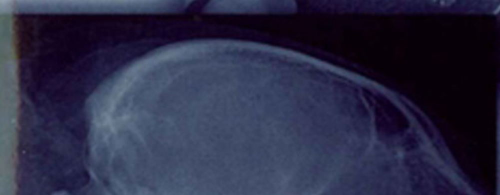
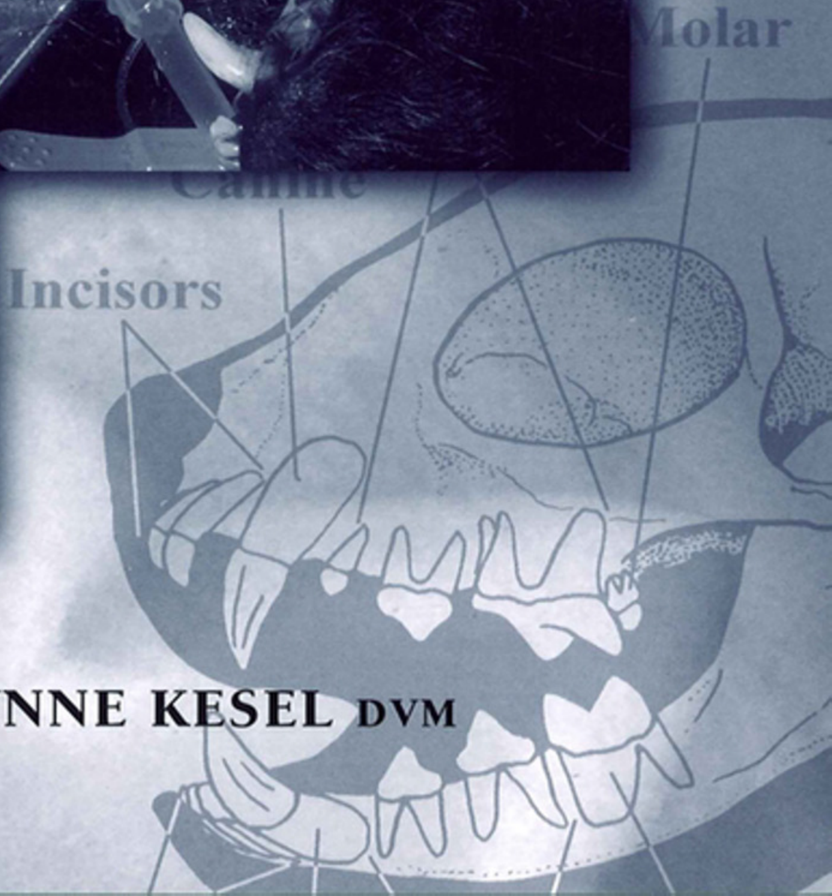
VETERINARY DENTISTRY

for the Small Animal Technician





M. LYNNE KESEL DVM

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M. Lynne Kesel DVM

with illustrations by M. Lynne Kesel DVM
and Anna Kendall

Blackwell Publishing

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For

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Contents

Preface

Early in 1997, Dr. Bernie Rollin suggested I write this book. He and I had previously collaborated in coediting a major reference work in the laboratory animal field for which we had both written chapters. Since beginning our project in the two-volume work *The Experimental Animal in Biomedical Research,* I had changed jobs in the university from laboratory animal medicine and was teaching veterinary students in clinical rotations involving routine surgeries and small animal dentistry. When Bernie said I should get busy and write a dental book for veterinarians, I smugly quashed the notion, pointing out that there were several excellent books recently published or being published on that topic. And then he said, "How about a book on dentistry for technicians?" The complete lack of books on the subject and my interest made it a natural.

Small animal dentistry is, I feel, one area of veterinary medicine in which technicians can act like nurse-practitioners in the human field. The nurse-practitioner is highly trained (to the level of a physician) in one limited area. He or she does not have the in-depth, general education of a physician or see the complete range of rotations that a physician in training would. The nurse-practitioner works with a physician, uses the physician's wider knowledge and experience as a resource, and knows when to refer problems to the physician. For instance, the nurse-midwife would seek a physician's guidance if a pregnant patient showed signs of a heart condition.

In this book, I have attempted to explain even fairly complicated dental procedures so that the technician can understand what is being done and how to assist, but not necessarily how to do them. In veterinary medicine, technicians have been taught how to administer anesthetics and even how to perform routine surgeries to free veterinarians for other tasks. Depending on the jurisdiction this may be perfectly legal as long as the veterinarian provides supervision. There are some areas where the law severely limits the role of anyone except the licensed veterinarian in providing service. Often, this has evolved because of abuses in the system (e.g., the veterinarian takes a day off, and the technicians do the surgery). The technician should always be aware of the legal limits of his or her job and refuse to perform unlawfully. If something should go wrong, there is always the possibility of being named in a lawsuit and losing a technician license and/or money for damages.

The American Veterinary Dental College has published thorough guidelines describing who should provide veterinary dental care (see Appendix 3). To stay within these suggested guidelines for technicians is always safe. If a veterinarian expects the technician to exceed these guidelines (which is very common), it is worth consulting local or regional technician organizations or even the state board of veterinary medicine. In some areas, the response will be “Whatever the veterinarian asks of the technician is legal as long as he or she is supervised by the veterinarian.”

Many veterinary schools still do not have dental specialists on staff to teach veterinary students about dentistry, and technicians who have learned only the material in Chapters 1, 4, and 5 may well have more knowledge about anatomy, periodontal disease, and cleaning teeth than their bosses! Because I have attempted to present information in an accessible manner, technicians who have purchased this book may want to loan it to their veterinarians; veterinarians may want to purchase it for their technicians. (I hope so!)

In the final analysis, the technician is providing an invaluable service to pets and their owners even if limited to dental prophies (cleanings) and client education. In most cases, home and professional dental care can ward off periodontal disease and its potential ramifications, which can be painful, debilitating, and even life threatening.

Acknowledgments

First among many, I would like to thank my dear friends Bernard Rollin and Vicki Matteson, who read the manuscript chapter by chapter as it came out of my printer. They faced a daunting task: attempting to make my prose intelligible when I wandered off the path with run-on sentences or bizarre ways of expressing myself, as well as cleaning up my spelling and occasional grammatical lapses. Any errors in style or substance still belong to me, however, since I had the final word at the keyboard as I decided whether to accept their improvements (I gratefully accepted most). Bernie also was my goad to write this book in the first place, and Vicki was my inspiration as a technician par excellence.

I want to thank my dental mentor, Dr. Ed Eisner, for the knowledge he has imparted to me over the years and for the photographs of cases he shared for this book. Most of the other photographs in the book were taken by Jenger Smith or Charles Kerlee of the Colorado State University Photo Lab. They also "duped" slides for me and scanned illustrations, and all of their help is very appreciated.

My daughter Anna Kendall aided me not only by producing highly detailed drawings but also with manipulation of computer images of the illustrations, and to her I say, "Thanks, babe."

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Oral and Dental Functional Anatomy

By tradition as well as necessity, a text must begin with the basics. A mechanic could not fix a car effectively if he did not understand the layout and appearance of the engine (the anatomy) or the way it should work (the physiology). A surgeon would be ineffective, and probably dangerous, if she or he ignored the importance of understanding the anatomy and physiology of the structures she or he was intending to alter by surgery. So it is with you, the veterinary dental technician. You should have an understanding of oral and dental structures and how they work in health as well as illness. With this knowledge, you can be a full participant in the total health care of the patient. Understanding begins with knowing about the formation of teeth in the jaw (Fig. 1-1).

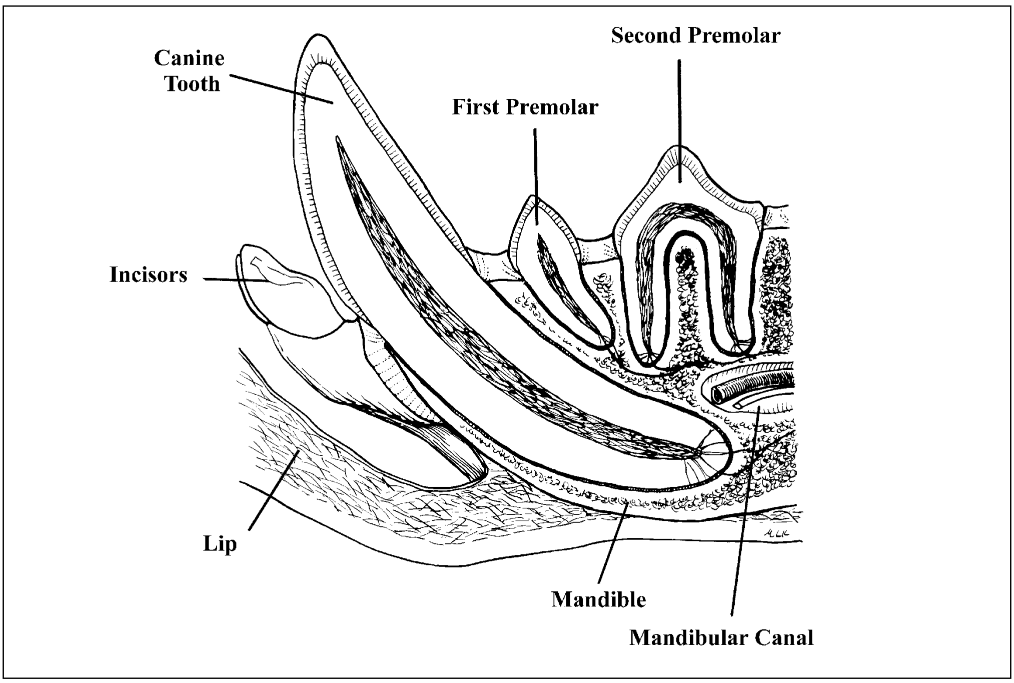


Figure 1-1

Diagrammatic representation of the rostral mandible of a dog. The lip, canine tooth, and the first and second premolars are shown in a cutaway view to demonstrate the relationship of the teeth to each other, the periodontal tissues, and the mandibular canal. The incisors rostral to the canine are not shown as a sectioned view.

THE EMBRYOLOGY OF THE TOOTH

To grossly simplify embryology, which is a complex and fascinating subject, we can speak of three basic tissues that are transformed into all of the organs and structures of the animal: the ectoderm, mesoderm, and endoderm. The ectoderm is the layer on the outside of the early embryo, which will eventually become epithelium (skin), as well as other things (like the enamel of teeth). The association of tooth enamel with the epithelium is important because something that can affect one may affect the other. For instance, before it became rare due to widespread vaccination, canine distemper caused enamel deficits in dogs who were infected as puppies because the virus has a tropism for (attraction to) epithelial cells such as the ameloblast, the enamel-producing cell. When the ameloblast is actively producing enamel for a tooth and it is infected by the virus, it stops functioning, and there will be no enamel on the tooth surface where that cell was situated. Severe fevers during tooth development can cause damage to the enamel organ (the collective name for all the ameloblasts making the enamel of a tooth crown) as well, just as they can cause the loss of hair follicles in the skin by killing those cells.

The mesoderm is the middle tissue of the early embryo. It will become the bones, muscles, and most of the solid organs (like the liver and kidneys) of the animal. It also forms the major part of the tooth, the dentin.

The endoderm is the third early embryonic tissue. It forms the heart and blood vessels. Since teeth have a blood supply in their pulp, it could be said that teeth are unique in having components of all three types of tissues.

The ectoderm, or epithelium, initiates the formation of a "tooth bud." In the place where a tooth will develop, the epithelium invaginates (pokes) into the mesoderm, or mesothelium, of the tissue that will become bone (Fig. 1-2A). The process is much like pushing your finger into a flaccid water balloon; as the wall of the balloon "invaginates" into the water, it forms a tunnel. As the tunnel that will become the tooth bud gets deeper in the mesothelium, it flares out and then acts as if it were pushed up in the middle of the point (Fig. 1-2B). Eventually it forms a double-walled, roughly bell-shaped structure in the outline of the crown of the tooth (the crown is the portion of the tooth that will be covered with enamel and erupted into the mouth). The formation of this crown-shaped bell induces mesothelial cells inside it (a bud-shaped bit of tissue known as the dental papilla) to differentiate into odontoblasts, which will make dentin, the main structural component of the tooth. Simultaneously, epithelial cells adjacent to the odontoblasts are induced to become ameloblasts, which will make enamel. The rest of the "bell" becomes support cells for the ameloblasts; the entire epithelial complex is referred to as the enamel organ.

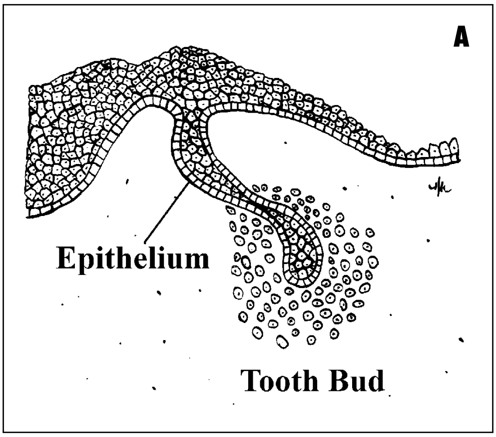
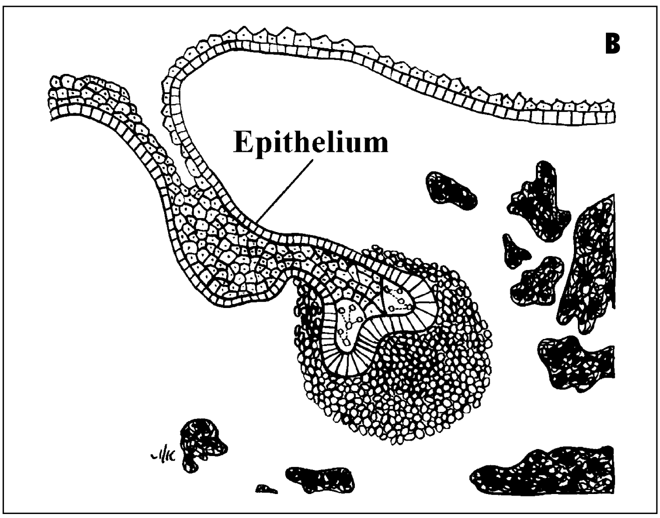


Figure 1-2

Initial formation of the tooth bud.

(A) The appearance of the invagination of ectodermal cells (epithelium) into the mesoderm is the first stage of a developing tooth. The presence of the ectoderm is stimulating the concentration of mesodermal cells that will eventually form the dentin of the tooth.

(B) The bell-shaped cup of the tooth bud is beginning to take shape. The depression in the middle of the tip is where the crown of the tooth will form.



The growth of the tooth begins at the tip of the crown and progresses toward the root. The growth of the enamel organ ceases when the crown has reached its full length and enamel thickness, but dentin continues to be laid down as the root develops. Once the enamel is fully formed, the tooth will begin to erupt with the root unfinished. If the tooth is a primary, or deciduous ("baby"), tooth, it will be replaced by a secondary or permanent tooth. When the primary tooth bud is formed, the epithelial cells form a secondary tooth bud, which will remain dormant until it is time for the permanent tooth to replace the primary one (Fig. 1-3).

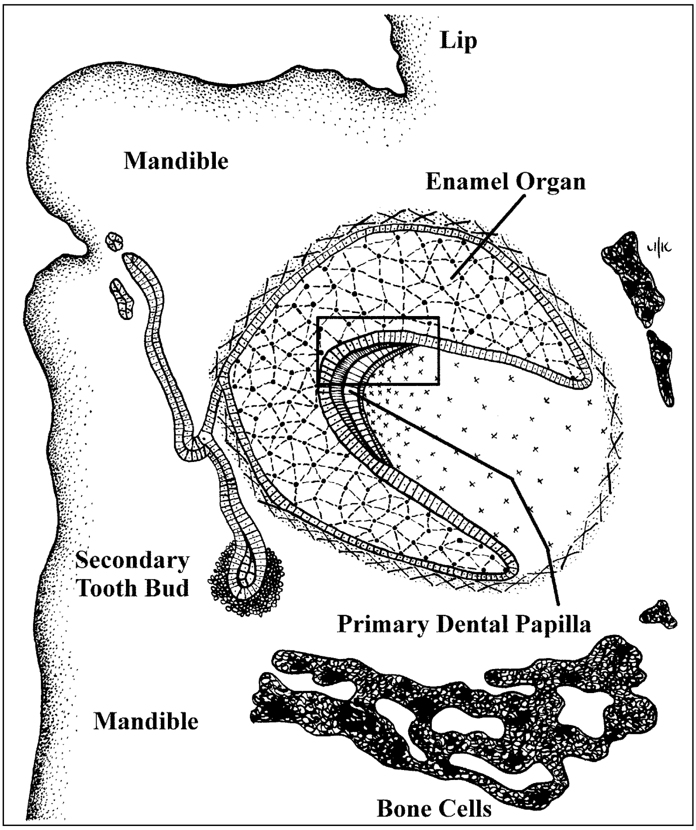


Figure 1-3

An active enamel organ/tooth bud. Enamel and dentin are beginning to form at the tip of the future tooth crown. When enough enamel and dentin are mineralized, the arrowhead-shaped tooth crowns will be visible on X rays of pups in utero. Imaging of tooth buds at this later stage signals that a pup is mature enough to survive outside the uterus.

FORMATION OF THE ROOT

There is no enamel on the surface of the root. Instead a structure called Hertwig's epithelial root sheath takes over the growth of the root. It starts as a band around the tooth at the base of the crown (or more than one band at the base of the crown in a multiple-rooted tooth). Hertwig's sheath is the source of the cementocytes that produce the partially mineralized surface of the root, called cementum. Odontoblasts multiply at the apical (root side) edge of Hertwig's sheath, lengthening the root as they form dentin. This formation of root dentin pushes the crown toward the surface of the jaw through the bone. This is necessary to allow the root to lengthen within the limited width of the jaw. Hertwig's epithelial root sheath stays essentially in the same position while the root lengthens and the tooth erupts. It ceases to

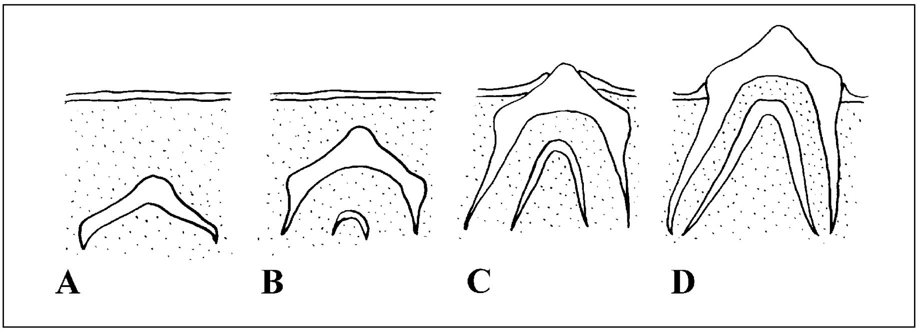


Figure 1-4

The development of the tooth from deep in the bone.

(A) The tooth crown is first evident.

(B) Once the crown is complete, the root starts to grow, forcing the crown toward the surface of the jaw.

(C) The root is still lengthening when the tooth breaks through the gingiva.

(D) The roots are full-length and are beginning to constrict at the apex. Note that the growing portion of the root stays in the same place while the tooth crown moves.

function when the root tip, or apex, is formed. As the growth of the root reaches its predetermined length, the sheath constricts until only a tiny opening for blood supply and nerves is left (Fig. 1-4).

This process is called apexification (for the formation of the apex of the root), and it has important implications for the pulp inside the tooth. A tooth will not erupt further if the tooth has apexified, which is a condition found in impacted teeth, where something mechanically obstructs eruption, partially or completely.

FORMATION OF ENAMEL

Enamel is the hardest tissue produced by a living thing; it exceeds the hardness of coral. The ameloblasts secrete the enamel matrix toward the odontoblasts, and the body of the ameloblast cell is thereby moved away from the dentin of the tooth. Enamel is composed almost entirely of mineral in crystallized prisms that are lined up at right angles to the surface of the tooth. When enamel is broken or chipped, it will typically do so in these right angles, following these prisms all the way to the surface of the dentin, rather than across the enamel surface (Fig. 1-5). The enamel of teeth is intended to act as a deterrent to wear and as a cover for dentinal tubules (see below), but it is very brittle. It is therefore typically very thin, usually a millimeter or less in thickness when mature, regardless of species.

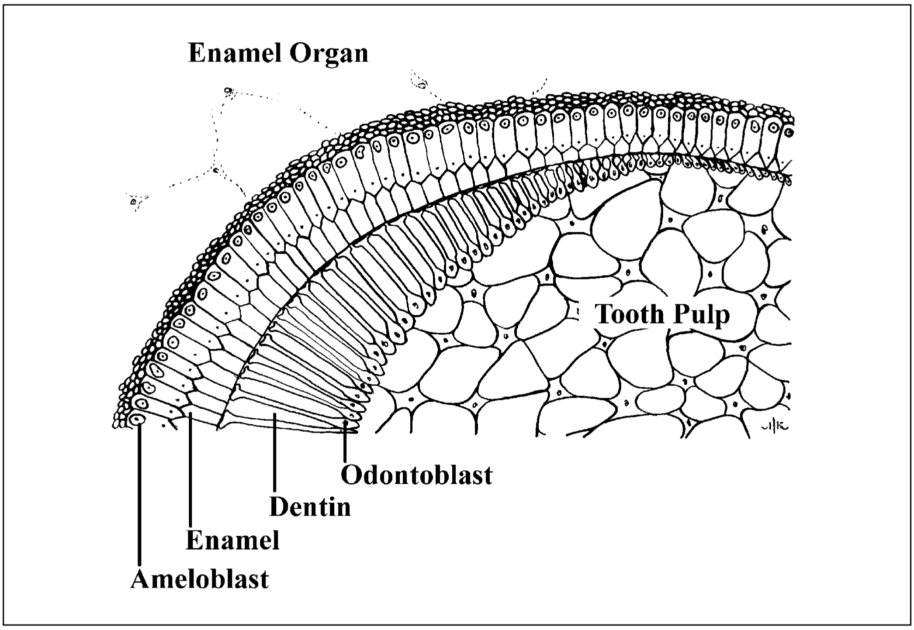


Figure 1-5

Detail of Figure 1-3. The tip of the tooth crown shows the cell bodies of the ameloblasts forming enamel prisms. Adjacent to the prisms are the ends of the processes of the odontoblasts. Dentin is being formed between the processes of the odontoblasts, and the cell bodies of the odontoblasts reside next to the rest of the tooth pulp, the cells of which provide nourishment for the odontoblasts.

FORMATION OF DENTIN

Odontoblasts are modified bone cells. The minerals they secrete (called calcium hydroxy-apatite) are mostly calcium and are similar in makeup to that of enamel and bone. The main difference in the three is how the material is laid down and how much organic (nonmineral, or soft) material it contains. The odontoblast, like the ameloblast, secretes its product toward the enamel/dentin interface. The body of the odontoblast retreats away from this surface toward the middle of the tooth. It forms a layer with other odontoblasts along the boundary of the soft tissue center of the tooth called the tooth pulp. During this retreat, the odontoblasts leave a threadlike process of cytoplasm behind within a tubule formed of dentin; the dentin from adjacent odontoblasts joins to form a solid dentinal wall perforated by dentinal tubules. Dentinal tubules extend nearly to the surface of the dentin/enamel interface (or the dentin/cementum interface of the root), and they allow fluid exchange within the dentin of the tooth as long as the odontoblast is alive. Therefore dentin is a live tissue. Enamel is not a live tissue since no part of a live cell stays within it.

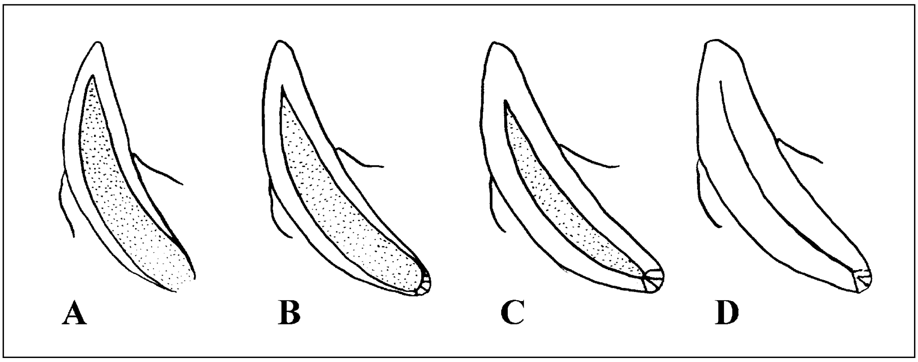


Figure 1-6

Root and pulp development and aging.

(A) A recently erupted canine tooth of a dog, age six months. The apex has not closed (apexified), and a wide-open pulp is surrounded by only a thin shell of dentin on the root.

(B) At approximately 14–18 months of age the canine root apex closes.

(C) A mature dog (4 to 5 years) shows the result of further deposition of dentin with age.

(D) The dentinal walls of the old dog (>10 years) are so thick that the pulp is almost nonexistent and contains little blood supply.

The dentin that is formed before the tooth erupts is called primary dentin (not to be confused with primary teeth). The dentin that completes the tooth root and continues to form as the tooth matures, causing the dentinal walls to thicken throughout life (Fig. 1-6), is the secondary dentin.

It can be seen that the odontoblasts get closer and closer together as they secrete dentin behind them toward the outside of the tooth. This may be why dentin laid down late in life is of a darker color (tan or brownish); more dentinal tubules mean more organic material, which is more likely to take up stain from the mouth.

It also may be that dentin nearer the center of the tooth has been rapidly laid down in response to a stimulus, such as wear or a closed fracture (a chip that does not enter the pulp), and therefore contains or incorporates more organic matter. Once damage has occurred to the tooth, and the protective enamel is lost from the surface, the dentinal tubules are left open to the oral environment. Since the tubules are too small to allow the ingression of bacteria, an infection does not occur, yet thermal and chemical stimuli are transmitted more readily to the nerve in the pulp. This is why when we get a “cavity” we get a sharp pain in the tooth with cold, heat, or sugar. The tooth pulp tries to cover over the open tubules by increasing the amount of dentinal “insulation” between itself and the stimulus; odontoblasts toward the stimulus are turned on, and additional mineral is laid down within the tubules. This dentin that is laid down in response to a stimulus is called tertiary dentin; it was formerly known as reparative dentin, for obvious reasons.

When a tooth is quite young, its walls are relatively thin. However, dentinal tubules are wide and contain more cell cytoplasm in the odontoblastic processes. This young tooth is more resilient because of the amount of organic material in the pulp and odontoblastic processes as well as the intracellular fluid that bathes the dentin from the processes. As the tooth ages, the blood supply becomes atretic (decreases to nonfunctional) because the pulp narrows; the cell processes are lost as tubules also are mineralized. These old teeth are not fractured as often as young teeth because old animals do not tend to abuse their teeth as much as young animals and the teeth are stronger from an increased thickness of dentin. You can appreciate this when you think of the wall of the tooth of a young animal as a single-thickness pane of glass as compared with that of an old animal, which is more like the thickness of a glass tabletop. It takes a tremendous blow to break the tabletop, whereas a sharp tap with a hard object will shatter the windowpane.

THE TOOTH PULP

The bulk of the tooth pulp is composed of blood vessels (arterial and venous capillaries), lymph vessels, and sensory nerve tissue maintained in a latticework of fibrous tissue and fibrocytes. In this way, it is similar to subcutaneous tissue without the fat cells, except that the odontoblasts are lined up on the periphery of the tooth pulp. The vessels and nerves are branches of the main vessels and nerves of the respective jaws. The blood supply supports the functioning of the odontoblasts as well as the other elements of the pulp. As in other live tissues, the sensory nerves are present to avoid damage to the pulp by noxious stimuli. An interesting fact in dogs and cats is that the apex of the tooth root completely closes over in about 80 percent of the teeth, leaving only small, sievelike microscopic openings for the vessels and nerves that enter the pulp. In humans, the apex of the tooth is constricted but is almost always formed as a canal rather than the so-called apical delta of our common pets. This has implications for endodontic therapy (see Chap. 10).

THE PERIODONTIUM

Up to this point we have ignored perhaps the most important aspect of the tooth: the tissues that support it so that it can perform its intended function. All of the tissues that come into contact with the tooth are part of the *perio-* ("around") *dontium* ("tooth"). Just as a fencepost cannot function to hold up a fence if the ground around it is soft mud, a tooth will loosen and exfoliate (fall out) if the periodontal tissues lose their integrity.

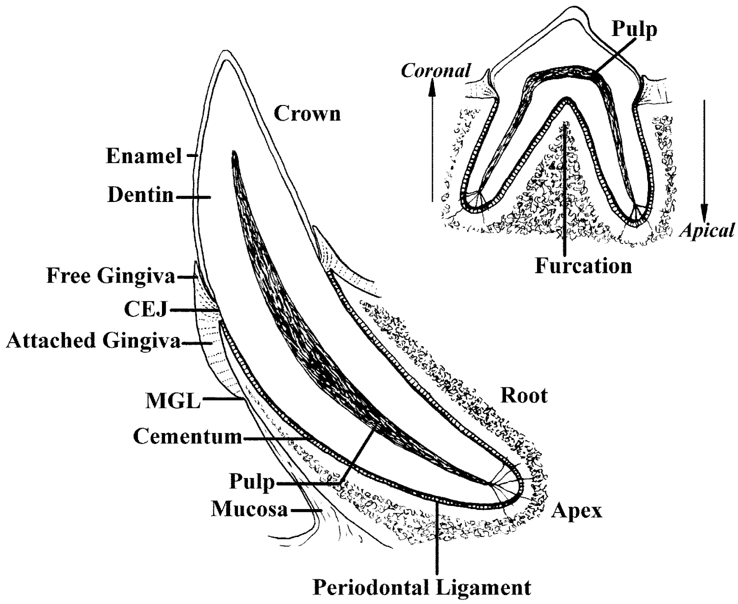


Figure 1-7
The tooth and its parts.

The most critical part of the periodontium is the periodontal ligament (Fig. 1-7). Ligaments in general are fibrous bands between bones; the tooth's dentin, of course, is a modified bone. The fibers of the periodontal ligament are lined up perpendicular to the root surface and suspend the tooth between the bone of the tooth's alveolus (the root's "socket") and the root. The fibers intermesh both with the fibers and the calcified tissue of the cementum on the tooth side and with Sharpey's fibers attached to the bone on the other. The space between the fibers of the ligament is filled with fibrocytes, blood vessels, and nerves. When we adjust how hard we bite down on something, the sensation comes from nerves in the periodontal ligament. The periodontal ligament, like all of the periodontium, has a good blood supply and is constantly renewing and repairing itself in the face of constant wear and tear.

The periodontal ligament has two functions other than sensation and holding the tooth in its socket: cushioning of forces to the tooth and separation of dentin from bone. Imagine, if you will, teeth made of glass within glass jaws, the glass of the teeth being just a little bit tougher than that of the jaws. In one case let us put a thin layer of sponge rubber between tooth and jaw, in the alveolus. In the other, we will glue the tooth to the alveolus. The process of normal chewing will cause microscopic or major fractures to the jaw with the tooth solidly attached, as opposed to cushioned. Catching a tennis ball or a flying disc will be even more likely to cause a fracture in the uncushioned model.

To understand the importance of a physical barrier between bone and dentin, we must review the physiology of normal bone. All live bone is constantly being replaced on a microscopic level. A bone cell called an osteoclast tunnels through the formed bone and, like the video character Pac Man, "eats" the calcified tissue. Right behind the osteoclast is another bone cell, an osteoblast. The osteoblast follows along the tunnel and fills it up with new bone; the structure the two create is called an osteoid seam. Dentin, since it is made of similar components to bone, could be considered a denser bone, and osteoclasts would be very happy to tunnel through it. Why they usually do not is the presence of the periodontal ligament, which acts as a barrier to osteoclasts, except in certain disease conditions (see Chaps. 4 and 10). One of the concepts important to remember here is that, unlike bone, dentin does not remodel or change once it is formed, except to lose vitality (if odontoblasts die) or to be destroyed by disease conditions such as caries ("cavities") or resorptive lesions.

The alveolar bone is the same as the bone on the surface of the jaw or any other bone. It is a dense, white cortical type of bone. Surrounding it and continuous with it is less-dense cancellous bone. In a radiograph (X ray) the dense dentin of the tooth will be the whitest part of the image, with a darker pulp present in its center. At the surface of the tooth another dark band occurs where the nonmineralized periodontal ligament lies. The alveolar bone just next to the ligament is whiter than the rest of the bone because it is on edge in the radiograph and is denser than the surrounding cancellous bone. This white line is called the lamina dura.

The continuous line of bone that supports the teeth is called the alveolar crest. This bone is dependent upon the presence of tooth roots for its existence; if teeth are never formed or if they are lost, the alveolar crest disappears, and the jaw becomes flat.

THE ATTACHED GINGIVA, GINGIVAL SULCUS, AND ORAL MUCOSA

Although the periodontal ligament gets the credit for holding the tooth in place, the attached gingiva protects the periodontal ligament from invasion by oral bacteria. The attached gingiva, commonly and inexactly called the gums, is the firm epidermal tissue that mounds up at the base of the tooth. In dogs, it can be either unpigmented (pink) or pigmented. In cats it is essentially unpigmented. The attached gingiva adheres closely to the underlying bone. If you look closely at attached gingiva (yours or an animal's), you will see pinpoint divots all over its surface. These divots are evidence of the attachment of epidermal pegs to the underside of the surface layer, which in turn are attached to the bone, like tie-downs for skin. The attached gingiva does not move over the bone, unlike the oral mucosa adjacent to it. The oral mucosa moves freely over bone or the connective tissue of the cheeks and lips and is very elastic, to allow for full opening of the mouth. Oral mucosa is not, strictly speaking, a periodontal tissue, since its loose attachment would allow bacteria to enter; it is never next to the teeth in a normal mouth. The border between the oral mucosa and the attached gingiva is sharply delineated. It is called the mucogingival line, or MGL.

The attached gingiva has a leading edge that laps over the tooth called the free gingival margin. This margin varies in width by species (it is usually a millimeter or less wide in cats, for instance) and by tooth. In most healthy dogs it ranges from about 2 to 4 mm wide. The crevice between the tooth and the free gingival margin is called the gingival sulcus. The bottom of the sulcus is formed by fibers of epithelium that adhere the attached gingiva to the tooth at the border between root and crown, otherwise known as the cemento-enamel junction, or CEJ. This is an important landmark for periodontal health, as loss of this attachment signals the beginning of periodontal destruction.

The epithelium that faces the tooth surface within the sulcus is called, not surprisingly, sulcular or junctional epithelium. Histologists think that junctional epithelium is a remnant of the enamel organ ("reduced enamel epithelium") left over as the tooth erupted. Wherever it comes from, this epithelium is unique in that it is very porous, like a membrane. It is designed to produce a constant flow of sulcular fluid; this fluid contains antibodies and even white blood cells to fight the bacteria that live in the mouth. The fluid also helps to keep the marginal gingiva in position flat against the tooth even in the absence of saliva; like a flat, thin rubber stopper in a wet sink or tub, the marginal gingiva is meant to form a tight seal against the tooth with the moisture between them.

None of the epithelium of the mouth is as keratinized as skin is, so it can be subject to trauma during activities like chewing. However, the periodontium and oral mucosa are highly vascularized, and the generous circulation of blood through the tissues aids in rapid healing. The attached gingiva has such a profuse blood supply that it is almost impossible to incise it in such a way that the blood supply is compromised. The blood supply of the oral mucosa in the antrum and the vestibule of the mouth (the free space between lips or cheeks and the teeth/periodontium) is generally at right angles to the attached gingiva. The surface of the roof of the mouth, called the palatal mucosa, functions like attached gingiva because it is firmly adhered to the palatal bone. In the caudal part of the mouth, it continues without bone as the soft palate, an arch of connective tissue covered by epithelium that separates the caudal part

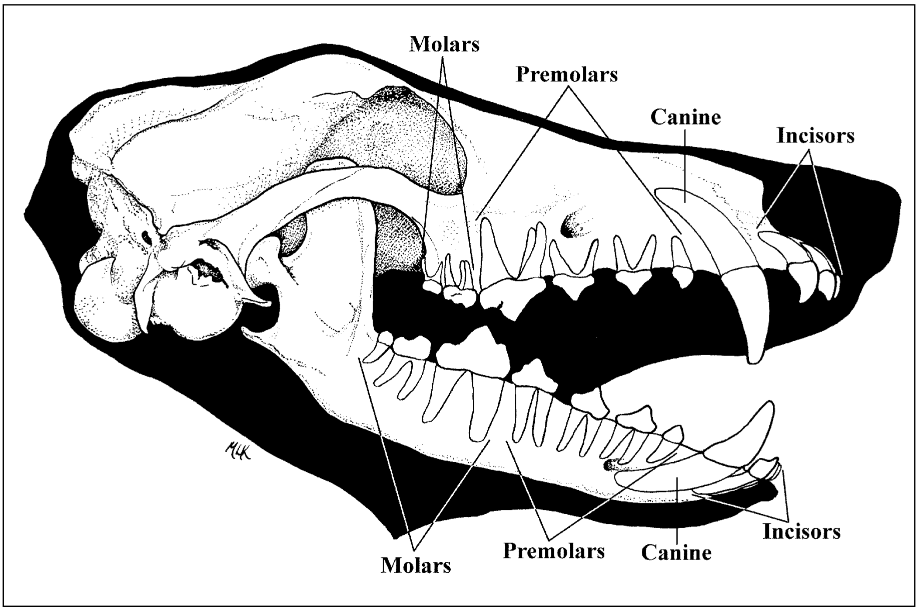


Figure 1-8
The skull of the dog showing the position and number of teeth and their roots.

of the nasal cavity from the oral cavity. The palatal mucosa is served by palatal arteries that run rostrally (forward, or toward the front) adjacent to the teeth after perforating the palatal bone medial to the upper fourth premolar. The palatal mucosa is thrown up into folds, called rugae (a single one is a ruga), which apparently aid in swallowing.

An area sometimes mentioned in stomatitis in cats, as well as some other conditions, is the fauces. This is the mucosa-covered area caudal to the back teeth and soft palate that forms the arch just rostral to the pharynx.

MORE INFORMATION ON NORMAL ANATOMY AND TERMINOLOGY

All veterinary dental texts contain dental formulas for dogs and cats. The dental formula for the mature dog is I3/3, C1/1, P4/4, M2/3 (Fig. 1-8). This translates as saying that for each side of the mouth the dog has three incisors in the front of the top jaw (the maxilla) over three incisors in the bottom jaw (the mandible), followed by one canine top and bottom, followed by four premolars top and bottom, followed by two molars over three, for a total of 42 when you count both sides. The formula for an immature animal uses lowercase letters for deciduous teeth. The formula for the puppy is i3/3, c1/1, p3/3, for a