Tooth Development and Oral Hygiene

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Chapter 1

Tooth Development

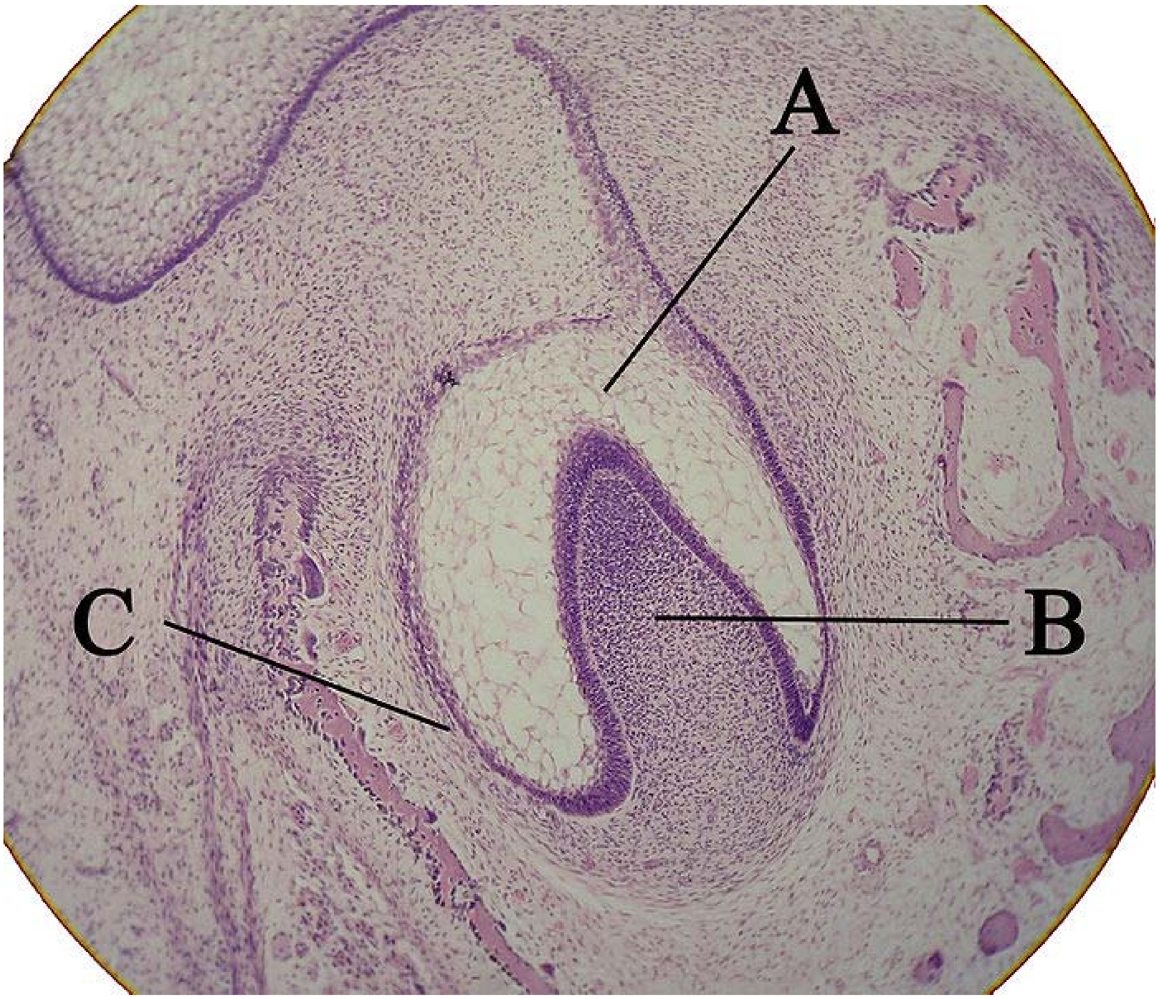
Radiograph of lower right (from left to right) third, second, and first molars in different stages of development.

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

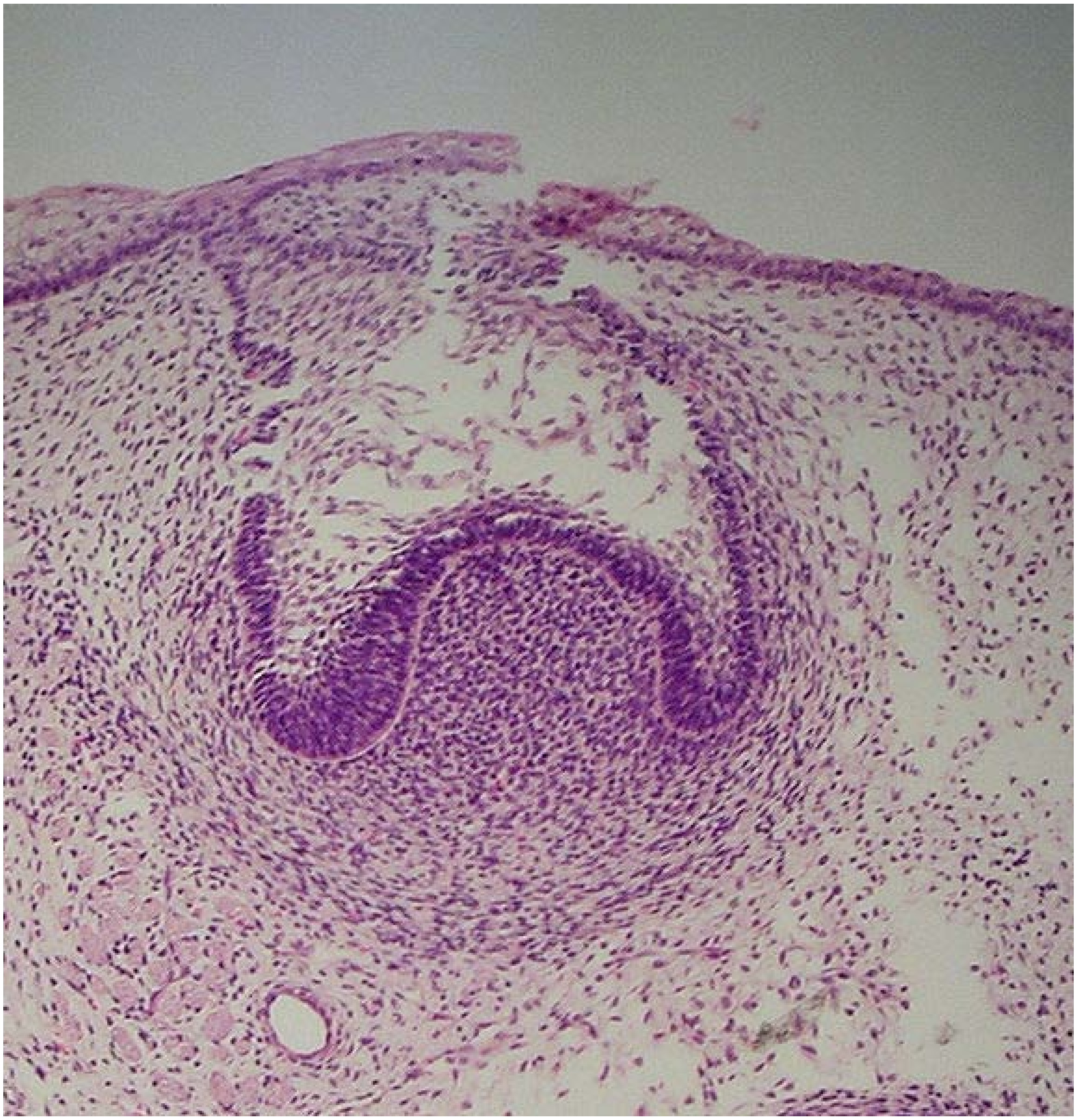
One of the earliest steps in the formation of a tooth that can be seen microscopically is the distinction between the vestibular lamina and the dental lamina. The dental lamina connects the developing tooth bud to the epithelial layer of the mouth for a significant time.

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

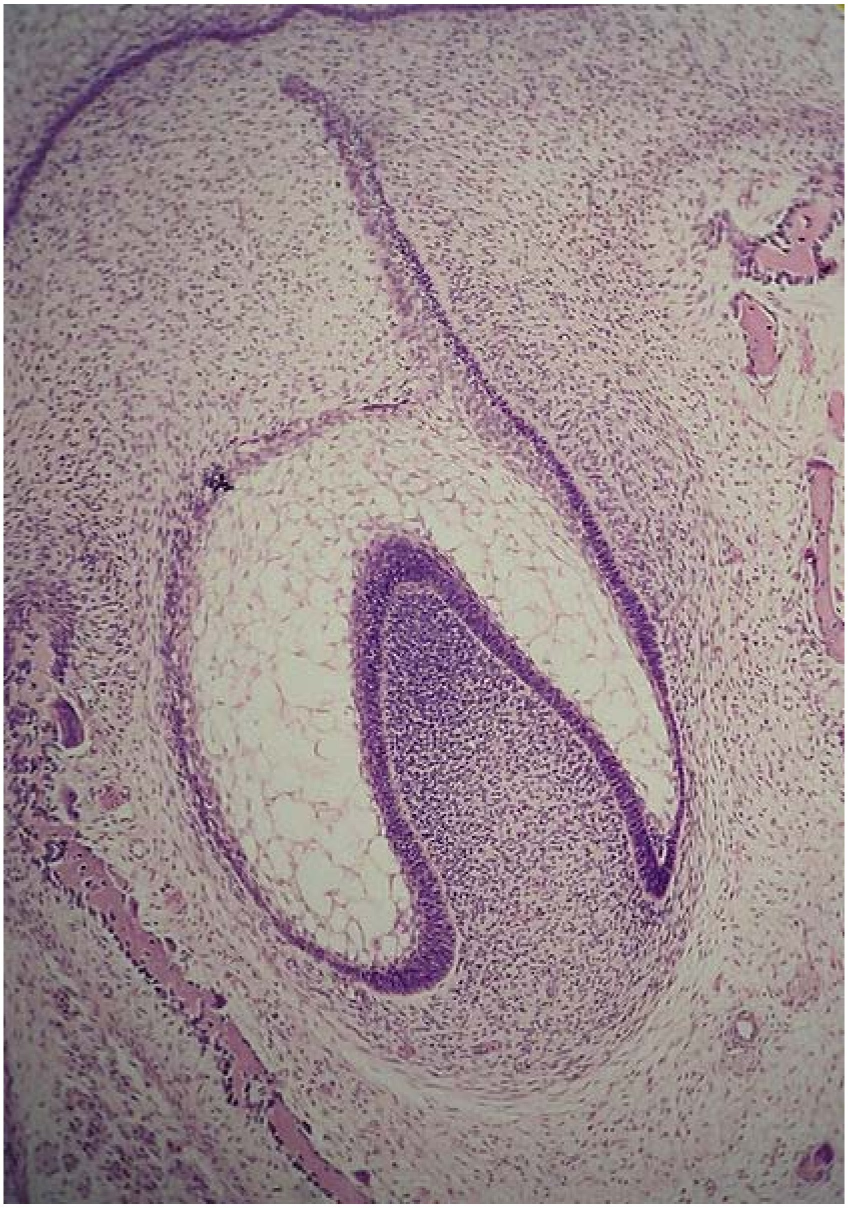
The bud stage is characterized by the appearance of a tooth bud without a clear arrangement of cells. The stage technically begins once epithelial cells proliferate into the ectomesenchyme of the jaw. Typically, this occurs when the fetus is around 6 weeks old. The tooth bud itself is the group of cells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

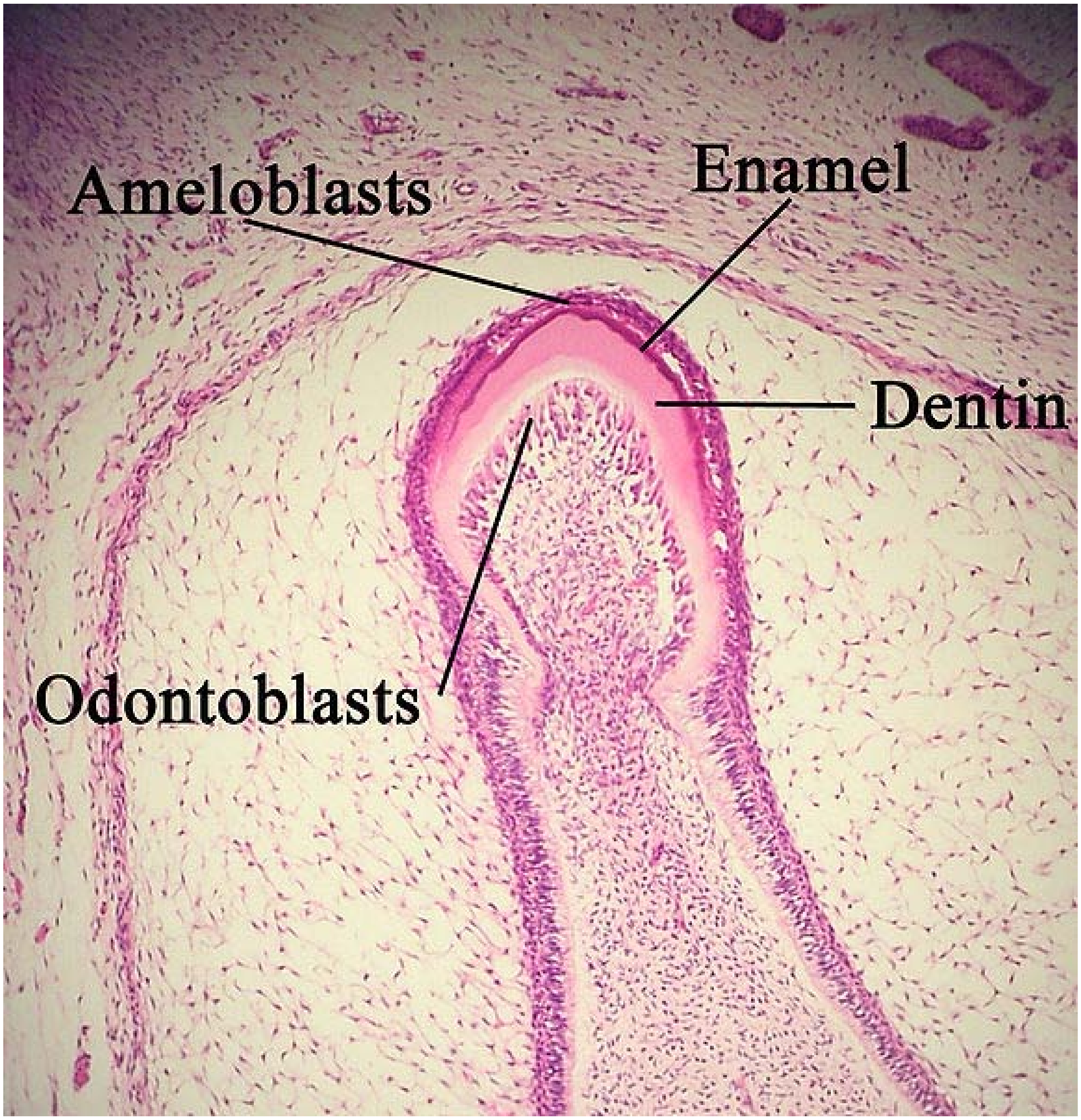
The bell stage is known for the histodifferentiation and morphodifferentiation that takes place. The dental organ is bell-shaped during this stage, and the majority of its cells are called stellate reticulum because of their star-shaped appearance. Cells on the periphery of the enamel organ separate 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.

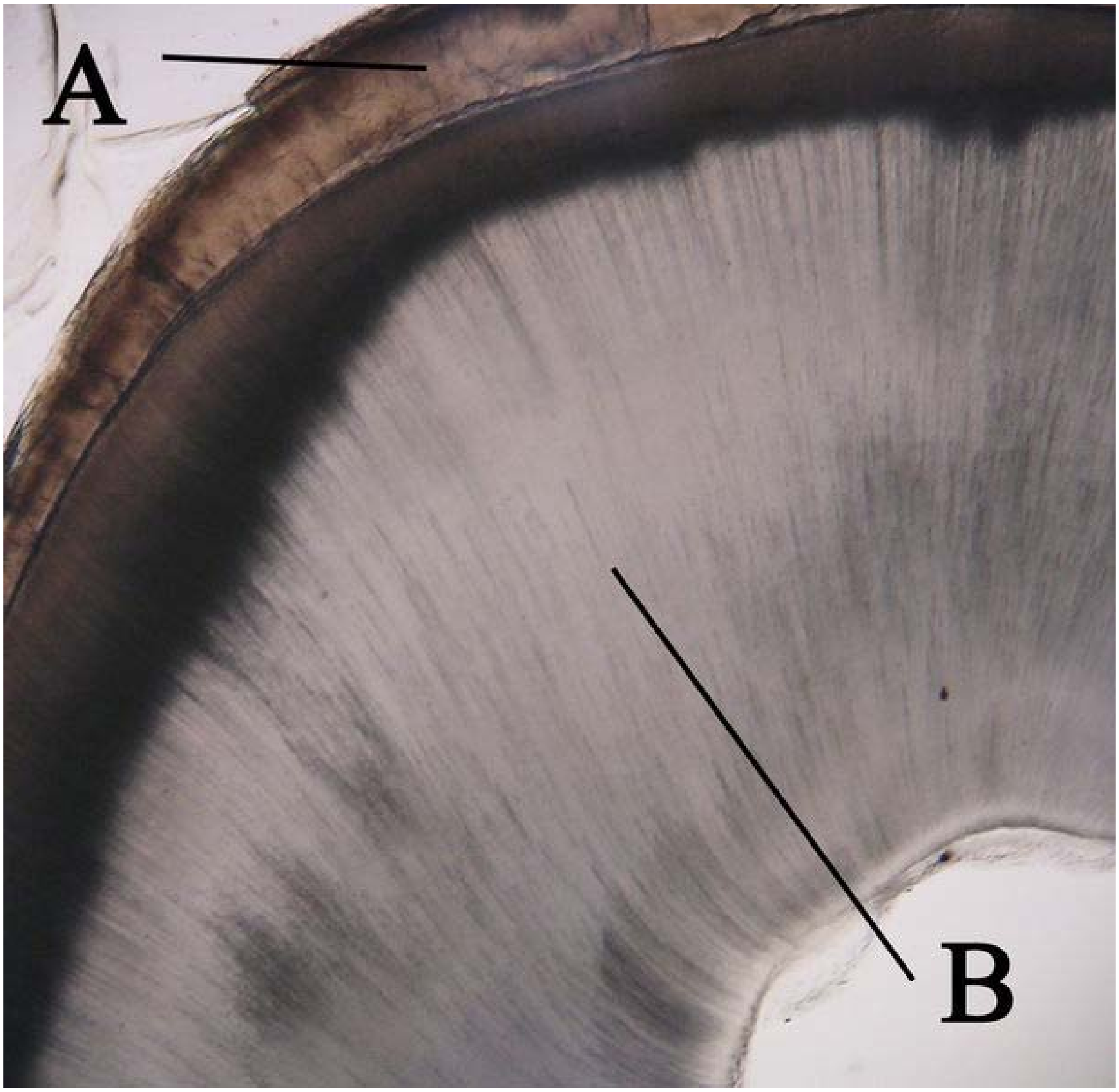
Other structures that may appear in a developing tooth in this stage are enamel knots, enamel cords, and enamel niche.



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.

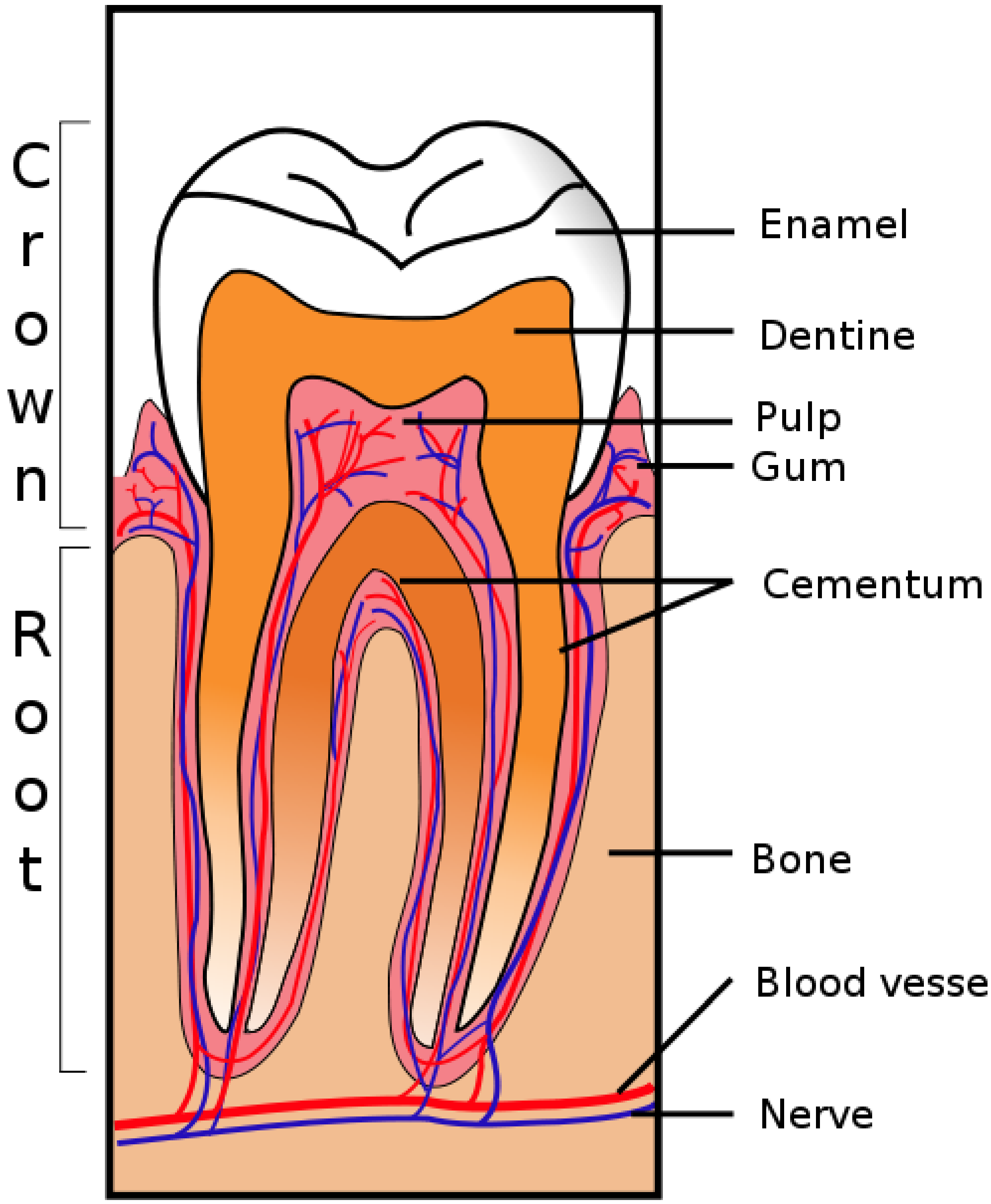


Histologic slide of tooth. Note the tubular appearance of dentin.
A: enamel
B: dentin

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.

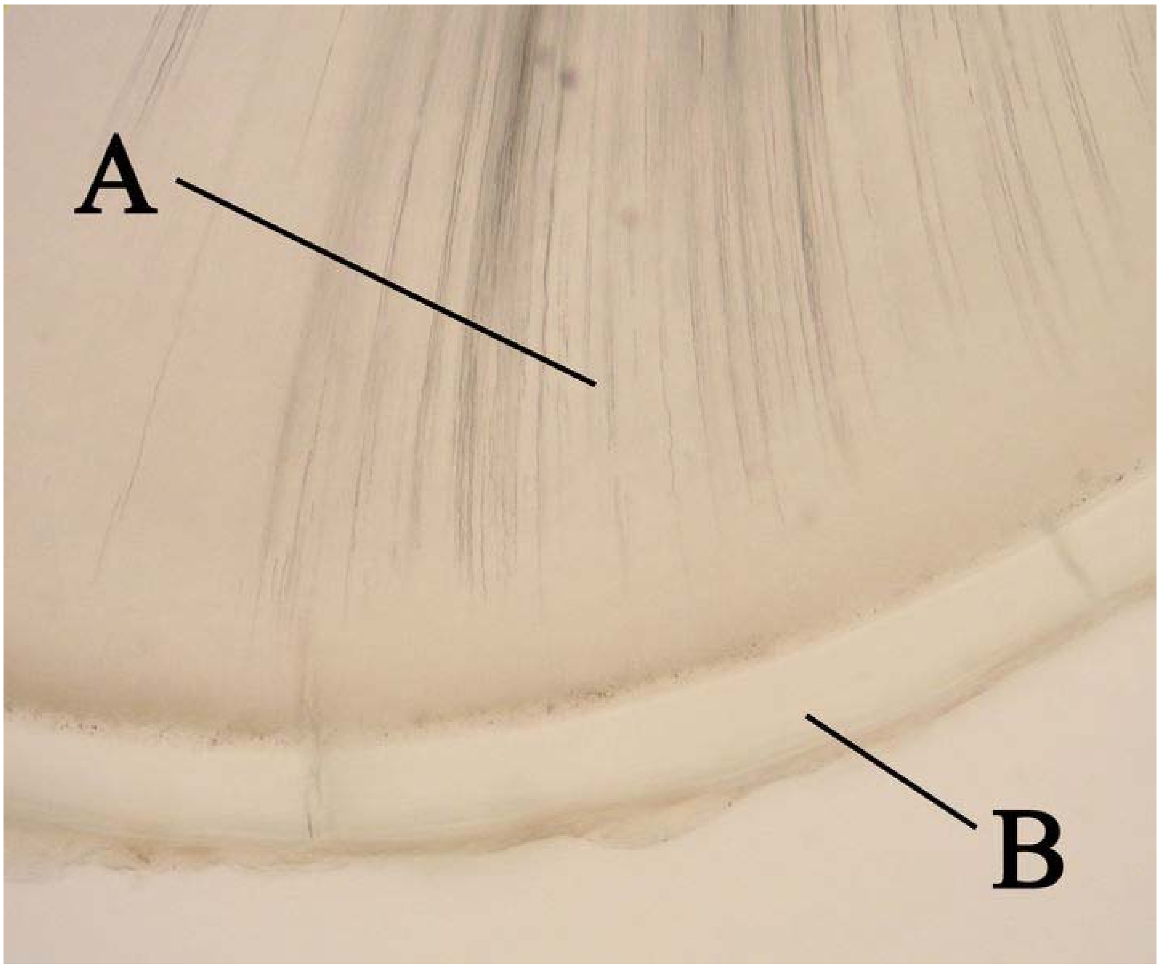
Dentin

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

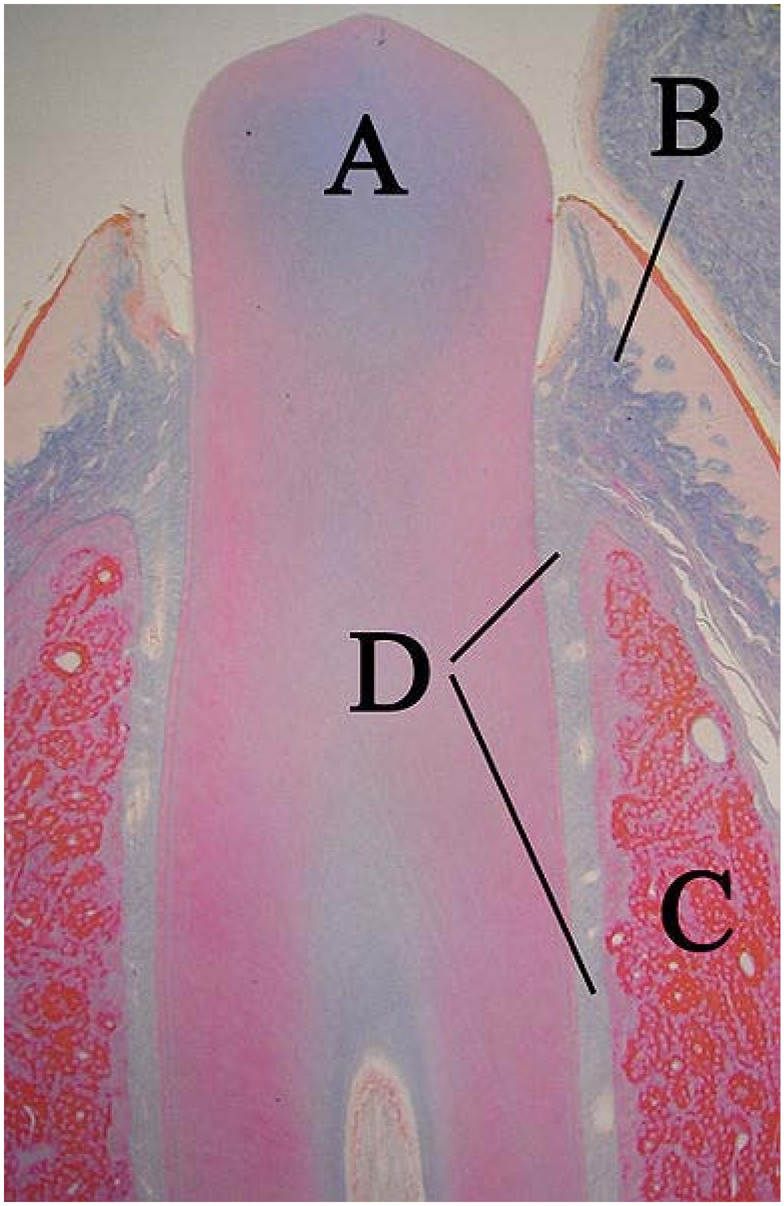
Cementum

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 2

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.

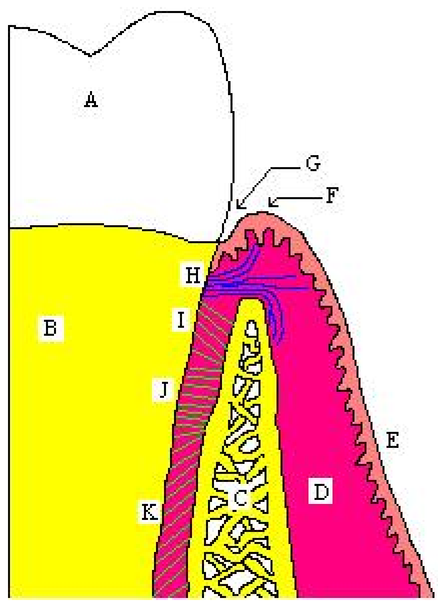
Secondary dentin is formed after root formation is finished and occurs at a much slower rate. It is not formed at a uniform rate along the tooth, but instead forms faster along sections closer to the crown of a tooth. This development continues throughout life and accounts for the smaller areas of pulp 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 3

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

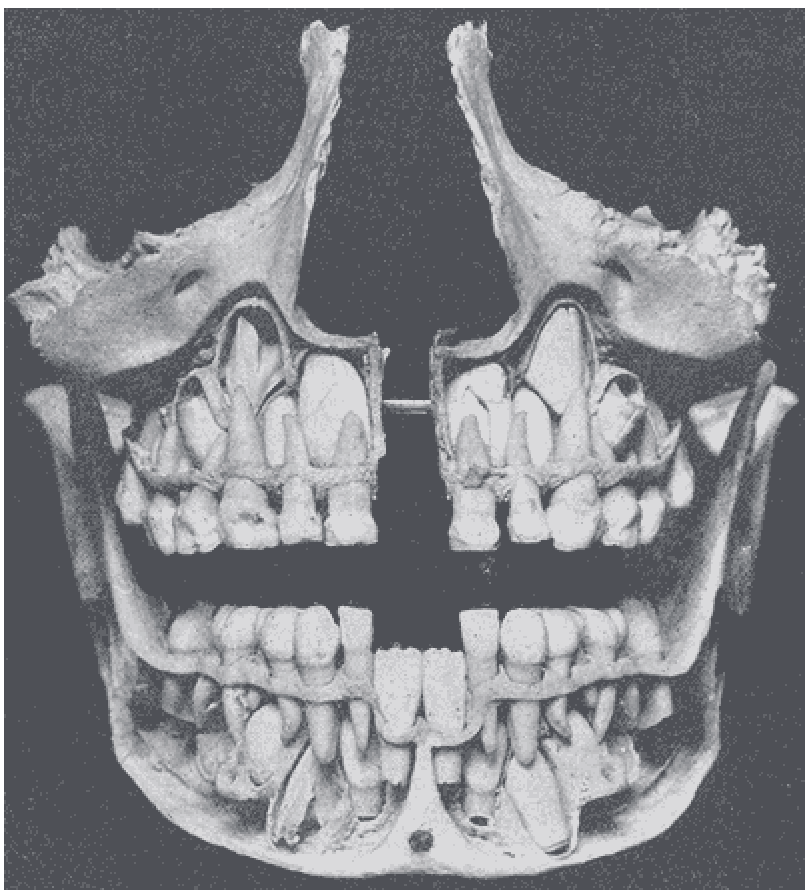
Interradicular fibers are only found between the roots of multi-rooted teeth, such as molars. They also attach from the cementum and insert to the nearby alveolar bone.

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 4

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 5

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 6

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.

Chapter 7

Oral Hygiene

Oral hygiene is the practice of keeping the mouth and teeth clean to prevent dental problems and bad breath.

Teeth cleaning

Teeth cleaning is the removal of dental plaque and tartar from teeth to prevent cavities, gingivitis, and gum disease. Severe gum disease causes at least one-third of adult tooth loss.

Tooth Decay is the most common global disease affecting every family. Over 80% of cavities occur inside pits and fissures on chewing surfaces where brushing cannot reach food left trapped after every meal or snack and saliva or fluoride have no access to neutralise acid and remineralise demineralised tooth.

Fissure sealants dentists apply over grooves in chewing surfaces of back teeth, block food being trapped and halt the decay process. An elastomer strip has been shown to force sealant deeper inside opposing chewing surfaces at the same time and can also force fluoride toothpaste inside chewing surfaces before brushing to remineralise demineralised teeth.

Since before recorded history, a variety of oral hygiene measures have been used for teeth cleaning. This has been verified by various excavations done all over the world, in which chewsticks, tree twigs, bird feathers, animal bones and porcupine quills were recovered. Many people used different forms of teeth cleaning tools. Indian medicine (Ayurveda) has used the neem tree (a.k.a. *daatun*) and its products to create teeth cleaning twigs and similar products for millennia. A person chews one end of the neem twig until it somewhat resembles the bristles of a toothbrush, and then uses it to brush the teeth. In the Muslim world, the miswak, or *siwak*, made from a twig or root with antiseptic properties has been widely used since the Islamic Golden Age. Rubbing baking soda or chalk against the teeth was also common.

Generally, dentists recommend that teeth be cleaned professionally at least twice per year. Professional cleaning includes tooth scaling, tooth polishing, and, if too much tartar has built up, debridement. This is usually followed by a fluoride treatment. However, there is no good evidence that scaling and polishing is cost-effective .

Between cleanings by a dental hygienist, good oral hygiene is essential for preventing tartar build-up which causes the problems mentioned above. This is done by carefully and frequently brushing with a toothbrush and the use of dental floss to prevent accumulation of plaque on the teeth.

Plaque

Plaque is a yellow sticky film that forms on the teeth and gums. The bacteria in plaque release acid that attacks tooth enamel. Tooth decay can occur after repeated attacks. Some food causes plaque bacteria that produce acids. Thorough daily brushing and flossing can prevent tartar from forming on the teeth.

Plaque can also cause irritation to the gums, making them red, tender, or bleeding easily. In some cases, the gums pull away from the teeth, leaving cavities inhabited by bacteria and pus. If this is not treated, bones around the teeth can be destroyed. Teeth may become loose or have to be removed as with periodontal (gum) disease in mostly adults. Eating a balanced diet and limiting snacks can prevent tooth decay and periodontal disease. Nutritious foods such as raw vegetables, plain yogurt, cheese, or a piece of fruit are considered good snack foods to grab.

Flossing

The use of dental floss is an important element of oral hygiene, since it removes the plaque and the decaying food remaining stuck between the teeth. This food decay and plaque cause irritation to the gums, allowing the gum tissue to bleed more easily. Acid forming foods left on teeth also demineralise teeth eventually causing cavities. Flossing for a proper inter-dental cleaning is recommended at least once per day, preferably before bedtime, to help prevent receding gums, gum disease, and cavities between the teeth.

A dental hygienist demonstrates dental flossing.

It is recommended to use enough floss to enable easy use, usually ten or more inches with three to four inches of taut floss to put between teeth. Floss is then wrapped around the middle finger and/or index finger, and supported with the thumb on each hand. It is then held tightly to make taut, and then gently moved up and down between each tooth. It is important to floss under visible areas by curving the floss around each tooth instead of moving up and down on gums, which are much more sensitive than teeth. However, bleeding gums are normal upon first usage of floss, and will harden with use. One should use an unused section of the floss when moving around different teeth. Removing floss from between teeth requires using the same back-and-forth motion as flossing, but gently bringing the floss up and out of gaps between teeth.

Tongue cleaning

Cleaning the tongue as part of daily oral hygiene is essential, since it removes the white/yellow bad-breath-generating coating of bacteria, decaying food particles, fungi (such as Candida), and dead cells from the dorsal area of the tongue. Tongue cleaning also removes some of the bacteria species which generate tooth decay and gum problems.

Gum care

Massaging gums with toothbrush bristles is generally recommended for good oral health. Flossing is recommended at least once per day, preferably before bed, to help prevent receding gums, gum disease, and cavities between the teeth.

Oral irrigation

Some dental professionals recommend oral irrigation as a way to clean teeth and gums.

Oral irrigators reach 3–4 mm under the gum line. Oral irrigators use a pressured, directed stream of water to disrupt plaque and bacteria.

Food and drink

Foods that help muscles and bones also help teeth and gums. Breads and cereals are rich in vitamin B while fruits and vegetables contain vitamin C, both of which contribute to healthy gum tissue.(8) Lean meat, fish, and poultry provide magnesium and zinc for teeth. Some people recommend that teeth be brushed after every meal and at bedtime, and flossed at least once per day, preferably at night before sleep. For some people, flossing might be recommended after every meal.

Beneficial foods

Some foods may protect against cavities. Fluoride is a primary protector against dental cavities. Fluoride makes the surface of teeth more resistant to acids during the process of remineralisation. Drinking fluoridated water is recommended by some dental professionals while others say that using toothpaste alone is enough. Milk and cheese are also rich in calcium and phosphate, and may also encourage remineralisation. All foods increase saliva production, and since saliva contains buffer chemicals this helps to stabilize the pH to near 7 (neutral) in the mouth. Foods high in fiber may also help to increase the flow of saliva. Sugar-free chewing gum stimulates saliva production, and helps to clean the surface of the teeth.(8)

According to World Dental, these are the top ten beneficial foods for teeth.

1. Green tea contains polyphenol antioxidant plant compounds that reduce plaque and help reduce cavities and gum disease. Tea may help reduce bad breath. Tooth enamel is strengthened because green tea contains fluoride which promotes healthy teeth.
2. Milk and yogurt are good for teeth because they contain low acidity, which means that wearing of teeth is less. They are also low in decay-inducing sugar. Milk is a good source of calcium, the main component of teeth and bones.
3. Cheese contains calcium and phosphate, which helps balance pH in the mouth, preserves (and rebuilds) tooth enamel, produces saliva, and kills bacteria that cause cavities and disease.

4. Fruits such as apples, strawberries and kiwis contain Vitamin C. This vitamin is considered the element that holds cells together. If this vitamin is neglected, gum cells can break down, making gums tender and susceptible to disease.
5. Vegetables: Vitamin A, found in pumpkins, carrots, sweet potatoes and broccoli, is necessary for the formation of tooth enamel. Crunchy vegetables may also help clean gums.
6. Onions contain antibacterial sulfur compounds. Tests show that onions kill various types of bacteria, especially when eaten raw.
7. Celery protects teeth by producing saliva which neutralizes bacteria that cause cavities. It also massages the teeth and gums.
8. Sesame seeds reduce plaque and help build tooth enamel. They are also very high in calcium.
9. Animal food: beef, chicken, turkey, and eggs contain phosphorus which, with calcium, is one of the two most vital minerals of teeth and bone.
10. Water cleans the mouth and produces saliva that deposits essential minerals into the teeth. It keeps teeth hydrated and washes away particles from the teeth.

Detrimental foods

Sugars are commonly associated with dental cavities. Other carbohydrates, especially cooked starches, e.g. crisps/potato chips, may also damage teeth, although to a lesser degree since starch has to be converted by enzymes in saliva first.

Sucrose (table sugar) is most commonly associated with cavities. The amount of sugar consumed at any one time is less important than how often food and drinks that contain sugar are consumed. The more frequently sugars are consumed, the greater the time during which the tooth is exposed to low pH levels, at which point demineralisation occurs (below 5.5 for most people). It is important therefore to try to encourage infrequent consumption of food and drinks containing sugar so that teeth have a chance to be repaired by remineralisation and fluoride. Limiting sugar-containing foods and drinks to meal times is one way to reduce the incidence of cavities. Sugars from fruit and fruit juices, e.g., glucose, fructose, and maltose seem equally likely to cause cavities.

Acids contained in fruit juice, vinegar and soft drinks lower the pH level of the oral cavity which causes the enamel to demineralize. Drinking drinks such as orange juice or cola throughout the day raises the risk of dental cavities tremendously.

Another factor which affects the risk of developing cavities is the stickiness of foods. Some foods or sweets may stick to the teeth and so reduce the pH in the mouth for an extended time, particularly if they are sugary. It is important that teeth be cleaned at least twice a day, preferably with a toothbrush and fluoride toothpaste, to remove any food sticking to the teeth. Regular brushing and the use of dental floss also removes the dental plaque coating the tooth surface.

Chewing gum assists oral irrigation between and around the teeth, cleaning and removing particles, but for teeth in poor condition it may damage or remove loose fillings as well.

Other

Smoking and chewing tobacco are both strongly linked with multiple dental diseases. Regular vomiting, as seen in bulimia nervosa, also causes significant damage.

Mouthwash or mouth rinse improve oral hygiene. Dental chewing gums claim to improve dental health.

Retainers can be cleaned in mouthwash or denture cleaning fluid. Dental braces may be recommended by a dentist for best oral hygiene and health. Dentures, retainers, and other appliances must be kept extremely clean. This includes regular brushing and may include soaking them in a cleansing solution.

Oral hygiene and systemic diseases

Several recent clinical studies show a direct link between poor oral hygiene (oral bacteria & oral infections) and serious systemic diseases, such as:

- Cardiovascular Disease (Heart attack and Stroke)
- Bacterial Pneumonia
- Low Birth Weight/Extreme High Birth Weight
- Diabetes complications
- Osteoporosis

Chapter 8

Calculus (Dental) and Electric Toothbrush

Calculus (dental)

Heavy staining and calculus deposits exhibited on the lingual surface of the mandibular anterior teeth, along the gumline.

In dentistry, **calculus** or **tartar** is a form of hardened dental plaque. It is caused by the continual accumulation of minerals from saliva on plaque on the teeth. Its rough surface provides an ideal medium for further plaque formation, threatening the health of the gingiva.

Brushing and flossing can remove plaque from which calculus forms; however, once formed, it is too hard and firmly attached to be removed with a toothbrush. Routine dental visits are necessary so that calculus buildup can be professionally removed with ultrasonic tools and specialized sharp instruments.

Clinical significance

Plaque accumulation causes the gingiva to become irritated and inflamed, and this is referred to as gingivitis. When the gingiva become so irritated that there is a loss of the connective tissue fibers that attach the gums to the teeth and bone that surrounds the tooth, this is known as periodontitis. Because dental plaque is the sole cause of periodontitis, it is referred to as the primary aetiology. Plaque that remains in the oral cavity long enough will eventually calcify and become calculus. Calculus is detrimental to gingival health because it serves as a trap for increased plaque formation and retention; thus, calculus, along with everything else that causes a localized build-up of plaque, is referred to as a secondary etiology of periodontitis.

Calculus can form both along the gumline, where it is referred to as *supragingival* ("above the gum"), and within the narrow sulcus that exists between the teeth and the gingiva, where it is referred to as *subgingival* ("below the gum"). Calculus formation can result in a number of clinical manifestations, including bad breath, receding gums and chronically inflamed gingiva.

When plaque is supragingival, the bacterial content consists mostly of aerobic bacteria and yeast, or those bacteria which utilize and can survive in an environment containing oxygen. Subgingival plaque, however, is composed mainly of anaerobic bacteria, or those bacteria which cannot exist in an environment containing oxygen. Anaerobic bacteria are especially dangerous to the gingiva and the gingival fibers that attach the teeth to the gums, leading to periodontitis. Almost all individuals with periodontitis exhibit considerable subgingival calculus deposits. These anaerobic bacteria have been linked to cardiovascular disease and mothers giving birth to pre-term low weight babies, but there is no conclusive evidence yet that periodontitis is a significant risk factor for either of these two conditions.

Prevention

The best way to prevent the build up of calculus is through twice daily toothbrushing and flossing and regular cleaning visits based on a schedule recommended by the dental health care provider. Calculus accumulates more easily in some individuals, requiring more frequent brushing and dental visits. There are also some external factors that facilitate the accumulation of calculus, including smoking and diabetes. While toothpaste with an additive ingredient of zinc citrate has been shown to produce a statistically significant reduction in plaque accumulation, it is of such a small degree that its clinical importance is questionable.

Sub-gingival calculus formation and chemical dissolution

Sub-gingival calculus (tartar) is comprised almost entirely of two components: fossilized anaerobic bacteria whose biologic composition has been replaced by calcium phosphate salts, and calcium phosphate salts that have joined the fossilized bacteria in calculus formations. The initial attachment mechanism and the development of mature calculus formations are based on electrical charge. Unlike calcium phosphate, the primary component of teeth, calcium phosphate salts exist as electrically unstable ions. The following minerals are detectable in calculus by X-ray diffraction: brushite, octacalcium phosphate, magnesium-containing whitlockite, and carbonate-containing hydroxyapatite.

The reason fossilized bacteria are initially attracted to one part of the subgingival tooth surface over another is not fully understood; once the first layer is attached, ionized calculus components are naturally attracted to the same places due to electrical charge. The fossilized bacteria pile on top of one another, in a rather haphazard manner. All the while, free-floating ionic components fill in the gaps left by the fossilized bacteria. The resultant hardened structure can be compared to concrete; with the fossilized bacteria playing the role of aggregate, and the smaller calcium phosphate salts being the cement. The once purely electrical association of fossilized bacteria then becomes mechanical, with the introduction of free-floating calcium phosphate salts. The “hardened” calculus formations are at the heart of periodontal disease and treatment.

Electric toothbrush

Electric toothbrush.

An **electric toothbrush** is a toothbrush that uses electric power supplied usually by a battery to move the brush head rapidly, either oscillating side to side, or rotation-oscillation (where brush heads rotate in one direction and then the other).

History

The first successful electric toothbrush, the Broxodent, was conceived in Switzerland in 1954 by Dr. Philippe-Guy Woog. Woog's electric toothbrushes were originally manufactured in Switzerland (later in France) for Broxo S.A. The first clinical study showing its superiority over manual brushing was published by Pr. Arthur Jean Held in Geneva in 1956. Electric toothbrushes were initially created for patients with limited motor skills, as well as orthodontic patients (such as those with braces). Claims have been made that electric toothbrushes are more effective than manual ones as they are less dependent upon patients brushing correctly.

The Broxo Electric Toothbrush was introduced in the USA by E. R. Squibb and Sons Pharmaceuticals at the centennial of the American Dental Association in 1959. After introduction, it was marketed in the USA by Squibb under the names Broxo-Dent or Broxodent. In the 1980s Squibb transferred distribution of the Broxodent line to the Somerset Labs division of Bristol Myers/Squibb.

While the Broxodent may have been the first electric toothbrush and a superior product, the electric toothbrush that caught the public's attention in USA was the General Electric Automatic Toothbrush introduced in the early 1960s. Similar to the Broxodent in function, it differed in that it was cordless with rechargeable NiCad batteries, while the Broxodent plugged into a standard wall outlet and run on AC line voltage.

This difference in power source was significant for several reasons. The GE toothbrush, although portable, was rather bulky, about the size of a two-D-cell flashlight handle. NiCad batteries of this period left much to be desired: they suffered from memory and lazy battery effects. The GE Automatic Toothbrush came with a charging stand which held the hand piece upright; most units were kept in the charger which is not the best way to get maximum service life from a NiCad battery. Early NiCad batteries did not hold much energy, and it was not uncommon for the GE Automatic toothbrush to run out of power before brushing was complete, particularly if several people used the same battery-holding handle (with separate brushes) without recharging. Finally, early NiCad batteries tended to have a short lifespan. The batteries were sealed inside the GE device, and the whole unit had to be discarded when the batteries failed. The purchase price of each GE Automatic Toothbrush was lower than a Broxodent. The GE Automatic Toothbrush sold well.

The Broxodent hand piece was slim and remarkably compact, even by today's standards. Since it was powered by AC line voltage, it never ran out of power, although it could grow warm after extended use. Early Broxodent models came with a straight power cord, later units with a coiled cord. All Broxodent cords had a small molded strain relief where the cord entered the hand piece, but this was still the likeliest place for a cord to fail. Since the Broxodent hand pieces were sealed, a cord failure was not repairable and the expensive toothbrush had to be discarded. That said, it was not unusual for a Broxodent toothbrush to last for 20 years or longer; failures were rare.

The use of an AC line voltage appliance in a bathroom environment was problematic. By the early 1990s Underwriter Laboratories (UL) and Canadian Standards Association (CSA) would no longer certify line-voltage appliances for bathroom use. Newer appliances had to use a step-down transformer to operate the actual toothbrush at low voltage (typically 12, 16 or 24 volts). Wiring standards in many countries require that outlets in bath areas must be protected by a RCD/GFCI device (e.g., required in USA since the 1970s on bathroom outlets in new construction).

By the 1990s there were problems with safety certification of Broxo's original design. Further, improved battery-operated toothbrushes were providing formidable competition. Broxo S. A. still produces and markets a low-voltage model, but its public visibility in the USA has been limited in the face of large competitors, such as Philips Sonicare and Braun Oral-B models. Later Broxo models had no major distributor (such as Squibb) in the USA, and only sell online.

The Broxo low-voltage models used several different methods to attach the actual brushes to the hand piece; however, brushes were often not interchangeable between Broxo models. By the 1990s replacement brushes for line-voltage Broxodent models were no longer sold in the USA, so the original Broxodent Electric Toothbrush was no longer suitable for use there although it had started a trend and sold for over 30 years.

Types of electric toothbrushes

Electric brushes can be classified into two categories according to the type of action that they employ: vibration or rotation-oscillation. When using vibrating toothbrushes a brushing technique similar to that used with a manual toothbrush is said to be preferable, whereas with rotating-oscillating brushes one can apparently simply move the brush from tooth to tooth.

Effectiveness of electric toothbrushes

Independent research finds that although most electric toothbrushes are no more effective than manual brushes—assuming that people using a manual toothbrush will brush effectively—The rotation-oscillation-models have been found to be marginally better than manual ones. The research concludes that the way brushing is done is more important than the choice of brush. For certain patients with limited manual dexterity or where difficulty exists in reaching rear teeth, however, dentists strongly feel that electric toothbrushes can be especially beneficial .

The effectiveness of an electric toothbrush depends not only on its type of action and on correct use, but also on the condition of the brush head, which loses its effectiveness over time due to bristle breakdown and wear. Most manufacturers, as well as dental professionals, recommend that heads be changed every three to six months at minimum, or as soon as the brush head has visibly deteriorated. (The same frequency regular dental check-ups and cleanings are recommended by the American Dental Association)

Power source and charging

Modern electric toothbrushes run on low voltage, 12v or less. A few units use a step-down transformer to power the brush, but most use a battery, usually but not always rechargeable and non-replaceable, fitted inside the handle, which is hermetically sealed to prevent water damage. While early NiCad battery toothbrushes used metal tabs to connect with the charging base, modern toothbrushes use contactless inductive charging: the brush unit and charger stand each contain a coil of wire; when placed in proximity, the powered coil from the stand transfers power by induction to the handle, charging the battery.

Optional features

Timer

Many modern electric toothbrushes have a timer which buzzes or briefly interrupts power, typically after two minutes, and sometimes every 30 seconds. This is associated with a customary recommendation to brush for two minutes, 30 seconds for each of the four quadrants of the mouth.

Display

Some electric toothbrushes have LCD screens which show brushing time and sometimes smiley face icons or other images to encourage optimal brushing. These features could encourage people with lower mental capacity and ability, to brush more accurately.

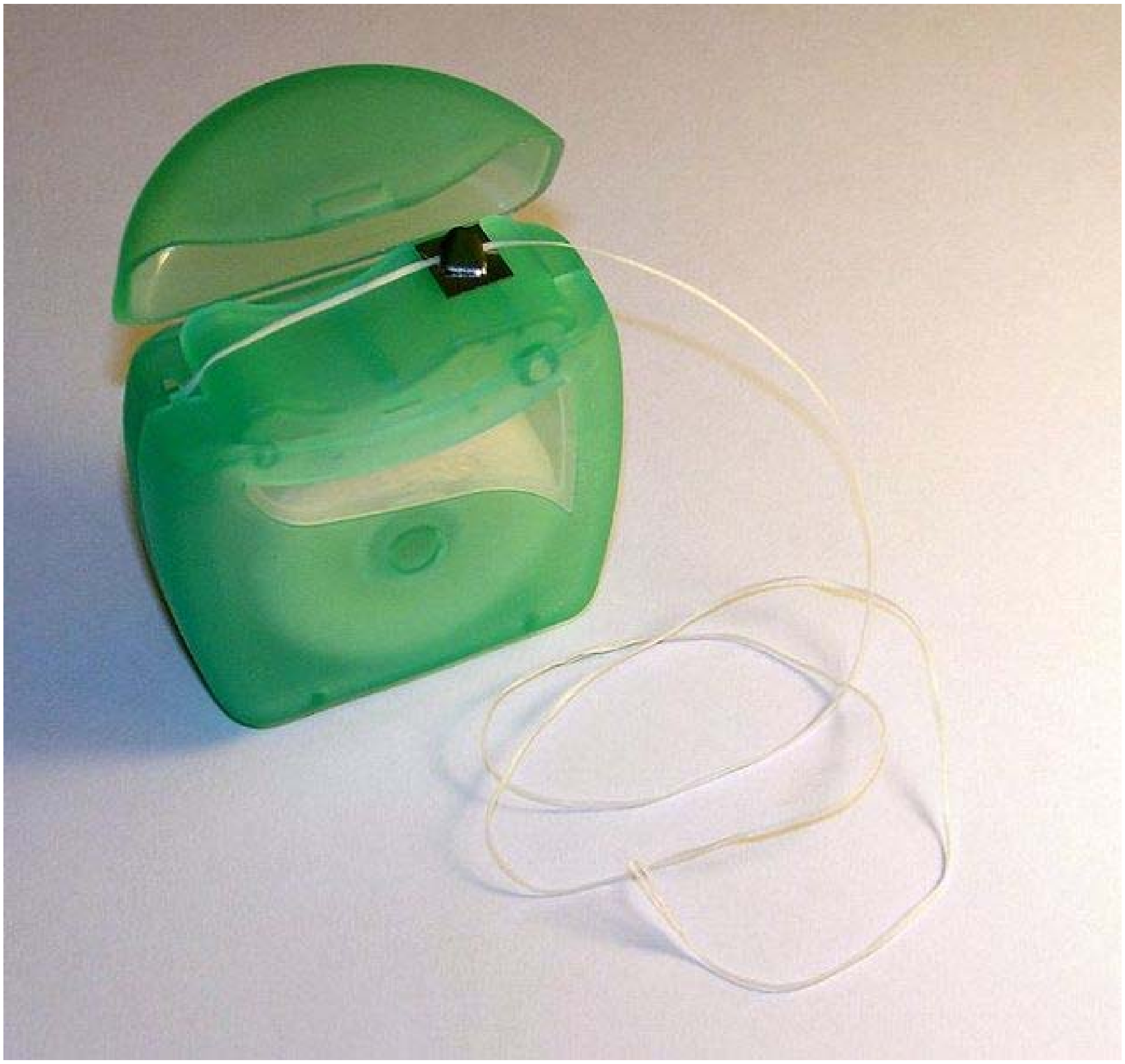
Chapter 9

Dental Floss

Dental hygienist flossing a patient's teeth during a periodic tooth cleaning.

Dental floss is either a bundle of thin nylon filaments or a plastic (Teflon or polyethylene) ribbon used to remove food and dental plaque from teeth. The floss is gently inserted between the teeth and scraped along the teeth sides, especially close to the gums. Dental floss may be flavored or unflavored, and waxed or unwaxed. An alternative tool to achieve the same effect is the interdental brush.

History



Dental floss

Levi Spear Parmly, a dentist from New Orleans, is credited with inventing the first form of dental floss. He recommended that people should clean their teeth with silk floss in 1815.

Dental floss was still unavailable to the consumer until the Codman and Shurtleft company started producing human-usable unwaxed silk floss in 1882. In 1898, the Johnson & Johnson Corporation received the first patent for dental floss. Other early brands included Red Cross, Salter Sill Co. and Brunswick.

A character is depicted using dental floss in James Joyce's famous novel *Ulysses* (serialised 1918-1920) and is an early mention of the practice in literary fiction.

The adoption of floss was poor before World War II. It was around this time, however, that Dr. Charles C. Bass developed nylon floss. Nylon floss was found to be better than silk because of its greater abrasion resistance and elasticity. In response to environmental concerns, dental floss made from biodegradable materials is now available.

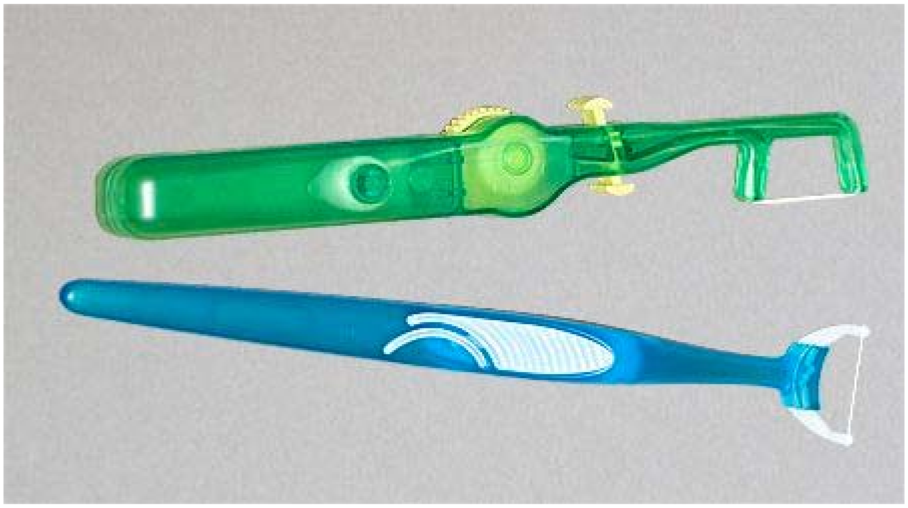
Dentists and dental hygienists urge the daily oral hygiene regimen of toothbrushing and flossing. Nearly all Americans brush their teeth. However, studies have found that only 10 to 40% of Americans report flossing on a daily basis.

Use

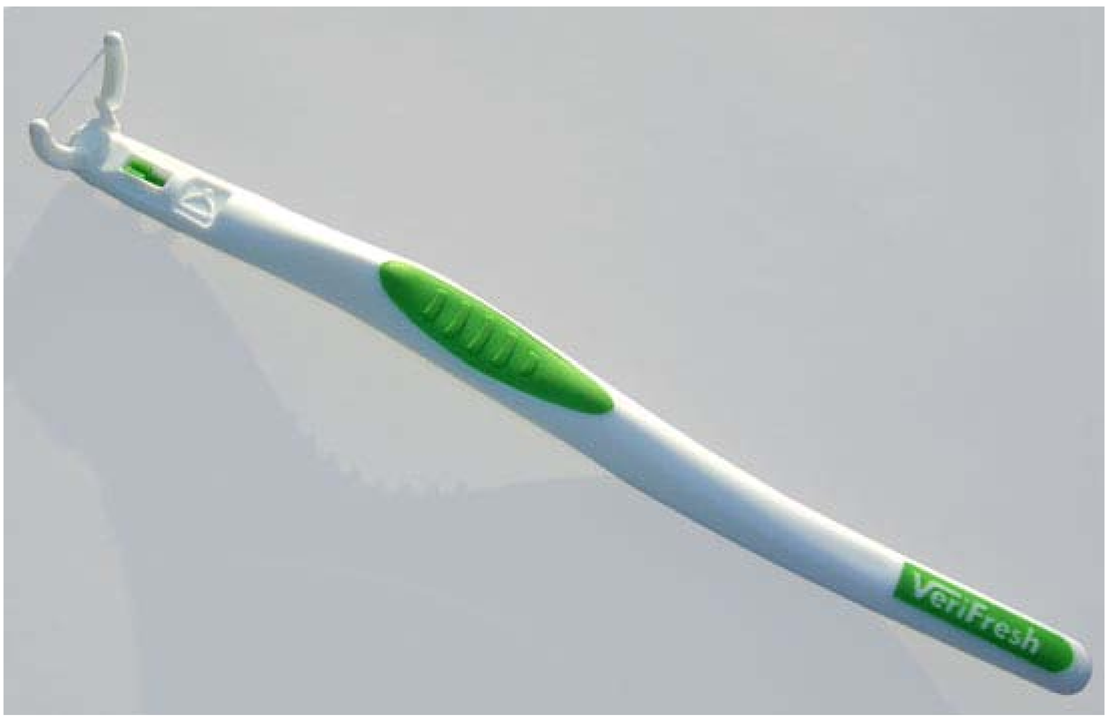
Dental floss is commonly supplied in plastic dispensers that contain 10 to 50 meters of floss. After pulling out the desired amount, the floss is pulled against a small protected blade in the dispenser to sever it.

Dental floss is held between the fingers. The floss is guided between each tooth and under the gumline to remove particles of food stuck between teeth and dento-bacterial plaque that adhere to such dental surfaces. Ideally using a C-shape, the floss is curved around a tooth and placed under the gumline, and then moved away from the gumline, the floss scrapes the side of each tooth, and can also clean the front or back of the tooth. Gently moving the floss from below the gumline to away from the gumline removes dento-bacterial plaque attached to teeth surfaces above and below the gumline. A clean section of floss can be used to clean each tooth to avoid transmitting plaque bacteria from one tooth to another.

There are many different kinds of dental floss commonly available. The most important variable is thickness. If the floss is too thick for the space between a pair of teeth then it will be difficult or impossible to get the floss down between the teeth. On the other hand, if the floss is too thin, it may be too weak and break. Different floss will suit different mouths, and even different parts of one mouth. This is because some teeth have a smaller gap between them than others. It's possible that thicker floss does a better job of scraping bacterial plaque off teeth, given that there is space enough between the teeth to use it. When a piece of hard food is tightly wedged between the teeth, one may need to switch to thinner floss, because thick floss cannot get past the food. It is possible to split some kinds of dental floss lengthwise generating a pair of thinner pieces that are much weaker but sometimes usable. This is possible because some kinds of dental floss are made of many very thin strands that are not woven together but rather run more or less in parallel. This can also be useful if the dental floss you have is too thick for you, for any other reason, and you do not have access to any other, for example when travelling in a foreign country.



F-shaped and Y-shaped dental floss wands



Ergonomic flosser with swiveling, disposable heads

Specialized plastic wands, or floss picks, have been produced to hold the floss. These may be attached to or separate from a floss dispenser. While not pinching the finger, using a wand may be awkward and also make it difficult to floss at all the angles possible with a finger. At the same time, the enhanced reach can make flossing the back teeth easier. These types of flossers may be missing the area under the gum line that needs to be flossed.

Ergonomic flossers with improved handle for better grip and swiveling floss heads allow easy access to any pair of teeth in the mouth, to the front teeth as well as to the rear teeth. Also their floss heads feature a lateral flexibility that enables improved control for the dental floss to hug the sides of the teeth and clean under the gum line without the danger of hurting the gums.

Occasional flossing and/or improper flossing can typically lead to bleeding gums. The main cause of the bleeding is inflammation of the gingival tissue due to gingivitis.

Directions

The American Dental Association advises to floss thoroughly once or more per day. While they do not make a recommendation regarding the order of brushing and flossing, flossing prior to brushing allows for fluoride from the toothpaste to reach between the teeth. Overly vigorous or incorrect flossing can result in gum tissue damage. For proper flossing, the Association advises to curve the floss against the side of the tooth in a 'C' shape, and then to wipe the tooth from under the gumline (very gently) to the tip two or three times, repeated on adjacent and subsequent teeth.

Vibration

Some power flossers use vibration which transfers through the floss, originating from the ends. This is likely inspired by the similar use of vibration of the bristles in modern electric toothbrushes. As the vibration causes subtle movement, the floss will find the path of least resistance when pressed down. The movement would also help in temporarily separating tooth and gum for floss to get through.

This allows easier penetration under the gumline, with less force applied to push into the gap between teeth. With less force applied, more control of flossing is possible. In normal flossing, pressure may be applied until the floss 'pops' through the teeth, and the momentum can carry on and painfully impact the gum tissue. With more control, this can be reduced or avoided completely.

Many consider vibrations to be soothing; it is a common technique in massage and orthopedic devices. Much like electric toothbrushes are soothing to the teeth and gums, vibrating floss can soothe and massage the gumline.

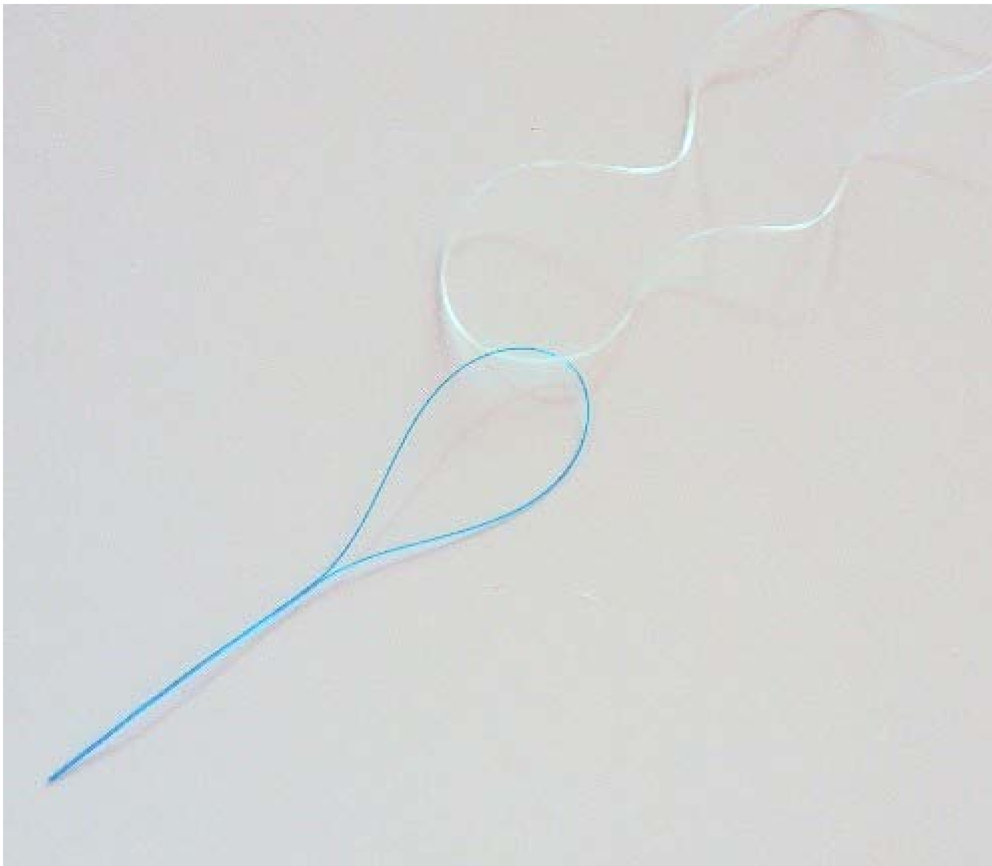
Cuts become less likely as the floss will not press against as isolated an area, and less pressure is applied. Any abrasions to the gum would be more evenly distributed, leading to more equal adaptation of the tissue.

Benefits

Flossing in combination with toothbrushing can prevent gum disease, halitosis, and dental caries. Regular flossing is also linked to reduced incidence of heart disease.

Flossing is correlated with greater longevity, potentially as a result of the prevention of gum inflammation.

Floss threader



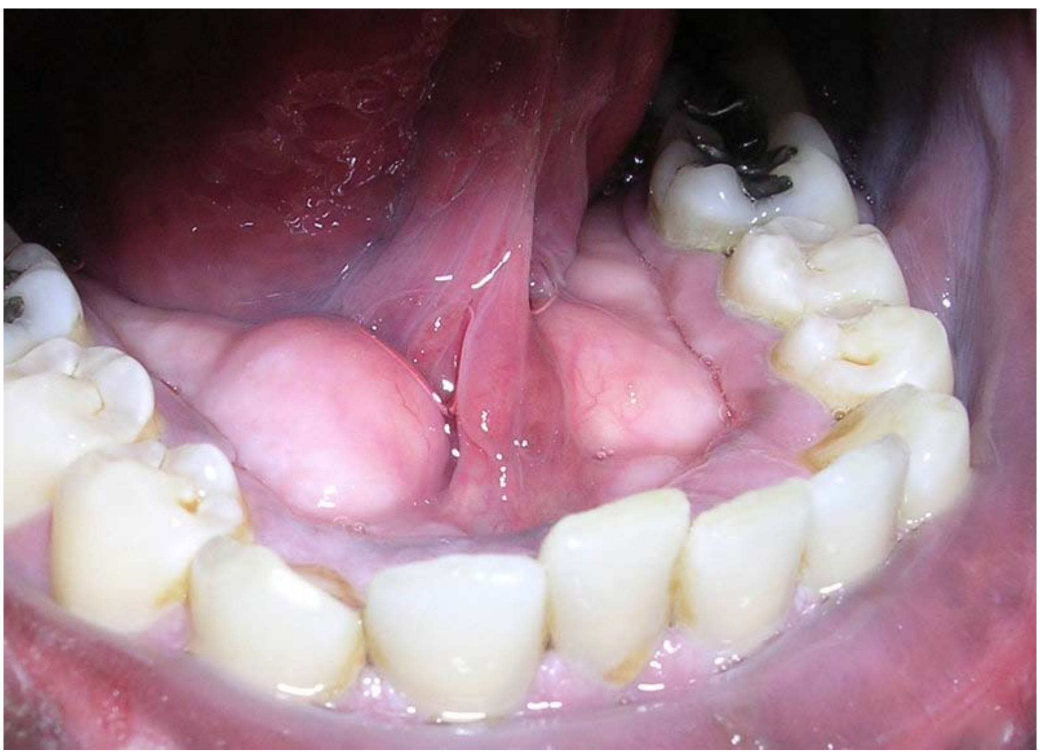
A Floss Threader

A floss threader is loop of fiber (similar to fishing line) used to thread floss into small places around teeth. Threaders are sometimes required to floss with dental braces, fix retainers, bridges, and crowns.

Chapter 10

Dental Plaque and Tongue Cleaner

Dental plaque



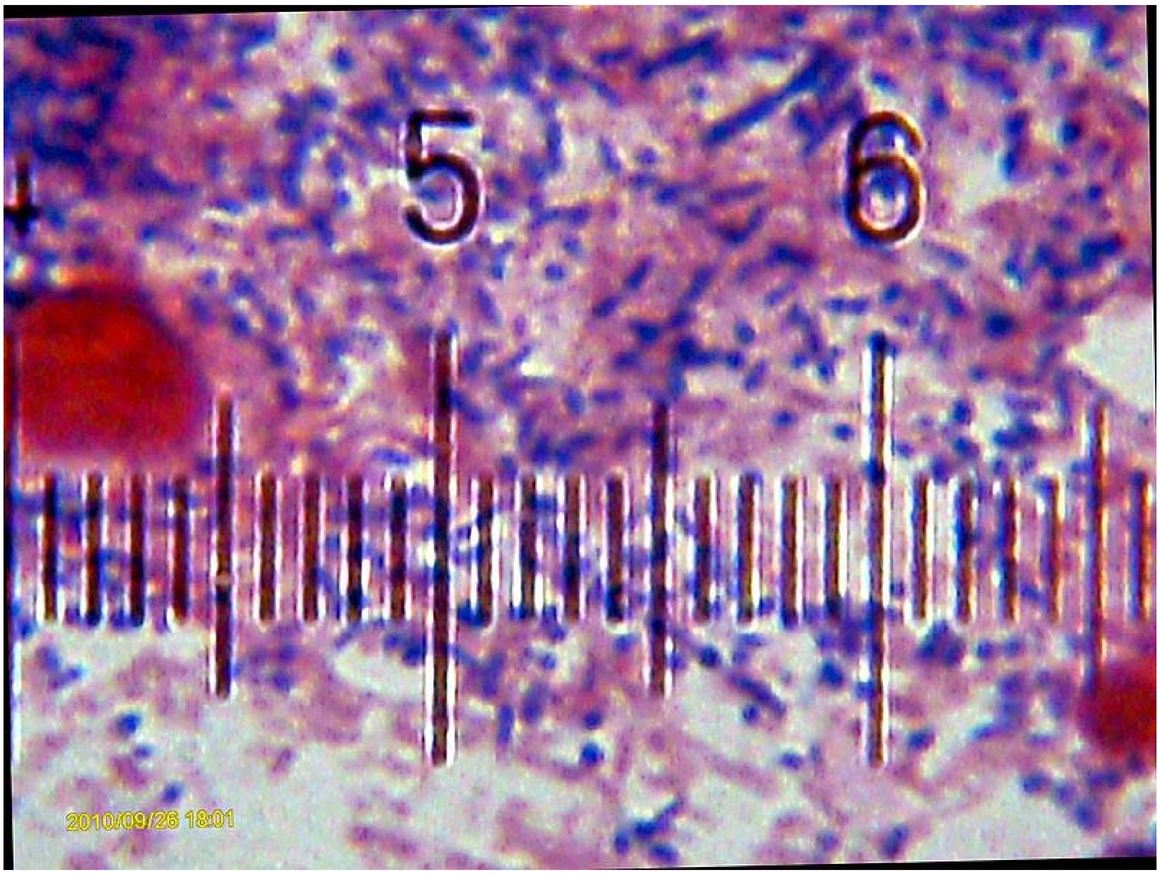
Inadequate removal of plaque caused a build up of calculus (dark yellow color) near the gums on almost all the teeth.

Dental plaque is a biofilm, usually colorless, that develops naturally on the teeth. It is formed, as in any biofilm, by colonizing bacteria trying to attach itself to a smooth surface (of a tooth). It has been also speculated that plaque forms part of the defense systems of the host by helping to prevent colonization by microorganisms which may be pathogenic.

The film is soft enough to come off by using finger nail. It starts to harden within 48 hours; in about 10 days the plaque becomes dental calculus (tartar), rock-hard and difficult to remove.

Dental plaque can give rise to dental caries (tooth decay)—the localised destruction of the tissues of the tooth by acid produced from the bacterial degradation of fermentable sugars—and periodontal problems such as gingivitis and chronic periodontitis.

Plaque formation



Microscopic view of some of the bacteria of which plaque is composed. Numbered ticks are 10 μm apart.

The mechanisms of plaque formation include

- Absorption of proteins and bacteria to form a film on the tooth surface.
- The effect of van der Waals and electrostatic forces between microbial surfaces and the film to create reversible adhesion to the teeth.
- Irreversible adhesion due to intermolecular interactions between cell surfaces and the pellicle.
- Secondary colonisers attach to primary colonisers by intermolecular interaction.
- The cells divide and generate a biofilm.

Components of plaque

Plaque consists of microorganisms and extracellular matrix.

The microorganisms that form the biofilm are mainly Streptococcus mutans and anaerobes, with the composition varying by location in the mouth. Examples of such anaerobes include fusobacterium and actinobacteria.

The extracellular matrix contains proteins, long chain polysaccharides and lipids.

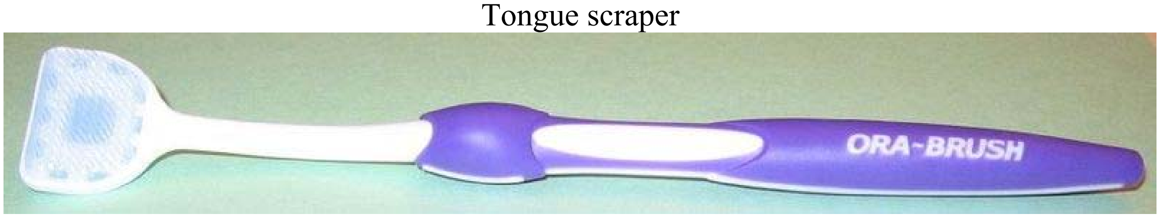
The microorganisms present in dental plaque are all naturally present in the oral cavity, and are normally harmless. However, failure to remove plaque by regular tooth brushing means that they are allowed to build up in a thick layer. Those microorganisms nearest the tooth surface convert to anaerobic respiration; it is in this state that they start to produce acids.

- Acids released from dental plaque lead to demineralization of the adjacent tooth surface, and consequently to dental caries. Saliva is also unable to penetrate the build-up of plaque and thus cannot act to neutralize the acid produced by the bacteria and remineralize the tooth surface.
- They also cause irritation of the gums around the teeth that could lead to gingivitis, periodontal disease and tooth loss.
- Plaque build up can also become mineralized and form calculus (tartar).

Tongue cleaner

Tongue cleaner

Tongue scraper



Tongue brush

A **tongue cleaner** (also called a **tongue scraper** or **tongue brush**) is an oral hygiene device designed to clean the bacterial build-up, food debris, fungi, and dead cells from the surface of the tongue. The bacteria and fungi that grow on the tongue are related to many common oral care and general health problems. In addition, decaying bacteria produce volatile sulphur compounds on the rear of the tongue; these molecules account for 80 to 95 percent of all cases of halitosis (bad breath).

General

The top surface of the tongue can be cleaned using a tongue cleaner, a tongue brush/scraper or a toothbrush. However, toothbrushes are not considered as effective for this purpose because they are designed for brushing the teeth, which have a solid structure unlike the spongy tissue of the tongue.

Ergonomic tongue cleaners are shaped in accordance with the anatomy of the tongue, and are optimized to lift and trap the plaque coating and effectively clean the surface of the tongue. There are many different types of tongue cleaners; they are made from plastic, metal or other materials. Their effectiveness varies widely depending on the shape, dimensions, configuration, quality of the contact surfaces and materials used. In addition, tongue cleaning gels used in association with the tongue cleaners as anti-bacterial agents may enhance cleaning effects.

Historical background

Tongue cleaning has been used since ancient times in India and China.

Ayurveda, the practice of traditional Indian medicine, recommends tongue cleaning as part of one's daily hygiene regimen, to remove the toxic debris, known as Ama.

In the 19th century, specially designed, handcrafted tongue cleaners made of sterling silver, ivory, and tortoise shell were available.

Health effects

Fresh breath

Tongue cleaning may remove some of the millions of bacteria (up to 500 different types), decaying food debris, fungi (such as Candida), and dead cells, from the rear surface of the tongue. Tongue cleaning is generally viewed as an effective solution for many cases of halitosis, or bad breath.

Scientific studies have shown tongue bacteria produce malodorous compounds and fatty acids, that may account for 80 to 95 percent of all cases of bad breath. The remaining 5–20% of cases originate in the stomach, from the tonsils, from decaying food stuck between the teeth, gum disease, tooth decay, or plaque accumulated on the teeth.

Clinical studies have shown that using tongue cleaners on a daily basis has a significant effect on eliminating anaerobic bacteria and decreasing oral malodor. Dental specialists generally assume that a majority of cases of halitosis originate on the back of the tongue, an area that can be cleaned efficiently by using an ergonomically designed tongue cleaner.

Oral hygiene

In the past several years, dental professionals (dentists and hygienists) have studied the importance of tongue cleaning as a way to maintain a high level of oral hygiene.

The surface of the tongue may be viewed as an excellent breeding ground for different bacteria. These microorganisms colonize and multiply on the protein-rich areas of the tongue, and eventually, through the saliva, reach all areas of the mouth including the teeth and gums. These bacteria are considered as major contributors to periodontal problems, plaque on the teeth, tooth decay, gum infections, gum recession and even tooth loss.

General health

In addition, physicians have reevaluated the link between oral health and pathologies of the rest of the body. Many clinical studies concluded that oral bacteria are associated with a number of serious systemic diseases.

- Cardiovascular problems (heart attack, cerebral stroke),
- Pneumonia due to inhaling bacteria present in the mouth,
- Premature birth, and low fetus weight at birth time,
- Increased risk of diabetes patients,
- Osteoporosis of the jaw and generalized,
- Infertility problems for men.

Side effects

There are reports of cases where cleaning the tongue may generate vomiting or the so called gag reflex if touching certain sensitive areas; this can easily be avoided by relaxing the tongue and the muscles of the throat during use.

Using an inappropriately designed tongue cleaner too much or in an aggressive way may cause damage to the taste buds present on the surface of the tongue. There are opinions claiming that even in such cases, the taste buds actually regenerate soon after being damaged. Using a safe ergonomic tongue cleaner carefully may avoid such circumstances.

Alternative medicine

Cleaning the tongue with an appropriately designed tongue cleaner also massages the tongue. This is an important element of traditional Chinese medicine where the tongue surface is identified as an important reflexogenic zone.

Tongue cleaning improves the sense of taste (because of cleaning the taste buds) and also stimulates the secretion of digestive enzymes.

Chapter 11

Toothbrush and Toothpaste

Toothbrush

Toothbrushes

The **toothbrush** is an oral hygiene instrument used to clean the teeth and gums that consists of a head of tightly clustered bristles mounted on a handle, which facilitates the cleansing of hard-to-reach areas of the mouth. Toothpaste, which often contains fluoride, is commonly used in conjunction with a toothbrush to increase the effectiveness of toothbrushing. Toothbrushes are available with different bristle textures, sizes and forms.

Most dentists recommend using a toothbrush labelled "soft", since hard bristled toothbrushes can damage tooth enamel and irritate the gums. Toothbrushes have usually been made from synthetic fibers since they were developed, although animal bristles are still sometimes used.

History

A variety of oral hygiene measures have been used since before recorded history. This has been verified by various excavations done all over the world, in which chewsticks, tree twigs, bird feathers, animal bones and porcupine quills were recovered. The first toothbrush recorded in history was made in 3000 BC, a twig with a frayed end called a chewstick.

Various forms of toothbrush have been used. Indian medicine (Ayurveda) used the twigs of the neem or banyan tree to make toothbrushes and other oral-hygiene-related products for millennia. The end of a neem twig is chewed until it is soft and splayed, and it is then used to brush the teeth. In the Muslim world, chewing miswak, or *siwak*, the roots or twigs of the Arak tree (Salvadora persica), which have antiseptic properties, is common practice. The usage of *miswak* dates back at least to the time of the Prophet Muhammad, who pioneered its use. Rubbing baking soda or chalk against the teeth has also been common practice in history.

In 1223, Japanese Zen master Dōgen Kigen recorded on Shōbōgenzō that he saw monks in China clean their teeth with brushes made of horse-tail hairs attached to an ox-bone handle.

A photo from 1899 showing the use of a toothbrush.

The earliest identified use of the word toothbrush in English was in the autobiography of Anthony Wood, who wrote in 1690 that he had bought a toothbrush off J. Barret.

William Addis of England is believed to have produced the first mass-produced toothbrush in 1780. In 1770 he had been jailed for causing a riot; while in prison he decided that the method used to clean teeth – at the time rubbing a rag with soot and salt on the teeth – could be improved, so he took a small animal bone, drilled small holes in it, obtained some bristles from a guard, tied them in tufts, passed the tufts through the holes on the bone, and glued them. He soon became very wealthy. He died in 1808, and left the business to his eldest son, also called William; the company continues to this day. By 1840 toothbrushes were being mass-produced in England, France, Germany, and

Japan. Pig bristle was used for cheaper toothbrushes, and badger hair for the more expensive ones.

The first patent for a toothbrush was by H. N. Wadsworth in 1857 (US Patent No. 18,653) in the United States, but mass production in the USA only started in 1885. The rather advanced design had a bone handle with holes bored into it for the Siberian boar hair bristles. Animal bristle was not an ideal material as it retains bacteria and does not dry well, and the bristles often fell out. In the USA brushing teeth did not become routine until after World War II, when American soldiers had to clean their teeth daily.

A child being shown how to use a toothbrush.

Natural animal bristles were replaced by synthetic fibers, usually nylon, by DuPont in 1938. The first nylon bristle toothbrush, made with nylon yarn, went on sale on February 24, 1938. The first electric toothbrush, the Broxodent, was invented in Switzerland in 1954.

In January 2003 the toothbrush was selected as the number one invention Americans could not live without according to the Lemelson-MIT Invention Index.

Toothpaste

Toothpaste from a tube being applied to a toothbrush

Toothpaste is a paste or gel dentifrice used with a toothbrush as an accessory to clean and maintain the aesthetics and health of teeth. Toothpaste is used to promote oral hygiene: it serves as an abrasive that aids in removing the dental plaque and food from the teeth, assists in suppressing halitosis, and delivers active ingredients such as fluoride or xylitol to help prevent tooth and gum disease (gingivitis). Most of the cleaning is achieved by the mechanical action of the toothbrush, and not by the toothpaste. Salt and Baking soda are among materials that can be substituted for commercial toothpaste. Toothpaste is not intended to be swallowed.

Ingredients

In addition to 20-42% water, toothpastes are derived from a variety of components, including three main ones: abrasives, fluoride, and detergents.

Abrasives

Abrasives constitute at least 50% of a typical toothpaste. These insoluble particles help remove plaque from the teeth. The removal of plaque and calculus prevents cavities and periodontal disease. Representative abrasives include particles of aluminum hydroxide

($Al(OH)_3$), calcium carbonate ($CaCO_3$), various calcium hydrogen phosphates, various silicas and zeolites, and hydroxyapatite ($Ca_5(PO_4)_3OH$).

Abrasives, like the dental polishing agents used in dentists' offices, also cause a small amount of enamel erosion which is termed "polishing" action. Some brands contain powdered white mica which acts as a mild abrasive, and also adds a cosmetically-pleasing glittery shimmer to the paste. The polishing of teeth removes stains from tooth surfaces, but has not been shown to improve dental health over and above the effects of the removal of plaque and calculus.

Fluorides

Fluoride in various forms is the most popular active ingredient in toothpaste to prevent cavities. Although it occurs in small amounts in plants, animals, and some natural water sources, the additional fluoride has beneficial effects on the formation of dental enamel and bones. Sodium fluoride (NaF) is the most common source of fluoride but stannous fluoride (SnF_2), Olaflur (an organic salt of fluoride), and sodium monofluorophosphate (Na_2PO_3F) are also used. Much of the toothpaste sold in the United States has 1000 to 1100 parts per million fluoride. In the UK, the fluoride content is often higher, a NaF of 0.32% w/w (1,450 ppm fluoride) is not uncommon.

Surfactants

Many, although not all, toothpastes contain sodium lauryl sulfate (SLS) or related surfactants (detergents). SLS is found in many other personal care products as well, such as shampoo, and is mainly a foaming agent, which enables uniform distribution of toothpaste, improving its cleansing power.

Other components

Antibacterial agents

Triclosan, an antibacterial agent, is a common toothpaste ingredient in the UK. Triclosan or zinc chloride prevent gingivitis and, according to the American Dental Association, helps reduce tartar and bad breath.

Flavorants

Toothpaste comes in a variety of colorings, and flavors intended to encourage use of the product. Three most common flavorants are peppermint, spearmint, and wintergreen. Toothpaste flavored with peppermint-anise oil is popular in the Mediterranean region. These flavors are provided by the respective oils, e.g. peppermint oil. More exotic flavors include anise, apricot, bubblegum, cinnamon, fennel, lavender, neem, ginger, vanilla, lemon, orange, and pine. More unusual flavors have been used, e.g. peanut butter, iced tea, and even whisky. Unflavored toothpaste exist.

Remineralizers

Hydroxyapatite nanocrystals and calcium phosphate are included in some formulations for remineralization, i.e. the reformation of enamel.

Toothpaste is sold in many brands

Miscellaneous components

Agents are added to suppress the tendency of toothpaste to dry into a powder. Included are various sugar alcohols such as glycerol, sorbitol, xylitol, or related derivatives, such as 1,2-propylene glycol and polyethyleneglycol. Strontium chloride or potassium nitrate are included in some toothpastes to reduce sensitivity. Sodium polyphosphate is added to minimize the formation of tartar.

Safety

Fluoride

Although water fluoridation has been praised as one of the top medical achievements of the 20th century, fluoride-containing toothpaste can be acutely toxic if swallowed in large amounts. The risk of using fluoride is low enough that the use of 'full-strength' toothpaste (1350-1500ppm fluoride) is advised for all ages (although smaller volumes are used for young children; a 'smear' of toothpaste until 3 years). Several non-fluoride toothpastes are available.

Triclosan

Reports have suggested that triclosan, an active ingredient in many toothpastes, can combine with chlorine in tap water to form chloroform , which the United States Environmental Protection Agency classifies as a probable human carcinogen. An animal study revealed that the chemical might modify hormone regulation, and many other lab researches proved that bacteria might be able to develop resistance to triclosan in a way, which can help them to resist antibiotics also.

Diethylene glycol

The inclusion of sweet-tasting but toxic diethylene glycol in Chinese-made toothpaste led to a multi-nation and multi-brand toothpaste recall in 2007. The world outcry made Chinese officials ban the practice of using diethylene glycol in toothpaste.

Miscellaneous issues and debates

With the exception of toothpaste intended to be used on pets such as dogs and cats, and toothpaste used by astronauts, most toothpaste is not intended to be swallowed, and doing so may cause nausea or diarrhea. 'Tartar fighting' toothpastes have been debated. Case reports of plasma cell gingivitis have been reported with the use of herbal toothpaste containing cinnamon. SLS has been proposed increase the frequency of mouth ulcers in some people as it can dry out the protective layer of oral tissues causing the underlying tissues to become damaged.

Alteration of taste perception

After using toothpaste, orange juice and other juices have an unpleasant taste. This effect is attributed to products of the chemical reaction between stannous fluoride in toothpaste and the acetic acid in the juices. Sodium lauryl sulfate alters taste perception. It can break down phospholipids that inhibit taste receptors for bitterness, giving food a bitter taste. It is also thought to inhibit sweet receptors. In contrast, apples are known to taste more pleasant after using toothpaste. Distinguishing between the hypotheses that the bitter taste of orange juice results from stannous fluoride or from sodium lauryl sulfate is still an unresolved issue and it is thought that the menthol added for flavor may also take part in the alteration of taste perception when binding to lingual cold receptors.

Other types of toothpaste

Whitening toothpastes

Many toothpastes make whitening claims. Some of these toothpastes contain peroxide, the same ingredient found in tooth bleaching gels. The abrasive in these toothpaste remove the stains, not the peroxide. Whitening toothpaste cannot alter the natural color of teeth or reverse discoloration by penetrating surface stains or decay. To remove surface stains, whitening toothpaste may include abrasives and additives such as sodium tripolyphosphate. When used twice a day, whitening toothpaste typically takes two to four weeks to make teeth appear more white. Whitening toothpaste is generally safe for daily use, but excessive use might damage tooth enamel. Teeth whitening gels represent an alternative.

Herbal and "natural" toothpastes

Herbal toothpaste from Croatia

Herbal toothpastes are made from natural ingredients and some are even certified as organic. Many consumers have started to switch over to natural toothpastes in order to avoid synthetic and artificial flavors that are commonly found in regular toothpastes. Due to the increased demand of natural products, most of the toothpaste manufacturers now produce herbal toothpastes. This type of toothpaste does not contain dyes or artificial flavors.

Many herbal toothpastes do not contain fluoride or sodium lauryl sulfate. The ingredients found in natural toothpastes vary widely but often include baking soda, aloe, eucalyptus oil, myrrh, plant extract (strawberry extract), and essential oils. In addition to the commercially available products, it is possible to make one's own toothpaste using similar ingredients. When using a toothpaste that has not been proven to be efficient in preventing periodontal diseases it is particularly important to have regular dental checkups.

History

Early toothpastes

Toothpastes or powders came into general use in the 19th century. The Greeks, and then the Romans, improved the recipes for toothpaste by adding abrasives such as crushed bones and oyster shells. In the 9th century, the Persian musician and fashion designer Ziryab invented a type of toothpaste, which he popularized throughout Islamic Spain. The exact ingredients of this toothpaste are unknown, but it was reported to have been both "functional and pleasant to taste". It is not known whether these early toothpastes were used alone, were to be rubbed onto the teeth with rags, or were to be used with early toothbrushes, such as neem-tree twigs and *miswak*.

Washington Sheffield made the original collapsible toothpaste tubes lead.

Tooth powder

Tooth powders for use with toothbrushes came into general use in the 19th century in Britain. Most were homemade, with chalk, pulverized brick, or salt as ingredients. An 1866 Home Encyclopedia recommended pulverized charcoal, and cautioned that many patented tooth powders that were commercially marketed did more harm than good.

Modern toothpaste

Modern toothpaste gel

An 18th century American and British toothpaste recipe called for burnt bread. Another formula around this time called for dragon's blood (a resin), cinnamon, and burnt alum.

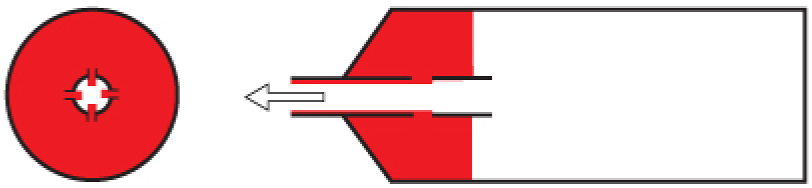
By 1900, a paste made of hydrogen peroxide and baking soda was recommended for use with toothbrushes. Pre-mixed toothpastes were first marketed in the 19th century, but did not surpass the popularity of tooth-powder until World War I. In 1892, Dr. Washington Sheffield of New London, Connecticut, manufactured toothpaste into a collapsible tube, Dr. Sheffield's Creme Dentifrice. He had the idea after his son traveled to Paris and saw painters using paint from tubes. In New York City in 1896, Colgate & Company Dental Cream was packaged in collapsible tubes imitating Sheffield.

Fluoride was first added to toothpastes in 1914, and was initially criticized by the American Dental Association (ADA) in 1937. Fluoride toothpastes developed in the 1950s received the ADA's approval. To develop the first ADA-approved fluoride toothpaste, Procter & Gamble started a research program in the early 1940s. In 1950, Procter & Gamble developed a joint research project team headed by Dr. Joseph Muhler at Indiana University to study new toothpaste with fluoride. In 1955, Procter & Gamble's Crest launched its first clinically proven fluoride-containing toothpaste. On August 1, 1960, the ADA reported that "Crest has been shown to be an effective anticavity (decay preventative) dentifrice that can be of significant value when used in a conscientiously applied program of oral hygiene and regular professional care." The amount of fluoride in toothpastes varies from country to country.

In 2006 appeared in Europe the first toothpaste containing synthetic hydroxylapatite as an alternative to fluoride for the remineralization and reparation of tooth enamel. The "biomimetic hydroxylapatite" is intended to protect the teeth by creating a new layer of synthetic enamel around the tooth instead of hardening the existing layer with fluoride that chemically changes it into Fluorapatite.

In June 2007, the US Food and Drug Administration and similar agencies in Panama, Puerto Rico and Australia advised consumers to avoid certain brands of toothpaste manufactured in China after some were found to contain the poisonous diethylene glycol, also called diglycol or labeled as "DEG" on the tube.

Striped toothpaste



The red area represents the material used for stripes, and the rest is the main toothpaste material. The two materials are not in separate compartments; they are sufficiently viscous that they will not mix. Applying pressure to the tube causes the main material to issue out through the pipe. Simultaneously, some of the pressure is forwarded to the stripe-material, which is then pressed onto the main material through holes in the pipe.

Striped toothpaste was invented by a New Yorker named Leonard Lawrence Marraffino in 1955. The patent (US patent 2,789,731, issued 1957) was subsequently sold to Unilever, who marketed the novelty under the 'Stripe' brand-name in the early 1960s. This was followed by the introduction of the 'Signal' brand in Europe in 1965 (UK patent 813,514). Although 'Stripe' was initially very successful, it never again achieved the 8% market share that it cornered during its second year.

Marraffino's design, which remains in use for single-color stripes, is simple. The main material, usually white, sits at the crimp end of the toothpaste tube and makes up most of its bulk. A thin pipe, through which that carrier material will flow, descends from the nozzle to it. The stripe-material (this was red in 'Stripe') fills the gap between the carrier material and the top of the tube. The two materials are not in separate compartments. The two materials are sufficiently viscous that they will not mix. When pressure is applied to the toothpaste tube, the main material squeezes down the thin pipe to the nozzle. Simultaneously, the pressure applied to the main material causes pressure to be forwarded to the stripe material, which then issues out through small holes (in the side of the pipe) onto the main carrier material as it is passing those holes.

In 1990 Colgate-Palmolive was granted a patent (USPTO 4,969,767) for two differently-colored stripes. In this scheme, the inner pipe has a cone-shaped plastic guard around it, and about half way up its length. Between the guard and the nozzle-end of the tube is then a space for the material for one color, which then issues out of holes in the pipe. On the other side of the guard is space for second stripe-material, which has its own set of holes.

Striped toothpaste should not be confused with layered toothpaste. Layered toothpaste requires a multi-chamber design (e.g. USPTO 5,020,694), in which two or three layers then extrude out of the nozzle. This scheme, like that of pump dispensers (USPTO 4,461,403), is more complicated (and thus, more expensive to manufacture) than either the Marraffino design or the Colgate design.

Chapter 12

Mouthwash

Mouthwash or **mouth rinse** is a product used to enhance oral hygiene. Some manufacturers of mouthwash claim that antiseptic and anti-plaque mouth rinse kill the bacterial plaque causing caries, gingivitis, and bad breath. Anti-cavity mouth rinse uses fluoride to protect against tooth decay. It is, however, generally agreed that the use of mouthwash does not eliminate the need for both brushing and flossing. As per the American Dental Association, regular brushing and proper flossing are enough in most cases although the ADA has placed its Seal of Approval on many mouthwashes containing alcohol (in addition to regular dental check-ups).

Mouthwash may also be used to help remove mucus and food particles deeper down in the throat. Alcoholic and strongly flavored mouthwash may cause coughing when used for this purpose.

History

The first known references to mouth rinsing is in Ayurveda and Chinese medicine, about 2700 BC, for treatment of gingivitis. Later, in the Greek and Roman periods, mouthrinsing following mechanical cleansing became common among the upper classes, and Hippocrates recommended a mixture of salt, alum, and vinegar. The Jewish Talmud, dating back about 1800 years, suggests a cure for gum ailments containing "dough water" and olive oil.

Anton van Leeuwenhoek, the famous 17th century microscopist, discovered living organisms (living, because they were motile) in deposits on the teeth (what we now call dental plaque). He also found organisms in water from the canal next to his home in Delft. He experimented with samples by adding vinegar or brandy and found that this resulted in the immediate immobilization or killing of the organisms suspended in water. Next he tried rinsing the mouth of himself and somebody else with a rather foul mouthwash containing vinegar or brandy and found that living organisms remained in the dental plaque. He concluded—correctly—that the mouthwash either did not reach, or was not present long enough, to kill the plaque organisms.

That remained the state of affairs until the late 1960s when Harald Loe (at the time a professor at the Royal Dental College in Aarhus, Denmark) demonstrated that a chlorhexidine compound could prevent the build-up of dental plaque. The reason for chlorhexidine effectiveness is that it strongly adheres to surfaces in the mouth and thus remains present in effective concentrations for many hours.

Since then commercial interest in mouthwashes has been intense and several newer products claim effectiveness in reducing the build-up in dental plaque and the associated severity of gingivitis (inflammation of the gums), in addition to fighting bad breath. Many of these solutions aim to control the Volatile Sulfur Compound (VSC)-creating anaerobic bacteria that live in the mouth and excrete substances that lead to bad breath and unpleasant mouth taste.

Usage

Common use involves rinsing the mouth with about 20ml (2/3 fl oz) of mouthwash two times a day after brushing. The wash is typically swished or gargled for about half a minute and then spat out. In some brands, the expectorate is stained, so that one can see the bacteria and debris. It is probably advisable to use mouthwash at least an hour after brushing with toothpaste when the toothpaste contains sodium lauryl sulfate, since the anionic compounds in the SLS toothpaste can deactivate cationic agents present in the mouthrinse.

Active ingredients

OTC mouthwash containing chlorhexidine from Mexico.

Active ingredients in commercial brands of mouthwash can include thymol, eucalyptol, hexetidine, methyl salicylate, menthol, chlorhexidine gluconate, benzalkonium chloride, cetylpyridinium chloride, methylparaben, hydrogen peroxide, domiphen bromide and sometimes fluoride, enzymes, and calcium. Ingredients also include water, sweeteners such as sorbitol, sucralose, sodium saccharin, and xylitol (which doubles as a bacterial inhibitor).

Sometimes a significant amount of alcohol (up to 27% vol) is added, as a carrier for the flavor, to provide "bite". Because of the alcohol content, it is possible to fail a breathalyzer test after rinsing although breath alcohol levels return to normal after 10mins; in addition, alcohol is a drying agent and may worsen chronic bad breath. Furthermore, it is possible for alcoholics to abuse mouthwash. Recently, the possibility that the alcohol used in mouthrinses acts as a carcinogen was raised, but there is to date no scientific consensus on the issue. Commercial mouthwashes usually contain a preservative such as sodium benzoate to preserve freshness once the container has been opened. Many newer brands are alcohol-free and contain odor-elimination agents such as oxidizers, as well as odor-preventing agents such as zinc ion to keep future bad breath from developing.

Alternative mouthwash ingredients

A **salt mouthwash** is a home treatment for mouth infections and/or injuries, or post extraction, and is made by dissolving a teaspoon of salt in a cup of warm water.

Recently, the use of herbal mouthwashes such as persica is increasing, due to the perceived discoloration effects and unpleasant taste of chlorhexidine. Research has also indicated that sesame and sunflower oils as cheap alternatives compared to chlorhexidine.

Other products like hydrogen peroxide have been tried out as stand-alone and in combination with chlorhexidine, due to some inconsistent results regarding its usefulness.

Another study has demonstrated that daily use of an alum-containing mouthrinse was safe and produced a significant effect on plaque that supplemented the benefits of daily toothbrushing.

However, many studies acknowledge that Chlorhexidine remains the most effective mouthwash when used on an already clean tooth surface or immediately after surgery. As chlorhexidine has difficulty in penetrating plaque biofilm, other mouthwashes may be more effective where pre-existing plaque is present. One side-effect as noted on the label is the staining of the teeth will occur for prolong usage.

Compounding

Custom mouthwashes, called "magic mouthwash" may be prescribed by dentists for post oral surgeries. Variations are common, and some are done with over-the-counter products.

Health risks

A literature review by McCullough and Farah from 2008 published in the *Dental Journal of Australia* concluded that there is "*sufficient evidence*" that "*alcohol-containing mouthwashes contribute to the increased risk of development of oral cancer*". The authors also state that the risk of acquiring cancer rises almost five times for users of alcohol-containing mouthwash who neither smoke nor drink (with a higher rate of increase for those who do). In addition, the authors highlight side effects from several mainstream mouthwashes that included dental erosion and accidental poisoning of children.

However, the study has been disputed by Yinka Ebo of Cancer Research UK, who concluded that "*there is still not enough evidence to suggest that using mouthwash that contains alcohol will increase the risk of mouth cancer*".

Both the American Dental Association (ADA) and the United States National Cancer Institute (NCI) agree that the alcohol contained in antiseptic mouthwash is safe and not a factor in oral cancers. Studies conducted in 1985, 1995, and 2003 summarize that alcohol-containing mouth rinses are not associated with oral cancer. However, a review of a study carried out in Cuba, Argentina, and Brazil was published December 2008 in the *Australian Dental Journal* and concluded that:

> “ There is now sufficient evidence to accept the proposition that developing oral cancer is increased or contributed to by the use of alcohol-containing mouthwashes. Whilst many of these products may have been shown to be effective in penetrating oral microbial biofilms in vitro and reducing oral bacterial load, it would be wise to restrict their use to short-term therapeutic situations if needed. Perhaps the use of mouthwashes that do not contain alcohol may be equally effective. Further, mouthrinses should be prescribed by dentists, like any other medication. There may well be a reason for the use of alcohol-containing mouthrinses, but only for a particular situation and for a limited and controlled period of time. As such, patients should be provided with written instructions for mouthwash use, and mouthwash use should be restricted to adults for short durations and specific, clearly defined reasons. It is the opinion of the authors that, in light of the evidence currently available of the association of alcohol-containing mouthwashes with the development of oral cancer, it would be inadvisable for oral healthcare professionals to recommend the long-term use of alcohol-containing mouthwashes. ”

Chapter 13

Colgate (Toothpaste) and Tooth Brushing

Colgate (toothpaste)

The Colgate logo

Colgate, an oral hygiene product line and one of the namesake brands of the Colgate-Palmolive Company, is a manufacturer of a wide range of toothpastes, toothbrushes, and mouthwashes. Toothpastes produced in Italy, Spain, Germany, Netherlands and Poland in Europe, Mexico and Brazil in Americas and in South Africa for African market. Toothbrushes of Colgate manufactured in People's Republic of China and Switzerland, in Switzerland produced and the mouthwash of Colgate, the Colgate Plax.

Colgate Ribbon Dental Cream was the first toothpaste in a collapsible tube, introduced in 1896. It had previously been sold in glass jars since 1873.

Products

Duraphat

Duraphat is a professional strength paste intended for the treatment and prevention of dental caries. The toothpaste is ideal for the management of high-risk patients such as those with rampant, early, existing or recurrent coronal or root caries. Since it is used in place of regular toothpaste, it is an easy treatment regime for patients to comply with. The prime constituent is sodium fluoride and it is sometimes prescribed as part of a program of fluoride therapy. It is available as a prescription-only product.

Colgate Total

Colgate Total contains the anti-microbial ingredient triclosan along with Copolymer Gantrez that enhances substantivity of triclosan upto twelve hours along with 1000ppm of fluoride, which reduces the number of bacteria that cause gingivitis, cavities and halitosis.

Colgate Cavity Protection

Although most Colgate toothpaste brands use sodium fluoride, the Colgate Cavity Protection variety instead contains Sodium monofluorophosphate as the active ingredient.

Colgate Simply White

A whitening toothpaste that is "Clinically-proven to whiten in 14 days". Its whitening ingredient is hydrogen peroxide, which gradually bleaches the teeth. It utilizes two separate chambers that contain a whitening agent and a cleaning gel.

Advertising

Colgate has a toothpaste and toothbrush mascot for children's entertainment, "Dr. Rabbit", which has also been used in three VHS tapes that teach about dental health and advertise Colgate toothpaste. These include *Dr. Rabbit's World Tour* and *Dr. Rabbit and the Legend of the Tooth Kingdom*. These tapes are frequently parodied on YouTube.

"Gardol" was actually their trademark for the ingredient Sodium lauroyl sarcosinate (and identified as such on the package and in their advertising), which today is an ingredient in Arm & Hammer's "Advance White" toothpaste, minus the "Gardol" identification.

Tooth brushing

A photo from 1899 showing the use of toothbrush.

Tooth brushing is the act of cleaning teeth with a toothbrush.

Modern medical research has shown that brushing teeth properly can prevent cavities, and periodontal, or gum disease, which causes at least one-third of adult tooth loss. If teeth are not brushed correctly and frequently, it could lead to the calcification of saliva minerals, forming tartar. Poor dental health has been associated with heart disease and shortened life expectancy.Brushing your teeth gets all the yellow gunk off and tries to make YOUR teeth white. But it usually doesn't work

Brushing one's teeth has long been considered an important part of dental care. As long ago as 3000 BC ancient Egyptians constructed crude toothbrushes from twigs and leaves to clean their teeth. Similarly, other cultures such as the Greeks, Romans, and Indians cleaned their teeth with twigs. Some would fray one end of the twig so that it could penetrate between the teeth more effectively.

Modern day toothbrushing as a regular habit became prevalent in Europe from the end of the 17th century. The first mass-produced toothbrush was developed in England in 1780. In the United States, although toothbrushes were available at the end of the 19th century, the practice did not become widespread until after the Second World War, when US soldiers continued the toothbrushing that had been required during their military service.

Toothbrush

Head of a toothbrush

The *toothbrush* is an instrument used to clean teeth, consisting of a small brush on a handle. Toothpaste, often containing fluoride, is commonly added to a toothbrush to aid in cleaning. Toothbrushes are offered with varying textures of bristles, and come in many different sizes and forms. Most dentists recommend using a toothbrush labelled "Soft", since firmer bristled toothbrushes can damage tooth enamel and irritate gums as indicated by the American Dental Association. Toothbrushes are often made from synthetic fibers, although natural toothbrushes are also known in many parts of the world.

Toothpaste

Modern toothpaste gel

Toothpaste is a paste or gel dentifrice used to clean and improve the aesthetic appearance and health of teeth. It is almost always used in conjunction with a toothbrush. Toothpaste use can promote good oral hygiene: it can aid in the removal of dental plaque and food from the teeth, it can aid in the elimination and/or masking of halitosis, and it can deliver active ingredients such as fluoride to prevent tooth and gum (Gingiva) disease.

Tooth powder

Tooth powder (or 'toothpaste powder') is an alternative to toothpaste. It may be recommended for people with sensitive teeth. Tooth powder typically does not contain the chemical sodium lauryl sulphate which can be a skin irritant. The function of sodium lauryl sulphate is to form suds when teeth are brushed. It is a common chemical in toothpaste.

Chapter 14

Tonsillolith

Tonsillolith

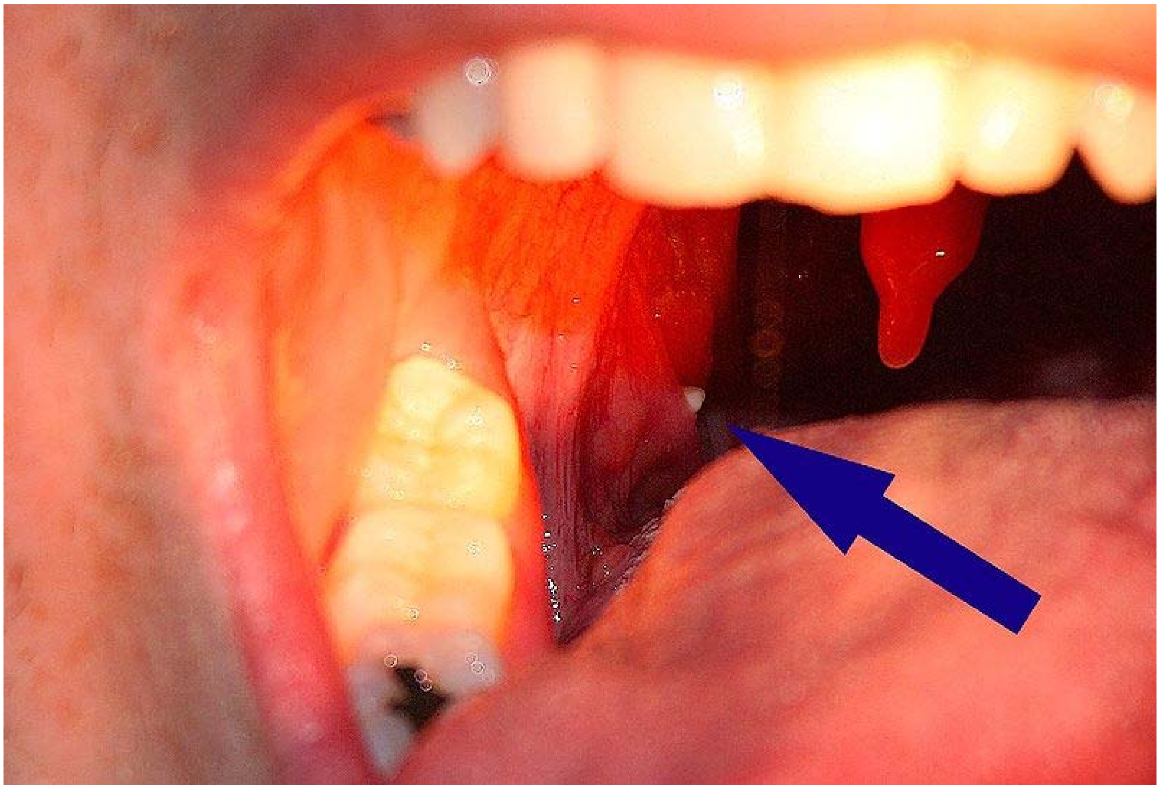
A tonsillolith lodged in the tonsillar crypt

ICD-10	J35.8

A **tonsillolith**, also known as a **tonsil stone** is a piece or, more commonly, a cluster of calcareous matter that forms in the rear of the mouth, in the crevasses (called *tonsillar crypts*) of the palatine tonsils (commonly known as *tonsils*). They can range up to the size of a peppercorn and are white/cream color. The main substance is mostly collagen, but they have a strong unpleasant odor because of hydrogen sulfide, methyl mercaptan and other substances.

Protruding tonsilloliths may feel like foreign objects lodged in the tonsil crypt. They may be a nuisance and hard to get out, but are usually not harmful. They are a cause of halitosis (bad breath).

Symptoms



A tonsillolith protrudes from the tonsil

Large tonsillolith half exposed on tonsil

Tonsilloliths occur more frequently in adults than in children. Many small tonsil stones do not cause any noticeable symptoms. Even when they are large, some tonsil stones are only discovered incidentally on X-rays or CAT scans.

Other symptoms include a metallic taste, throat closing or tightening, coughing fits, and choking.

Larger tonsilloliths may have multiple symptoms, including recurrent halitosis, which frequently accompanies a tonsil infection, sore throat, white debris, a bad taste in the back of the throat, difficulty swallowing, ear ache, and tonsil swelling. A medical study conducted in 2007 found an association between tonsilloliths and bad breath in patients with a certain type of recurrent tonsillitis. Among those with bad breath, 75% of the subjects had tonsilloliths while only 6% of subjects with normal halitometry values (normal breath) had tonsilloliths. A foreign body sensation may also exist in the back of throat. The condition may also be an asymptomatic condition, with detection upon palpating a hard intratonsillar or submucosal mass.

Classification

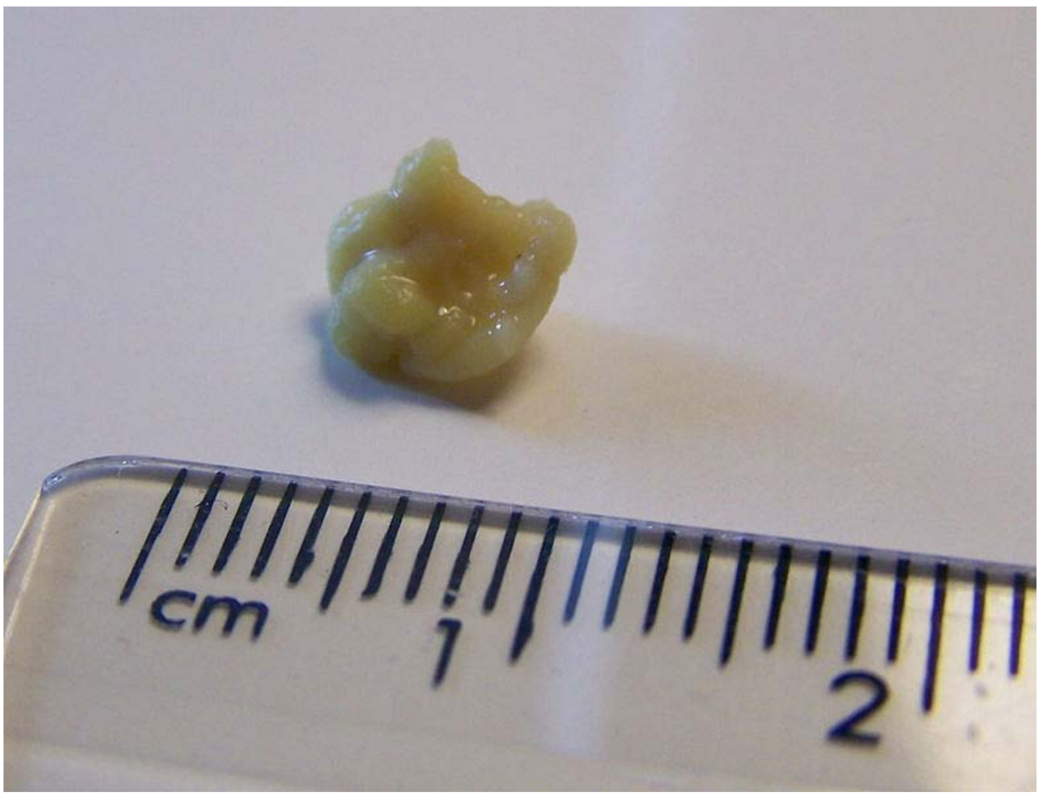
Tonsilloliths or tonsil stones are calcifications that form in the crypts of the palatal tonsils. They are also known to form in the throat and on the roof of the mouth. Tonsils are filled with crevices where bacteria and other materials, including dead cells and mucus, can become trapped. When this occurs, the debris can become concentrated in white formations that occur in the pockets. Tonsilloliths are formed when this trapped debris combines and hardens, or calcifies. This tends to occur most often in people who suffer from chronic inflammation in their tonsils or repeated bouts of tonsillitis. They are often associated with post-nasal drip. These calculi are composed of calcium salts such as hydroxyapatite or calcium carbonate apatite, oxalates and other magnesium salts or containing ammonium radicals, macroscopically appear white or yellowish in color, and are usually of small size - though there have been occasional reports of large tonsilloliths or calculi in peritonsillar locations. Many people have small tonsilloliths that develop in their tonsils, and it is quite rare to have a large and solidified tonsil stone.

Giant

Much rarer than the typical tonsil stones are giant tonsilloliths. Giant tonsilloliths may often be mistaken for other oral maladies, including peritonsillar abscess, and tumours of the tonsil.

A small tonsillolith

A large tonsillolith



Close up of a tonsillolith

Causes

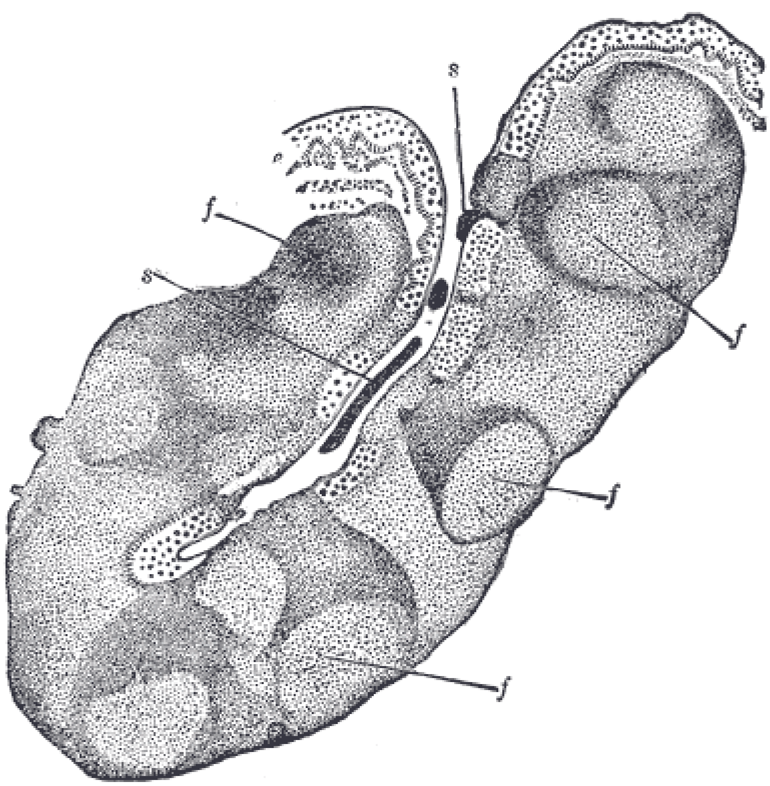
Tonsil stones, it is theorized, are the result of a combination of any of the following:

- dead white blood cells
- oral bacteria
- overactive salivary glands

- mucus secretions
- residual of enzyme action on retained food
- smoking without a filter
- tooth enamel deposits in the wrong place
- allergy/intolerance to dairy products
- large tonsil crevasses (e.g: large tonsillar crypts)

Tonsil stones are not a rare occurrence in people. It is common for both children and adults to have tonsil stones.

Pathophysiology



Low-power microscope magnification of a cross-section through one of the tonsillar crypts (running diagonally) as it opens onto the surface of the throat (at the top). Stratified epithelium (e) covers the throat's surface and continues as a lining of the crypt. Beneath the surface are numerous nodules (f) of lymphoid tissue. Many lymph cells (dark-colored region) pass from the nodules toward the surface and will eventually mix with the saliva as salivary corpuscles (s).

The mechanism by which these calculi form is subject to debate, though they appear to result from the accumulation of material retained within the crypts, along with the growth of bacteria and fungi such as *Leptothrix buccalis* – sometimes in association with persistent chronic purulent tonsillitis. In other words, "Because saliva contains digestive enzymes, trapped food begins to break down. Particularly, the starch or carbohydrate part of the food melts away, leaving firmer, harder remains of food in the tonsils."

Alternative mechanisms have been proposed for calculi that are located in peritonsillar areas, such as the existence of ectopic tonsillar tissue, the formation of calculi secondary to salivary stasis within the minor salivary gland secretory ducts in these locations, or the calcification of abscessified accumulations.

Recently an association between biofilms and tonsilloliths was shown. Central to the biofilm concept is the assumption that bacteria form a three dimensional structure; dormant bacteria being in the center to serve as a constant nidus of infection. This impermeable structure renders the biofilm immune to antibiotic treatment. By use of confocal microscopy and microelectrodes, biofilms similar to dental biofilms were shown to be present in the tonsillolith, with oxygen respiration at the outer layer of tonsillolith, denitrification toward the middle, and acidification toward the bottom.

Diagnosis

Diagnosis is usually made upon inspection. Differential diagnosis of tonsilloliths includes foreign body, calcified granuloma, malignancy, an enlarged styloid process or rarely, isolated bone which is usually derived from embryonic rests originating from the branchial arches.

Tonsilloliths are difficult to diagnose in the absence of clear manifestations, and often constitute casual findings of routine radiological studies.

Imaging diagnostic techniques can identify a radiopaque mass that may be mistaken for foreign bodies, displaced teeth or calcified blood vessels. Computed tomography (CT) may reveal nonspecific calcified images in the tonsillar zone. The differential diagnosis must be established with acute and chronic tonsillitis, tonsillar hypertrophy, peritonsillar abscesses, foreign bodies, phlebolites, ectopic bone or cartilage, lymph nodes, granulomatous lesions or calcification of the stylohyoid ligament in the context of Eagle syndrome (elongated styloid process).

Treatment

Drinking plenty of water along with gargling mouthwash will often stop the formation of tonsil stones.

Treatment, if required, is usually removal of concretions by curettage; larger lesions may require local excision although these treatments may not help the bad breath issues that are often associated with this condition.

One option is to decrease the surface area (crypts, crevices, etc.) of the tonsils via laser resurfacing. The procedure is called laser cryptolysis. It can be performed using a local anesthetic. A scanned carbon dioxide laser selectively vaporizes and smooths the surface of the tonsils. This technique flattens the edges of the crypts and crevices that collect the debris, preventing trapped material from forming stones.

The most drastic method, a tonsillectomy, is permanently effective but should only be considered when less aggressive options fail or are not desired/tolerable.

Epidemiology

Tonsilloliths occur in up to 10% of the population, frequently due to episodes of tonsillitis.