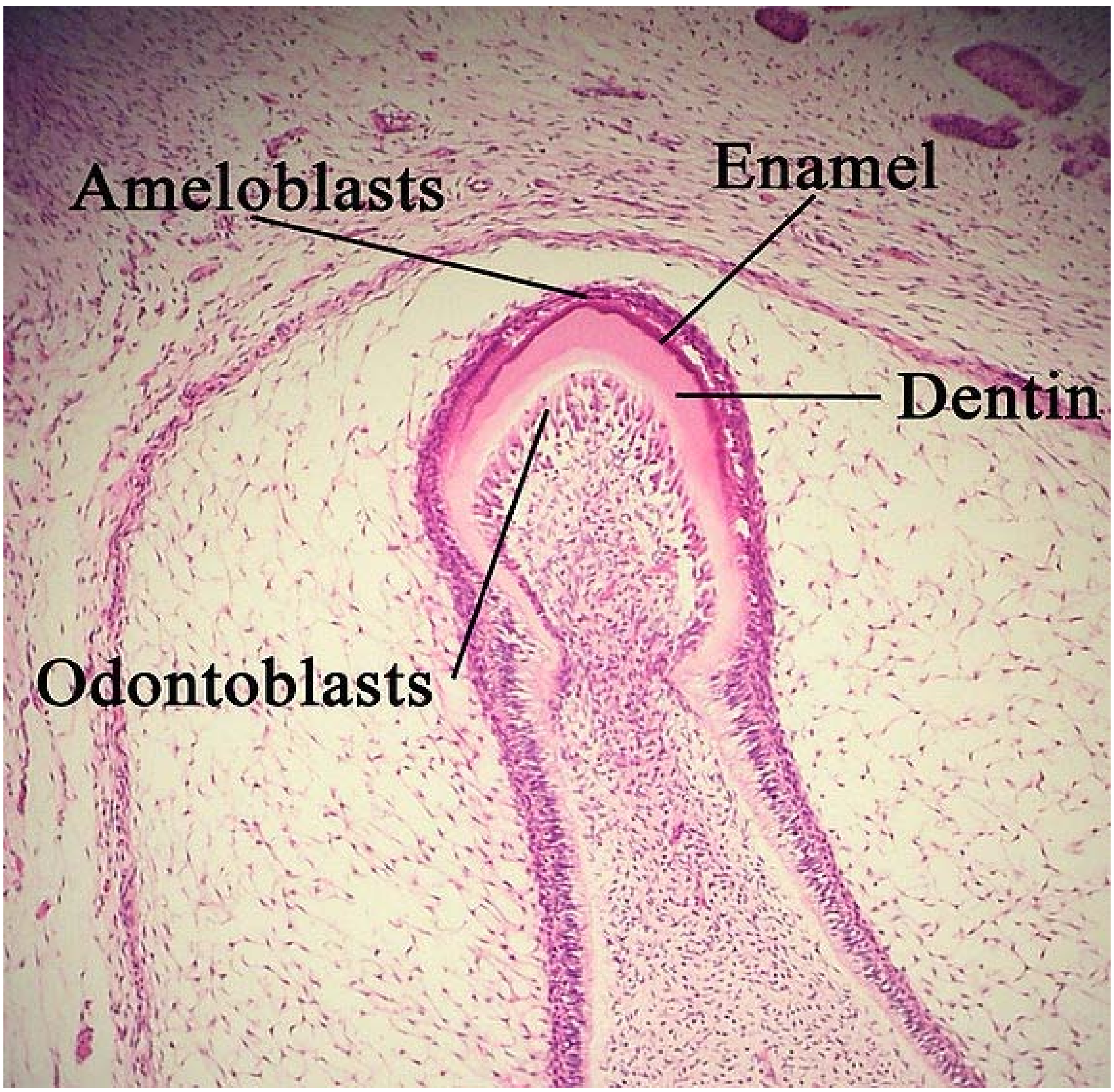
Other events occur during the bell stage. The dental lamina disintegrates, leaving the developing teeth completely separated from the epithelium of the oral cavity; the two will not join again until the final eruption of the tooth into the mouth.



Histologic slide of tooth in late bell stage. Note disintegration of dental lamina at top.

The crown of the tooth, which is influenced by the shape of the internal enamel epithelium, also takes shape during this stage. Throughout the mouth, all teeth undergo this same process; it is still uncertain why teeth form various crown shapes—for instance, incisors versus canines. There are two dominant hypotheses. The "field model" proposes there are components for each type of tooth shape found in the ectomesenchyme during tooth development. The components for particular types of teeth, such as incisors, are localized in one area and dissipate rapidly in different parts of the mouth. Thus, for example, the "incisor field" has factors that develop teeth into incisor shape, and this field is concentrated in the central incisor area, but decreases rapidly in the canine area. The other dominant hypothesis, the "clone model", proposes that the epithelium programs a group of ectomesenchymal cells to generate teeth of particular shapes. This group of cells, called a clone, coaxes the dental lamina into tooth development, causing a tooth bud to form. Growth of the dental lamina continues in an area called the "progress zone". Once the progress zone travels a certain distance from the first tooth bud, a second tooth bud will start to develop. These two models are not necessarily mutually exclusive, nor does widely accepted dental science consider them to be so: it is postulated that both models influence tooth development at different times.

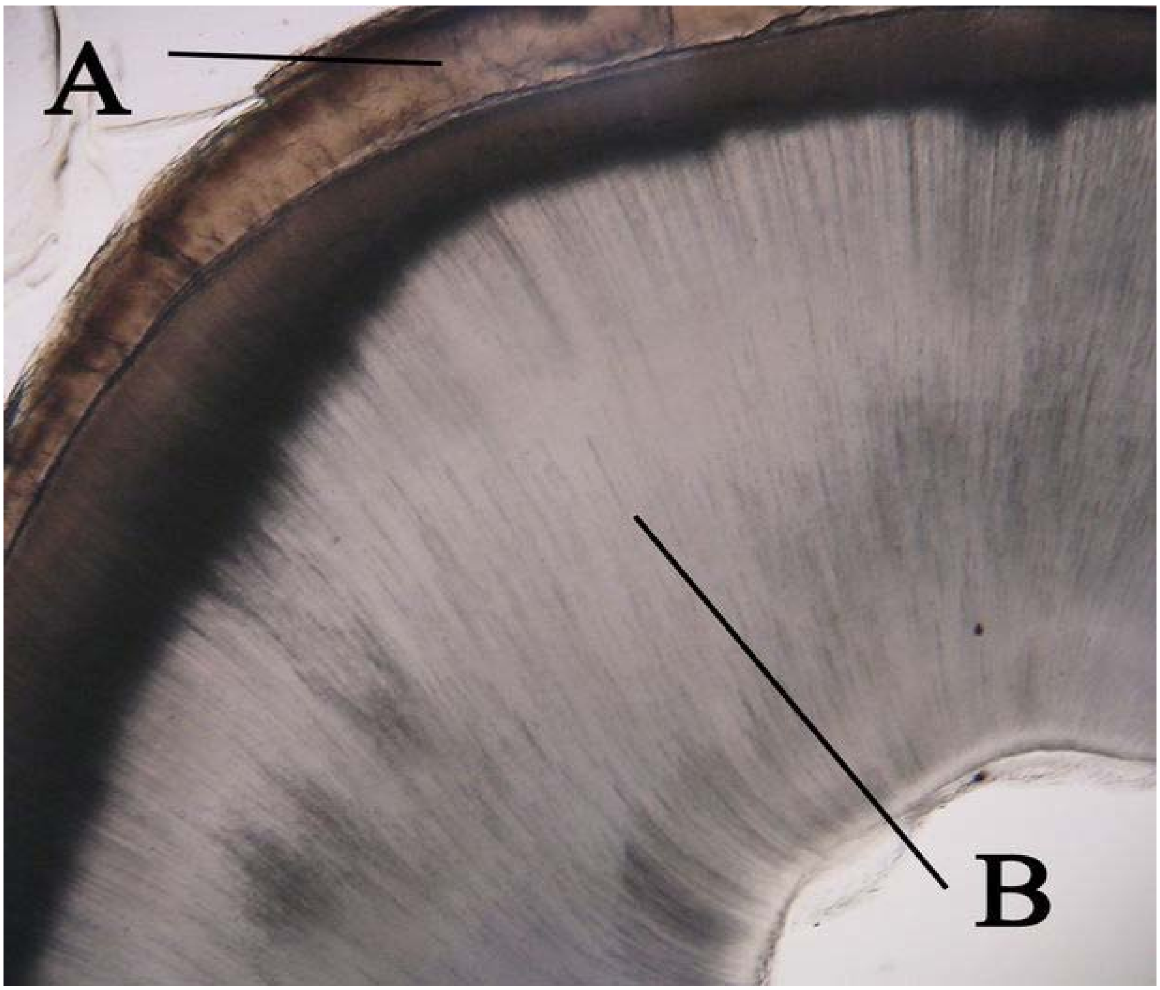
Other structures that may appear in a developing tooth in this stage are enamel knots, enamel cords, and enamel niche.



Histologic slide of developing hard tissues. Ameloblasts are forming enamel, while odontoblasts are forming dentin.

Crown stage

Hard tissues, including enamel and dentin, develop during the next stage of tooth development. This stage is called the crown, or maturation, stage by some researchers. Important cellular changes occur at this time. In prior stages, all of the inner enamel epithelium cells were dividing to increase the overall size of the tooth bud, but rapid dividing, called mitosis, stops during the crown stage at the location where the cusps of the teeth form. The first mineralized hard tissues form at this location. At the same time, the inner enamel epithelial cells change in shape from cuboidal to columnar. The nuclei of these cells move closer to the stratum intermedium and away from the dental papilla.

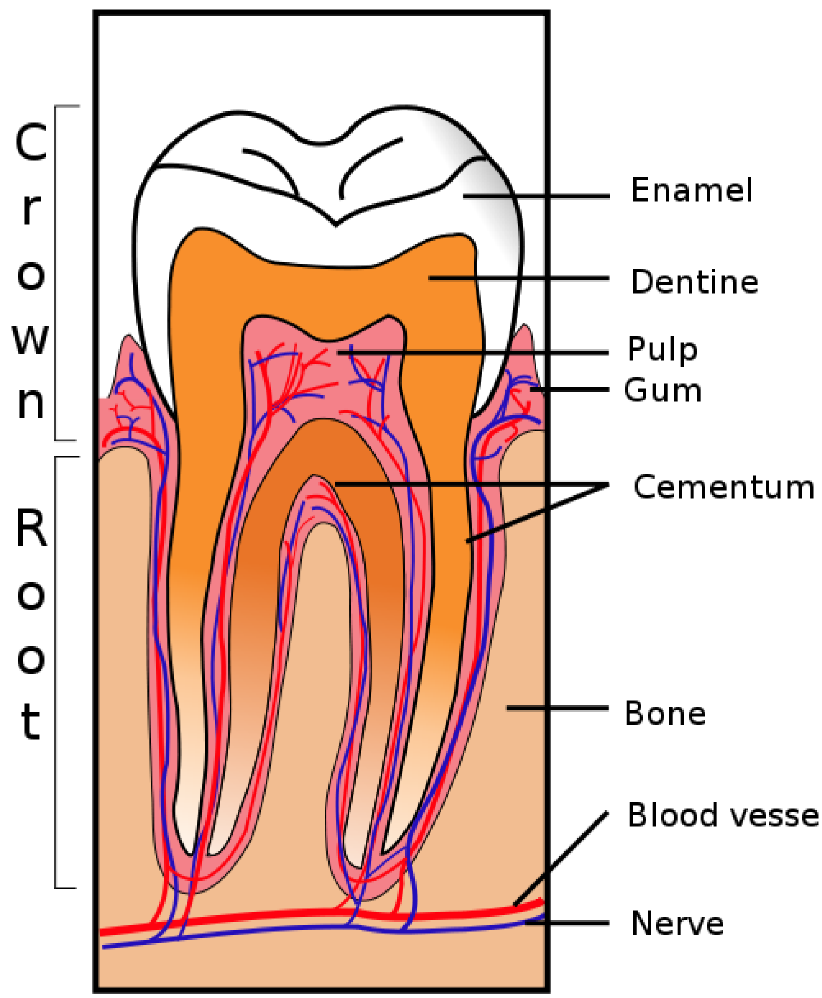


Histologic slide of tooth. Note the tubular appearance of dentin.
A: enamel
B: dentin

The adjacent layer of cells in the dental papilla suddenly increases in size and differentiates into odontoblasts, which are the cells that form dentin. Researchers believe that the odontoblasts would not form if it were not for the changes occurring in the inner enamel epithelium. As the changes to the inner enamel epithelium and the formation of odontoblasts continue from the tips of the cusps, the odontoblasts secrete a substance, an organic matrix, into their immediate surrounding. The organic matrix contains the material needed for dentin formation. As odontoblasts deposit organic matrix, they migrate toward the center of the dental papilla. Thus, unlike enamel, dentin starts forming in the surface closest to the outside of the tooth and proceeds inward. Cytoplasmic extensions are left behind as the odontoblasts move inward. The unique, tubular microscopic appearance of dentin is a result of the formation of dentin around these extensions.

After dentin formation begins, the cells of the inner enamel epithelium secrete an organic matrix against the dentin. This matrix immediately mineralizes and becomes the tooth's enamel. Outside the dentin are ameloblasts, which are cells that continue the process of enamel formation; therefore, enamel formation moves outwards, adding new material to the outer surface of the developing tooth.

Hard tissue formation



Sections of tooth undergoing development

Enamel

Enamel formation is called amelogenesis and occurs in the crown stage of tooth development. "Reciprocal induction" governs the relationship between the formation of dentin and enamel; dentin formation must always occur before enamel formation. Generally, enamel formation occurs in two stages: the secretory and maturation stages. Proteins and an organic matrix form a partially mineralized enamel in the secretory stage; the maturation stage completes enamel mineralization.

In the secretory stage, ameloblasts release enamel proteins that contribute to the enamel matrix, which is then partially mineralized by the enzyme alkaline phosphatase. The appearance of this mineralized tissue, which occurs usually around the third or fourth month of pregnancy, marks the first appearance of enamel in the body. Ameloblasts deposit enamel at the location of what become cusps of teeth alongside dentin. Enamel formation then continues outward, away from the center of the tooth.

In the maturation stage, the ameloblasts transport some of the substances used in enamel formation out of the enamel. Thus, the function of ameloblasts changes from enamel production, as occurs in the secretory stage, to transportation of substances. Most of the materials transported by ameloblasts in this stage are proteins used to complete mineralization. The important proteins involved are amelogenins, ameloblastins, enamelins, and tuftelins. By the end of this stage, the enamel has completed its mineralization.

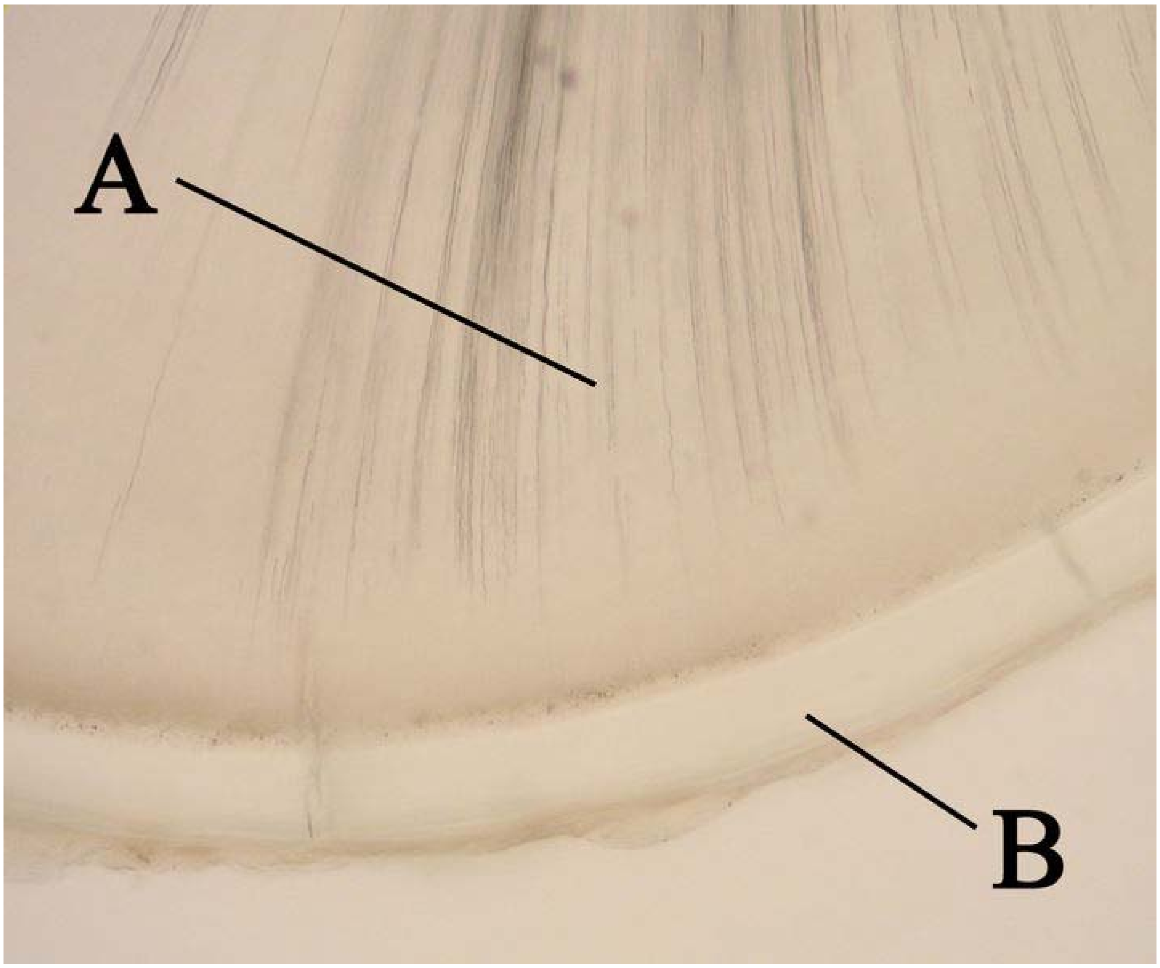
Dentin

Dentin formation, known as dentinogenesis, is the first identifiable feature in the crown stage of tooth development. The formation of dentin must always occur before the formation of enamel. The different stages of dentin formation result in different types of dentin: mantle dentin, primary dentin, secondary dentin, and tertiary dentin.

Odontoblasts, the dentin-forming cells, differentiate from cells of the dental papilla. They begin secreting an organic matrix around the area directly adjacent to the inner enamel epithelium, closest to the area of the future cusp of a tooth. The organic matrix contains collagen fibers with large diameters (0.1–0.2 μm in diameter). The odontoblasts begin to move toward the center of the tooth, forming an extension called the odontoblast process. Thus, dentin formation proceeds toward the inside of the tooth. The odontoblast process causes the secretion of hydroxyapatite crystals and mineralization of the matrix. This area of mineralization is known as mantle dentin and is a layer usually about 150 μm thick.

Whereas mantle dentin forms from the preexisting ground substance of the dental papilla, primary dentin forms through a different process. Odontoblasts increase in size, eliminating the availability of any extracellular resources to contribute to an organic matrix for mineralization. Additionally, the larger odontoblasts cause collagen to be secreted in smaller amounts, which results in more tightly arranged, heterogeneous nucleation that is used for mineralization. Other materials (such as lipids, phosphoproteins, and phospholipids) are also secreted.

Secondary dentin is formed after root formation is finished and occurs at a much slower rate. It is not formed at a uniform rate along the tooth, but instead forms faster along sections closer to the crown of a tooth. This development continues throughout life and accounts for the smaller areas of pulp found in older individuals. Tertiary dentin, also known as reparative dentin, forms in reaction to stimuli, such as attrition or dental caries.



Cross-section of tooth at root. Note clear, acellular appearance of cementum.
A: dentin
B: cementum

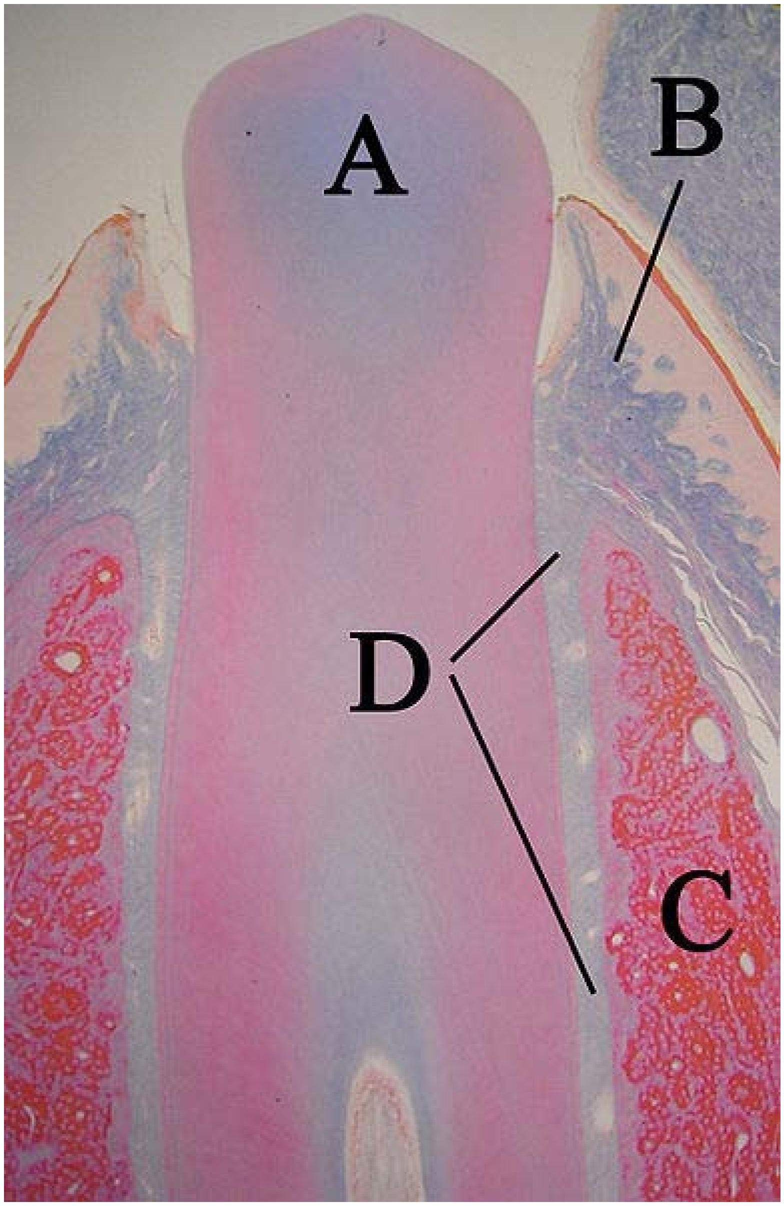
Cementum

Cementum formation is called cementogenesis and occurs late in the development of teeth. Cementoblasts are the cells responsible for cementogenesis. Two types of cementum form: cellular and acellular.

Acellular cementum forms first. The cementoblasts differentiate from follicular cells, which can only reach the surface of the tooth's root once Hertwig's Epithelial Root Sheath (HERS) has begun to deteriorate. The cementoblasts secrete fine collagen fibrils along the root surface at right angles before migrating away from the tooth. As the cementoblasts move, more collagen is deposited to lengthen and thicken the bundles of fibers. Noncollagenous proteins, such as bone sialoprotein and osteocalcin, are also secreted. Acellular cementum contains a secreted matrix of proteins and fibers. As mineralization takes place, the cementoblasts move away from the cementum, and the fibers left along the surface eventually join the forming periodontal ligaments.

Cellular cementum develops after most of the tooth formation is complete and after the tooth occludes (in contact) with a tooth in the opposite arch. This type of cementum forms around the fiber bundles of the periodontal ligaments. The cementoblasts forming cellular cementum become trapped in the cementum they produce.

The origin of the formative cementoblasts is believed to be different for cellular cementum and acellular cementum. One of the major current hypotheses is that cells producing cellular cementum migrate from the adjacent area of bone, while cells producing acellular cementum arise from the dental follicle. Nonetheless, it is known that cellular cementum is usually not found in teeth with one root. In premolars and molars, cellular cementum is found only in the part of the root closest to the apex and in interradicular areas between multiple roots.



Histologic slide of tooth erupting into the mouth.
A: tooth
B: gingiva
C: bone
D: periodontal ligaments

Formation of the periodontium

The periodontium, which is the supporting structure of a tooth, consists of the cementum, periodontal ligaments, gingiva, and alveolar bone. Cementum is the only one of these that is a part of a tooth. Alveolar bone surrounds the roots of teeth to provide support and creates what is commonly called a "socket". Periodontal ligaments connect the alveolar bone to the cementum, and the gingiva is the surrounding tissue visible in the mouth.

Periodontal ligament

Cells from the dental follicle give rise to the periodontal ligament (PDL). Specific events leading to the formation of the periodontal ligament vary between deciduous (baby) and permanent teeth and among various species of animals. Nonetheless, formation of the periodontal ligament begins with ligament fibroblasts from the dental follicle. These fibroblasts secrete collagen, which interacts with fibers on the surfaces of adjacent bone and cementum. This interaction leads to an attachment that develops as the tooth erupts into the mouth. The occlusion, which is the arrangement of teeth and how teeth in opposite arches come in contact with one another, continually affects the formation of periodontal ligament. This perpetual creation of periodontal ligament leads to the formation of groups of fibers in different orientations, such as horizontal and oblique fibers.

Alveolar bone

As root and cementum formation begin, bone is created in the adjacent area. Throughout the body, cells that form bone are called osteoblasts. In the case of alveolar bone, these osteoblast cells form from the dental follicle. Similar to the formation of primary cementum, collagen fibers are created on the surface nearest the tooth, and they remain there until attaching to periodontal ligaments.

Like any other bone in the human body, alveolar bone is modified throughout life. Osteoblasts create bone and osteoclasts destroy it, especially if force is placed on a tooth. As is the case when movement of teeth is attempted through orthodontics, an area of bone under compressive force from a tooth moving toward it has a high osteoclast level, resulting in bone resorption. An area of bone receiving tension from periodontal ligaments attached to a tooth moving away from it has a high number of osteoblasts, resulting in bone formation.

Gingiva

The connection between the gingiva and the tooth is called the dentogingival junction. This junction has three epithelial types: gingival, sulcular, and junctional epithelium. These three types form from a mass of epithelial cells known as the epithelial cuff between the tooth and the mouth.

Much about gingival formation is not fully understood, but it is known that hemidesmosomes form between the gingival epithelium and the tooth and are responsible for the *primary epithelial attachment*. Hemidesmosomes provide anchorage between cells through small filament-like structures provided by the remnants of ameloblasts. Once this occurs, junctional epithelium forms from reduced enamel epithelium, one of the products of the enamel organ, and divides rapidly. This results in the perpetually increasing size of the junctional epithelial layer and the isolation of the remnants of ameloblasts from any source of nutrition. As the ameloblasts degenerate, a gingival sulcus is created.

Nerve and vascular formation

Frequently, nerves and blood vessels run parallel to each other in the body, and the formation of both usually takes place simultaneously and in a similar fashion. However, this is not the case for nerves and blood vessels around the tooth, because of different rates of development.

Nerve formation

Nerve fibers start to near the tooth during the cap stage of tooth development and grow toward the dental follicle. Once there, the nerves develop around the tooth bud and enter the dental papilla when dentin formation has begun. Nerves never proliferate into the enamel organ.<

Vascular formation

Blood vessels grow in the dental follicle and enter the dental papilla in the cap stage. Groups of blood vessels form at the entrance of the dental papilla. The number of blood vessels reaches a maximum at the beginning of the crown stage, and the dental papilla eventually forms in the pulp of a tooth. Throughout life, the amount of pulpal tissue in a tooth decreases, which means that the blood supply to the tooth decreases with age. The enamel organ is devoid of blood vessels because of its epithelial origin, and the mineralized tissues of enamel and dentin do not need nutrients from the blood.

Tooth eruption

Tooth eruption occurs when the teeth enter the mouth and become visible. Although researchers agree that tooth eruption is a complex process, there is little agreement on the identity of the mechanism that controls eruption. Some commonly held theories that have been disproven over time include: (1) the tooth is pushed upward into the mouth by the growth of the tooth's root, (2) the tooth is pushed upward by the growth of the bone around the tooth, (3) the tooth is pushed upward by vascular pressure, and (4) the tooth is pushed upward by the cushioned hammock. The cushioned hammock theory, first proposed by Harry Sicher, was taught widely from the 1930s to the 1950s. This theory postulated that a ligament below a tooth, which Sicher observed on under a microscope on a histologic slide, was responsible for eruption. Later, the "ligament" Sicher observed was determined to be merely an artifact created in the process of preparing the slide.

The most widely held current theory is that while several forces might be involved in eruption, the periodontal ligaments provide the main impetus for the process. Theorists hypothesize that the periodontal ligaments promote eruption through the shrinking and cross-linking of their collagen fibers and the contraction of their fibroblasts.

Although tooth eruption occurs at different times for different people, a general eruption timeline exists. Typically, humans have 20 primary (baby) teeth and 32 permanent teeth. Tooth eruption has three stages. The first, known as deciduous dentition stage, occurs when only primary teeth are visible. Once the first permanent tooth erupts into the mouth, the teeth are in the mixed (or transitional) dentition. After the last primary tooth falls out of the mouth—a process known as exfoliation—the teeth are in the permanent dentition.

Primary dentition starts on the arrival of the mandibular central incisors, usually at eight months, and lasts until the first permanent molars appear in the mouth, usually at six years. The primary teeth typically erupt in the following order: (1) central incisor, (2) lateral incisor, (3) first molar, (4) canine, and (5) second molar. As a general rule, four teeth erupt for every six months of life, mandibular teeth erupt before maxillary teeth, and teeth erupt sooner in females than males. During primary dentition, the tooth buds of permanent teeth develop below the primary teeth, close to the palate or tongue.

Mixed dentition starts when the first permanent molar appears in the mouth, usually at six years, and lasts until the last primary tooth is lost, usually at eleven or twelve years. Permanent teeth in the maxilla erupt in a different order from permanent teeth on the mandible. Maxillary teeth erupt in the following order: (1) first molar (2) central incisor, (3) lateral incisor, (4) first premolar, (5) second premolar, (6) canine, (7) second molar, and (8) third molar. Mandibular teeth erupt in the following order: (1) first molar (2) central incisor, (3) lateral incisor, (4) canine, (5) first premolar, (6) second premolar, (7) second molar, and (8) third molar. Since there are no premolars in the primary dentition, the primary molars are replaced by permanent premolars. If any primary teeth are lost before permanent teeth are ready to replace them, some posterior teeth may drift forward and cause space to be lost in the mouth. This may cause crowding and/or misplacement once the permanent teeth erupt, which is usually referred to as malocclusion. Orthodontics may be required in such circumstances for an individual to achieve a straight set of teeth.

The permanent dentition begins when the last primary tooth is lost, usually at 11 to 12 years, and lasts for the rest of a person's life or until all of the teeth are lost (edentulism). During this stage, third molars (also called "wisdom teeth") are frequently extracted because of decay, pain or impactions. The main reasons for tooth loss are decay and periodontal disease.

Eruption times for primary and permanent teeth

	Primary teeth							
	Central incisor	**Lateral incisor**	**Canine**	**First premolar**	**Second premolar**	**First molar**	**Second molar**	**Third molar**
Maxillary teeth	10 mo	11 mo	19 mo			16 mo	29 mo	
Mandibular teeth	8 mo	13 mo	20 mo			16 mo	27 mo	
	Permanent teeth							
	Central incisor	**Lateral incisor**	**Canine**	**First premolar**	**Second premolar**	**First molar**	**Second molar**	**Third molar**

Maxillary teeth	7–8 yr	8–9 yr	11–12 yr	10–11 yr	10–12 yr	6–7 yr	12–13 yr	17–21 yr
Mandibular teeth	6–7 yr	7–8 yr	9–10 yr	10–12 yr	11–12 yr	6–7 yr	11–13 yr	17–21 yr

Immediately after the eruption enamel is covered by a specific film: Nasmyth's membrane or 'enamel cuticle', structure of embryological origin is composed of keratin which gives rise to the enamel organ.

Nutrition and tooth development

As in other aspects of human growth and development, nutrition has an effect on the developing tooth. Essential nutrients for a healthy tooth include calcium, phosphorus, and vitamins A, C, and D. Calcium and phosphorus are needed to properly form the hydroxyapatite crystals, and their levels in the blood are maintained by Vitamin D. Vitamin A is necessary for the formation of keratin, as Vitamin C is for collagen. Fluoride is incorporated into the hydroxyapatite crystal of a developing tooth and makes it more resistant to demineralization and subsequent decay.

Deficiencies of these nutrients can have a wide range of effects on tooth development. In situations where calcium, phosphorus, and vitamin D are deficient, the hard structures of a tooth may be less mineralized. A lack of vitamin A can cause a reduction in the amount of enamel formation. Fluoride deficiency causes increased demineralization when the tooth is exposed to an acidic environment, and also delays remineralization. Furthermore, an excess of fluoride while a tooth is in development can lead to a condition known as fluorosis.

Abnormalities

There are a number of tooth abnormalities relating to development.

Anodontia is a complete lack of tooth development, and hypodontia is a lack of some tooth development. Anodontia is rare, most often occurring in a condition called Hypohidrotic ectodermal dysplasia, while hypodontia is one of the most common developmental abnormalities, affecting 3.5–8.0% of the population (not including third molars). The absence of third molars is very common, occurring in 20–23% of the population, followed in prevalence by the second premolar and lateral incisor. Hypodontia is often associated with the absence of a dental lamina, which is vulnerable to environmental forces, such as infection and chemotherapy medications, and is also associated with many syndromes, such as Down syndrome and Crouzon syndrome.

Hyperdontia is the development of extraneous teeth. It occurs in 1–3% of Caucasians and is more frequent in Asians. About 86% of these cases involve a single extra tooth in the mouth, most commonly found in the maxilla, where the incisors are located. Hyperdontia is believed to be associated with an excess of dental lamina.

Dilaceration is an abnormal bend found on a tooth, and is nearly always associated with trauma that moves the developing tooth bud. As a tooth is forming, a force can move the tooth from its original position, leaving the rest of the tooth to form at an abnormal angle. Cysts or tumors adjacent to a tooth bud are forces known to cause dilaceration, as are primary (baby) teeth pushed upward by trauma into the gingiva where it moves the tooth bud of the permanent tooth.

Regional odontodysplasia is rare, but is most likely to occur in the maxilla and anterior teeth. The cause is unknown; a number of causes have been postulated, including a disturbance in the neural crest cells, infection, radiation therapy, and a decrease in vascular supply (the most widely held hypothesis). Teeth affected by regional odontodysplasia never erupt into the mouth, have small crowns, are yellow-brown, and have irregular shapes. The appearance of these teeth in radiographs is translucent and "wispy," resulting in the nickname "ghost teeth".

Molecular biology

In fish hox gene expression regulate mechanisms for teeth initiation.

In mouse WNT signals are required for the initiation of teeth development.

NGF-R was present in the condensing ecto-mesenchymal cells of the dental papilla in the early cap stage tooth germ and play multiple roles during morphogenetic and cytodifferentiation events in the tooth. There is a relationship between tooth agenesis and absence of the peripheral trigeminal nerve.

All stages (bud, cap, bell, crown), growth and morphogenesis of the teeth are regulated by a protein: sonic hedgehog.

During tooth development there are strong similarities between keratinization and amelogenesis. Keratin is also present in epithelial cells of tooth germ and a thin film of keratin is present on the tooth erupted recently (Nasmyth's membrane or enamel cuticle).

Enamel knots as a signaling center in the tooth morphogenesis and odontoblast differentiation.

Various phenotypic inputs modulate the size of the teeth.

The shape of the teeth in prehistoric man was different from that of modern man.

In some dermoid teratomas (particularly ovarian, lung, pancreas, testes) develop complete teeth.

For the tooth eruption is necessary parathyroid hormone.

Tooth development in animals

The organism with genome simplest with teeth is probably the worm genus Ancylostoma (Ancylostoma duodenale, Necator americanus).

Teeth is atavic structure and their development is similar in many vertebrates.

Fish have many specialized bony structures, it exist with (Archosargus probatocephalus order Perciformes, family Sparidae) and without teeth (Caristiidae order Perciformes, family Caristiidae, teeth in traces present in juveniles).

Unlike most animals, sharks continuously produce new teeth throughout life via a drastically different mechanism. Because shark teeth have no roots, sharks easily lose teeth when they feed (zoologists estimate that a single shark can lose up to 2,400 teeth in one year)—they must therefore be continually replaced. Shark teeth form from modified scales near the tongue and move outward on the jaw in rows until they fully develop, are used, and are eventually dislodged.

Snakes generally have teeth, with some exception (African Egg-eating Snake).

Today, birds do not have teeth, though it is speculated that prehistoric birds, such as archaeopteryx, did.

In order Tubulidentata (Class Mammalia) teeth are without enamel, they lack incisors and canines and the molars molars are growing continuously from the root.

Generally, tooth development in non-human mammals is similar to human tooth development. The variations lie in the morphology, number, development timeline, and types of teeth, not usually in the actual development of the teeth.

Enamel formation in non-human mammals is almost identical to that in humans. The ameloblasts and enamel organ, including the dental papilla, function similarly. Nonetheless, while ameloblasts die in humans and most other animals—making further enamel formation impossible—rodents continually produce enamel, forcing them to wear down their teeth by gnawing on various materials. If rodents are prevented from gnawing, their teeth eventually puncture the roofs of their mouths. In addition, rodent incisors consist of two halves, known as the crown and root analogues. The labial half is covered with enamel and resembles a crown, while the lingual half is covered with dentin and resembles a root. Both root and crown develop simultaneously in the rodent incisor and continue to grow for the life of the rodent.

The mineral distribution in rodent enamel is different from that of monkeys, dogs, pigs, and humans. In horse teeth, the enamel and dentin layers are intertwined, which increases the strength and decreases the wear rate of the teeth.

Supporting structures that create a "socket" are found exclusively in Mammalia and Crocodylia. In manatees, mandibular molars develop separately from the jaw, and are encased in a bony shell separated by soft tissue. This also occurs in elephants' successional teeth, which erupt to replace lost teeth.

Chapter 13

Amelogenesis and Dentinogenesis

Amelogenesis

Amelogenesis is the formation of enamel on teeth and occurs during the crown stage of tooth development after dentinogenesis, which is the formation of dentine. Although dentine must be present for enamel to be formed, it is also true that ameloblasts must be present in order for dentinogenesis to continue. A message is sent from the newly differentiated odontoblasts to the inner enamel epithelium (IEE), causing the epithelial cells to further differentiate into active secretory ameloblasts. Dentinogenesis is in turn dependent on signals from the differentiating IEE in order for the process to continue. This prerequisite is an example of the biological concept known as *reciprocal induction*, in this instance between mesenchymal and epithelial cells.

Amelogenesis is considered to have two stages. The first stage is known as the secretory phase, and the second stage is known as the maturation stage. Proteins and an organic matrix form a partially mineralized enamel in the secretory stage. The maturation stage completes enamel mineralization.

Stages

Inductive stage

Ameloblast differentiation is initiated by the presence of predentin. IDE cells elongate and become preameloblasts.

Initial Secretory stage

A shift in polarity occurs. Preameloblasts elongate and become postmitotic, polarized, secretory ameloblasts. No tomes' process yet. It is at this stage that a signal is sent from the newly differentiated ameloblasts back across the dental-enamel junction (DEJ) to stimulate dentinogenesis.

Secretory ameloblasts

Secretory stage ameloblasts are polarized, elongated cells with the cytoplasm full of organelles. Ameloblasts secrete organic matrix: enamel proteins and enzymes.

Secretory stage

In the secretory stage, ameloblasts are polarized columnar cells. In the rough endoplasmic reticulum of these cells, enamel proteins are released into the surrounding area and contribute to what is known as the enamel matrix, which is then partially mineralized by the enzyme alkaline phosphatase. When this first layer is formed, the ameloblasts move away from the dentin, allowing for the development of Tomes' processes at the end of the cell which is in contact with the DEJ. Tomes' process is the term given to the end of the cell which lays down the crystals of the enamel matrix. The Tomes' processes are angled, which introduces differences in crystallite orientation, and hence structure. Enamel formation continues around the adjoining ameloblasts, resulting in a walled area, or pit, that houses a Tomes' process, and also around the end of each Tomes' process, resulting in a deposition of enamel matrix inside of each pit. The matrix within the pit will eventually become an enamel rod, and the walls will eventually become interrod enamel. The only distinguishing factor between the two is the orientation of the calcium crystals.

Maturation stage

In the maturation stage, the ameloblasts transport substances used in the formation of enamel. Microscopically, the most notable aspect of this phase is that these cells become striated, or have a ruffled border. These signs demonstrate that the ameloblasts have changed their function from production, as in the secretory stage, to transportation. Proteins used for the final mineralization process compose most of the transported material. The noteworthy proteins involved are amelogenins, ameloblastins, enamelins, and tuftelins. During this process, amelogenins and ameloblastins are removed after use, leaving enamelins and tuftelin in the enamel. By the end of this stage, the enamel has completed its mineralization.

Dentinogenesis

Dentinogenesis is the formation of dentin, a substance that forms the majority of teeth. Dentinogenesis is performed by odontoblasts, which are a special type of biological cells on the outside of dental pulps, and it begins at the late bell stage of a developing tooth. The different stages of dentin formation result in different types of dentin: mantle dentin, primary dentin, secondary dentin, and tertiary dentin.

Odontoblasts differentiate from cells of the dental papilla. They begin secreting an organic matrix around the area directly adjacent to the inner enamel epithelium, closest to the area of the future cusp of a tooth. The organic matrix contains collagen fibers with large diameters (0.1-0.2 μm in diameter). The odontoblasts begin to move toward the center of the tooth, forming an extension called the odontoblast process. Thus, dentin formation proceeds toward the inside of the tooth. The odontoblast process causes the secretion of hydroxyapatite crystals and mineralization of the matrix. This area of mineralization is known as mantle dentin and is a layer usually about 5-30 μm thick.(Linde & Goldberg 1993)

Whereas mantle dentin forms from the preexisting ground substance of the dental papilla, primary dentin forms through a different process. Odontoblasts increase in size, eliminating the availability of any extracellular resources to contribute to an organic matrix for mineralization. Additionally, the larger odontoblasts cause collagen to be secreted in smaller amounts, which results in more tightly arranged, heterogeneous nucleation that is used for mineralization. Other materials (such as lipids, phosphoproteins, and phospholipids) are also secreted.

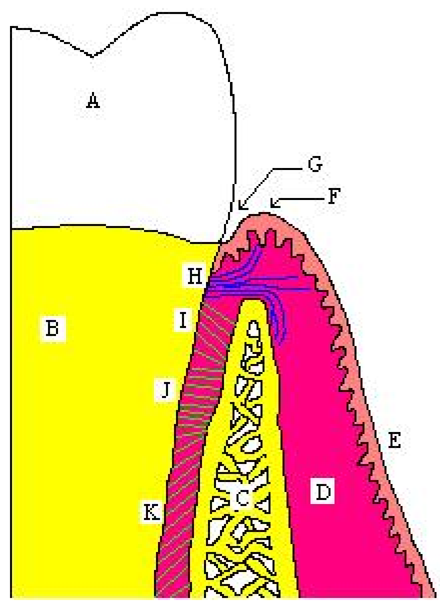
Secondary dentin is formed after root formation is finished and occurs at a much slower rate. It is not formed at a uniform rate along the tooth, but instead forms faster along sections closer to the crown of a tooth. This development continues throughout life and accounts for the smaller areas of pulp found in older individuals. Tertiary dentin, also known as reparative dentin, forms in reaction to stimuli, such as attrition or dental caries.

The dentin in the root of a tooth forms only after the presence of Hertwig's epithelial root sheath (HERS), near the cervical loop of the enamel organ. Root dentin is considered different from dentin found in the crown of the tooth (known as coronal dentin) because of the different orientation of collagen fibers, the decrease of phosphophoryn levels, and less mineralization.

Chapter 14

Cementum and Periodontal Ligament

Cementum



The **cementum** is the surface layer of the tooth root *(B)*. Rather than being a passive entity like paint on a wall, cementum is a dynamic entity within the periodontium. It is attached to the alveolar bone *(C)* by the fibers of the periodontal ligament and to the soft tissue of the gingiva by the gingival fibers *(H)*.

Cementum is a specialized calcified substance covering the root of a tooth. Cementum is excreted by cells called cementoblasts within the root of the tooth and is thickest at the root apex. These cementoblasts develop from undifferentiated mesenchymal cells in the connective tissue of the dental follicle. Cementum is slightly softer than dentin and consists of about 45% to 50% inorganic material (hydroxyapatite) by weight and 50% to 55% organic matter and water by weight. The organic portion is composed primarily of collagen and protein polysaccharides. Sharpey's fibers are portions of the principal collagenous fibers of the periodontal ligament embedded in the cementum and alveolar bone to attach the tooth to the alveolus. Cementum is avascular.

The cementum is light yellow and slightly lighter in color than dentin. It has the highest fluoride content of all mineralized tissue. Cementum also is permeable to a variety of materials. It is formed continuously throughout life because a new layer of cementum is deposited to keep the attachment intact as the superficial layer of cementum ages. Two kinds of cementum are formed: acellular and cellular. The acellular layer of cementum is living tissue that does not incorporate cells into its structure and usually predominates on the coronal half of the root; cellular cementum occurs more frequently on the apical half. Cementum on the root ends surrounds the apical foramen and may extend slightly onto the inner wall of the pulp canal. Cementum thickness can increase on the root end to compensate for attritional wear of the occlusal/incisal surface and passive eruption of the tooth.

The cementodentinal junction is a relatively smooth area in the permanent tooth, and attachment of cementum to the dentin is firm but not understood completely. The cementum joins the enamel to form the cementoenamel junction, which is referred to as the cervical line. In about 10% of teeth, enamel and cementum do not meet, and this can result in a sensitive area. Abrasion, erosion, caries, scaling, and the procedures of finishing and polishing may result in denuding the dentin of its cementum covering, which can cause the dentin to be sensitive to several types of stimuli (e.g., heat, cold, sweet substances, sour substances). Cementum is capable of repairing itself to a limited degree and is not resorbed under normal conditions. Some root resorption of the apical portion of the root may occur, however, if orthodontic pressures are excessive and movement is too fast. Some experts also agree on a third type of cementum, *afibrillar cementum*, which sometimes extends onto the enamel of the tooth.

The excessive build up of cementum on the roots of a tooth is a pathological condition known as hypercementosis.

Periodontal ligament

The **periodontal ligament**, commonly abbreviated as the **PDL**, is a group of specialized connective tissue fibers that essentially attach a tooth to the alveolar bone within which it sits. These fibers help the tooth withstand the naturally substantial compressive forces which occur during chewing and remain embedded in the bone.

Functions of PDL are Supportive, Sensory, Nutritive, Homeostatic and Eruptive.

Structure of the PDL

It consist of cells,extracellular compartment of fibers and ground substance

cells of PDL

Fibroblast epithelial undifferentiated mesenchymal cells bone and cementum cells

extracellular compartment of PDL

Extracellular compartment consist of collagen fibers bundles embedded in ground substance

Types of fibers

The PDL fibers are categorized according to their orientation and location along the tooth. They are:

Alveolar crest fibers

Alveolar crest fibers attach to the cementum just apical to the cementoenamel junction, run downward, and insert into the alveolar bone.

Horizontal fibers

Horizontal fibers attach to the cementum apical to the alveolar crest fibers and run perpendicularly from the root of the tooth to the alveolar bone.

Oblique fibers

Oblique fibers are the most numerous fibers in the periodontal ligament, running from cementum in an oblique direction to insert into bone coronally.

Apical fibers

radiating from cementum around the apex of the root to the bone, forming base of the socket

Interradicular fibers

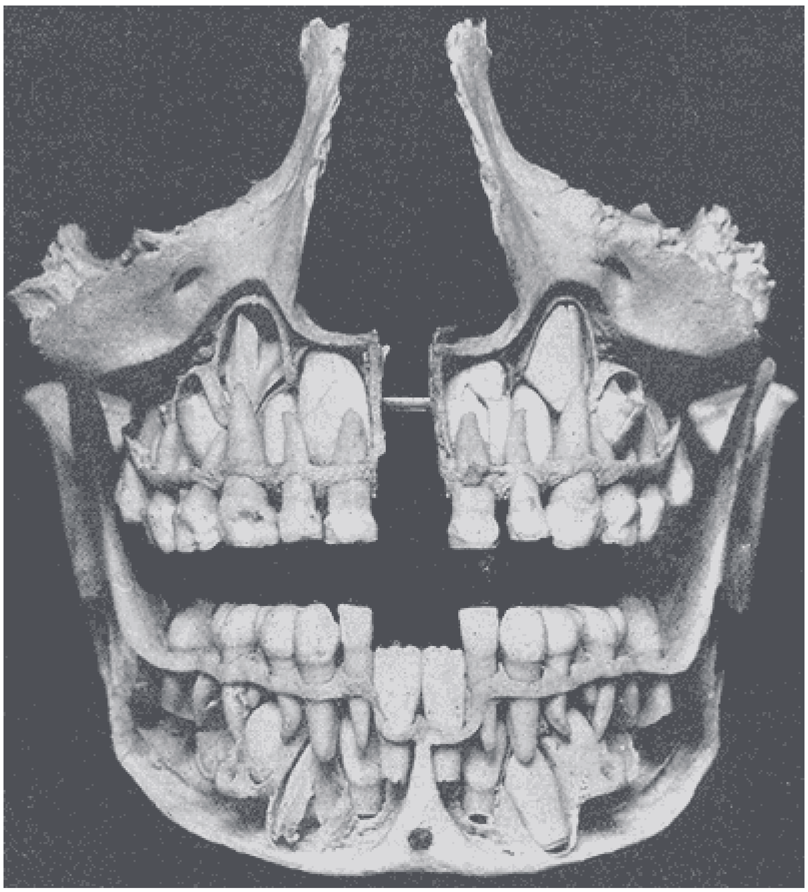
Interradicular fibers are only found between the roots of multi-rooted teeth, such as molars. They also attach from the cementum and insert to the nearby alveolar bone.

Ground substance of the PDL

The PDL substance has been estimated to be 70% water and is thought to have a significant effect on the tooth's ability to withstand stress loads

Chapter 15

Tooth Eruption



The removed bone reveals permanent teeth below the roots of primary teeth

Tooth eruption is a process in tooth development in which the teeth enter the mouth and become visible. It is currently believed that the periodontal ligaments play an important role in tooth eruption. Primary (baby) teeth erupt into the mouth from around 6 months until 2 years of age. These teeth are the only ones in the mouth until a person is about 6 years old. At that time, the first permanent tooth erupts and begins a time in which there is a combination of primary and permanent teeth. This stage, known as the mixed stage, lasts until the last primary tooth is lost. Then, the remaining permanent teeth erupt into the mouth.

Theories

Although researchers agree that tooth eruption is a complex process, there is little agreement on the identity of the mechanism that controls eruption. There have been many theories over time that have been eventually disproven. One of the theories is that the tooth is pushed upward into the mouth by the growth of the tooth's root. Others advocated that a tooth is pushed upward by the growth of the bone around the tooth. In addition, some believed teeth were pushed upward by vascular pressure or by an anatomical feature called the cushioned hammock. The cushioned hammock theory, first proposed by Harry Sicher, was taught widely from the 1930s to the 1950s. This theory postulated that a ligament below a tooth, which Sicher observed under a microscope on a histologic slide, was responsible for eruption. Later, the "ligament" Sicher observed was determined to be merely an artifact created in the process of preparing the slide.

The most widely held current theory is that while several forces might be involved in eruption, the periodontal ligaments provide the main impetus for the process. Theorists hypothesize that the periodontal ligaments promote eruption through the shrinking and cross-linking of their collagen fibers and the contraction of their fibroblasts.

There is good evidence from experimental animals that a traction force is unlikely to be involved in tooth eruption: Animals treated with lathyrogens that interfere with collagen cross-link formation showed similar eruption rates to control animals, provided occlusal forces were removed.

Timeline

Bottom teeth of a seven-year old, showing primary teeth *(left)*, a lost primary tooth *(middle)*, and a fully erupted permanent tooth *(right)*

Although tooth eruption occurs at different times for different people, a general eruption timeline exists. Typically, humans have 20 primary teeth and 32 permanent teeth. Tooth eruption has three stages. The first, known as primary dentition stage, occurs when only primary teeth are visible. Once the first permanent tooth erupts into the mouth, the teeth are in the mixed (or transitional) dentition. After the last primary tooth falls out of the mouth, the teeth are in the permanent dentition.

Primary teeth

Primary dentition starts on the arrival of the mandibular central incisors, usually at eight months, and lasts until the first permanent molars appear in the mouth, usually at six years. The primary teeth typically erupt in the following order: (1) central incisor, (2) lateral incisor, (3) first molar, (4) canine, and (5) second molar. As a general rule, four teeth erupt for every six months of life, mandibular teeth erupt before maxillary teeth, and teeth erupt sooner in females than males. During primary dentition, the tooth buds of permanent teeth develop below the primary teeth, close to the palate or tongue.

Mixed stage

Mixed dentition starts when the first permanent molar appears in the mouth, usually at five or six years, and lasts until the last primary tooth is lost, usually at ten, eleven, or twelve years. Permanent teeth in the maxilla erupt in a different order from permanent teeth on the mandible. Maxillary teeth erupt in the following order: (1) first molar (2) central incisor, (3) lateral incisor, (4) first premolar, (5) second premolar, (6) canine, (7) second molar, and (8) third molar. Mandibular teeth erupt in the following order: (1) first molar (2) central incisor, (3) lateral incisor, (4) canine, (5) first premolar, (6) second premolar, (7) second molar, and (8) third molar. Since there are no premolars in the primary dentition, the primary molars are replaced by permanent premolars. If any primary teeth are lost before permanent teeth are ready to replace them, some posterior teeth may drift forward and cause space to be lost in the mouth. This may cause crowding and/or misplacement once the permanent teeth erupt, which is usually referred to as malocclusion. Orthodontics may be required in such circumstances for an individual to achieve a straight set of teeth.

Permanent teeth

The permanent dentition begins when the last primary tooth is lost, usually at 11 to 12 years, and lasts for the rest of a person's life or until all of the teeth are lost (edentulism). During this stage, third molars (also called "wisdom teeth") are frequently extracted because of decay, pain or impactions. The main reasons for tooth loss are decay or periodontal disease.

Chapter 16

Deciduous Teeth

A six year old girl's deciduous teeth, which are beginning to fall out

Deciduous teeth, otherwise known as **reborner teeth**, **baby teeth**, **temporary teeth** and **primary teeth**, are the first set of teeth in the growth development of humans and many other mammals. In some Asian countries they are referred to as **fall teeth** as they will eventually fall out, while in almost all European languages they are called **milk teeth**. They develop during the embryonic stage of development and erupt—that is, they become visible in the mouth—during infancy. They are usually lost and replaced by permanent teeth, but in the absence of permanent replacements, they can remain functional for many years.

Description

Deciduous teeth start to form during the embryo phase of pregnancy. The development of deciduous teeth starts at the sixth week of development as the dental lamina. This process starts at the midline and then spreads back into the posterior region. By the time the embryo is eight weeks old, there are ten areas on the upper and lower arches that will eventually become the deciduous dentition. These teeth will continue to form until they erupt in the mouth. In the deciduous dentition there are a total of twenty teeth: five per quadrant and ten per arch. The eruption of these teeth begins at the age of six months and continues until twenty-five to thirty-three months of age. Usually, the first teeth seen in the mouth are the mandibular centrals and the last are the maxillary second molars.

The deciduous dentition is made up of central incisors, lateral incisors, canines, first molars, and secondary molars; there is one in each quadrant, making a total of four of each tooth. All of these are gradually replaced with a permanent counterpart except for the first and second molars; they are replaced by premolars. The replacement of deciduous teeth begins around age six. At that time, the permanent teeth start to appear in the mouth, resulting in mixed dentition. The erupting permanent teeth causes root resorption, where the permanent teeth push down on the roots of the deciduous teeth, causing the roots to be dissolved and become absorbed by the forming permanent teeth. The process of shedding deciduous teeth and the replacement by permanent teeth is called exfoliation. This may last from age six to age twelve. By age twelve there usually are only permanent teeth remaining.

An eight-year old's deciduous teeth

Teething age of deciduous teeth:

- Central incisors : 6–12 months
- Lateral incisors : 9–16 months
- Canine teeth : 16–23 months
- First molars : 13–19 months
- Second molars : 22–33 months

Deciduous teeth are considered essential in the development of the oral cavity by dental researchers and dentists. The permanent teeth replacements develop from the same tooth bud as the deciduous teeth; this provides a guide for permanent teeth eruption. Also the muscles of the jaw and the formation of the jaw bones depend on the primary teeth in order to maintain the proper space for permanent teeth. The roots of deciduous teeth provide an opening for the permanent teeth to erupt. These teeth are also needed for proper development of a child's speech and chewing of food.

Deciduous teeth care

Proper care of deciduous teeth is very important and starts at early stages even prior to their eruption. At the earliest stage, a child's mouth and gums are to be wiped with a clean damp cloth, gauze pad, or especially designed teeth wipes. Wiping the baby's teeth and gums after each feeding, and particularly at bedtime, helps prevent baby bottle tooth decay. This practice also helps reduce premature decay caused by harmful plaque-like film and bacteria that builds when babies ingest juices or any food containing sugar. Moreover, to reduce the possibilities to develop baby bottle tooth decay is it better to give the baby only plain water at bedtime or during the night and avoid juices, sugar water, milk or any other liquid containing sugar.

Once the first primary teeth come in, brushing starts. Warm water is normally used in these cases or a non fluoride toothpaste. The market offers special toothbrushes or finger toothbrushes for babies that help protect tender gums and gently clean baby teeth and gums. Other toothbrushes are specially designed for toddlers to easily grip them. They also come in catchy designs that encourage toddlers to use them. Toothbrush designs vary according to age, therefore, it is better to check the age recommendation on the package to obtain the most convenient one. Toothbrushes should be replaced every two to three months. It is also important to brush children's teeth after giving them medicine as their acids may affect the tooth enamel. Early brushing helps reduce harmful bacteria, remove plaque, sugar, or any other kind of food that may cause tooth decay.

Parents are advised to take their children to the first dentist visit when they are 12 months old. During this visit, the dentist can define dental care plan. Two possible ways to prevent tooth decay are the use of fluoride and sealants.

Fluoride makes teeth stronger over time which then prevents the initiation of dental caries and tooth decay. Also, it re-mineralizes those areas of the teeth which have been weakened by acid. Fluoride can be included in one's diet. Other ways of obtaining fluoride are in toothpastes and mouth rinses that are normally used at homes. The dentist can provide it through gels and foams he applies during dental visits.

To add to the benefits of the fluoride, dentists also apply sealant in order to preserve the teeth even more. Sealant is applied in some locations of the teeth that smooth their surface. Therefore, food and plaque are less likely to get trapped in those areas.

Children can start flossing when they are about 3-4 years old. However, at this age they might still need help and will be able to floss by themselves when they are 8-10 years old.

Cultural traditions

Various cultures have customs relating to the loss of deciduous teeth.

The legend of the tooth fairy is that of a fairy that gives a child money and/or gifts in exchange for a baby tooth that has fallen out. Children typically place the tooth under their pillow at night. The fairy is said to take the tooth from under the pillow and replace it with money once they have fallen asleep.

Tooth tradition is present in United States sometimes is under different names. A Ratón Pérez appeared in the tale of the Vain Little Mouse. The Ratoncito Pérez was used by Colgate marketing in Venezuela and Spain. In Italy, the Tooth Fairy (*Fatina*) is also often replaced by a small mouse (*topino*). In France and in French-speaking Belgium, this character is called *La Petite Souris* ("The Little Mouse"). From parts of lowland Scotland comes a tradition similar to the fairy mouse: a white fairy rat who purchases the teeth with coins. In medieval Scandinavia there was a tradition, surviving to the present day in Iceland, of *tannfé* ('tooth-money'), a gift to a child when it cuts its first tooth.

In Turkey, children traditionally throw their fallen "milk teeth" onto the roof of their house while making a wish. Similarly, in some Asian countries, such as India, Korea and Vietnam, when a child loses a tooth, the usual custom is that he or she should throw it onto the roof if it came from the lower jaw, or into the space beneath the floor if it came from the upper jaw. While doing this, the child shouts a request for the tooth to be replaced with the tooth of a mouse. This tradition is based on the fact that the teeth of mice grow for their entire lives, a characteristic of all rodents. In Japan, a different variation calls for lost upper teeth to be thrown straight down to the ground and lower teeth straight up into the air; the idea is that incoming teeth will grow in straight.

In parts of India, young children offer their discarded baby teeth to the sun, sometimes wrapped in a tiny rag of cotton turf.

The tradition of throwing a baby tooth up into the sky to the sun or to Allah and asking for a better tooth to replace it is common in Middle Eastern countries (including Iraq, Jordan, Palestine, Egypt and Sudan). It may originate in a pre-Islamic offering and certainly dates back to at least the 13th century, when Izz bin Hibat Allah Al Hadid mentions it.

Chapter 17

Teething

Teething is the process by which an infant's teeth sequentially appear by breaking through the gums. Teething may start as early as three months or as late, in some cases, as twelve months. The typical time frame for new teeth to appear is somewhere between six and nine months. It can take up to several years for all 20 deciduous (aka "baby" or "milk") teeth to emerge. Though the process of teething is sometimes referred to as *"cutting teeth"*, when teeth emerge through the gums they do not cut through the flesh. Instead, special chemicals are released within the body that cause some cells in the gums to die and separate, allowing the teeth to come through.

Sequence of appearance

9 month infant with right lower central incisor about to emerge

5 days later that incisor is visible

The infant teeth tend to emerge in pairs - first one lower incisor emerges then the other lower incisor emerges before the next set begin to emerge. The general pattern of emergence is:

1. Lower central incisors (2)
2. Upper central incisors (2)
3. Upper lateral incisors (2),
4. Lower lateral incisors (2)
5. First molars (4)
6. Canines (4)
7. Second molars (4)

Milk teeth tend to emerge sooner in females than in males. The exact pattern and initial starting times of teething appear to be hereditary. When and how teeth appear in an infant has no bearing on the health of the child.

Teething symptoms

The level of pain that a baby can handle will be different for each child. Some may be a lot fussier than others while they are teething. The soreness and swelling of the gums before a tooth comes through is the cause for the pain and fussiness a baby experiences during this change. These symptoms usually begin about three to five days before the tooth shows, and they disappear as soon as the tooth breaks the skin. Some babies are not even bothered by teething.

Common symptoms include drooling or dribbling, mood changes and feelings of irritability or crankiness and swollen gums. Crying, sleeplessness, restless sleep at night, and mild fever are also associated with teething. Teething can begin as early as 3 months and continue until a child's third birthday. In rare cases, an area can be filled with fluid and appears over where a tooth is erupting and cause the gums to be even more sensitive. Pain is often associated more with large molars since they cannot penetrate through the gums as easily as the other teeth.

Some of the signs or symptoms that a baby has entered the teething stage will be actions that are noticeable. They may chew on their fingers or toys to help relieve pressure on their gums. Babies might refuse to eat or drink due to the pain. Symptoms will generally fade on their own, but a doctor should be notified if they worsen or are persistent. Teething may cause signs and symptoms in the mouth and gums, but it doesn't cause problems elsewhere in the body.

Pulling on the ears is another sign of pain; the pain in the mouth throbs throughout the baby's head so they pull their ears believing that it will provide relief. Mild rash can develop around the mouth due to skin irritation that is caused because of excessive drooling or dribbling.

Teething has not been shown to cause fever or diarrhea. A slight rise of temperature may occur when the teeth come through the gum, but this does not make a baby ill.

Treatment

Before treating a baby for teething, it is important to know what is causing the baby to be upset. Rubbing a finger gently along the gums in search for swollen ridges or the feel of a tooth below the gums is one way to be certain. If unsure, it is recommended that the child be seen by a pediatrician before treatment is administered.

Infants chew on objects to aid in the teething process. This can be dangerous if the baby is allowed to chew on objects which are small enough to be swallowed or which could break while being chewed and cause choking. Teething rings and other toys, called teethers, are often designed with textures that will appeal to an infant during teething.

In cases where the infant is in obvious pain, some doctors recommend the use of anti-inflammatories or child-safe pain-relief treatments containing benzocaine. Some infants gain relief from chewing on cold objects.

Dentists recommend brushing infants' teeth as soon as they appear. It is not advisable to wait for the teething process to be complete. Dentists may recommend against the use of fluoride toothpaste during teething.

Not all parents are comfortable with the idea of using medications to treat a baby's pain and suffering. Medicines are often applied to the babies gums to relieve swelling and pain. These gels are similar to the toothache gel that is used by adults for sore gums and toothaches, but is administered in much smaller doses. Teething gels work as a numbing agent to dull the nerves in the gums so that the pain is less noticeable. It is important to follow the directions on the package to ensure that the correct amount of medication is administered and that proper techniques are used to reduce the risk for infection. It is important not to let the medicine numb the throat as it may interfere with the normal gag reflex and may make it possible for food to enter the lungs.

Acetaminophen and ibuprofen are also recommended to treat the pain and swelling that babies experience, but should not be administered to babies under six months of age. It should only be used a few times a day so that it does not mask symptoms that are being experienced due to other medical conditions and not because of teething. Products that contain aspirin should not be given to a child unless directed by a pediatrician. A teething ring is generally a soft plastic device that can be chewed on and allows the baby to break down some of the gum tissue which promotes the growth of the teeth out of the gum. Some teething rings can easily be broken or damaged, so other types of teething devices can be made from household items. Placing a wet washcloth in the freezer for a few minutes and then applying it gently to the gums can be effective, but care must be taken not to expose a baby's gums to coldness for too long.