CHAPTER

21

Dental and Oral Diseases

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Resorption of multiple teeth is very common in cats. However, its etiology remains a mystery up to this day. Similarly, stomatitis has been described for many decades, but progress in identifying its cause and providing effective treatment continues to be challenging. Oral and maxillofacial trauma also manifests somewhat uniquely in the cat in that the mandibular symphysis, the temporomandibular joints, and the hard palate are typically affected, but rarely the midportion of the mandibular body. Squamous cell carcinoma is the most common tumor of the oral cavity in the cat, and curative surgical treatment is usually reserved for those tumors affecting the lower jaw. A comprehensive review of dental and oral diseases in the cat has recently been published.[8]

ORAL ANATOMY

Eruption of Deciduous and Permanent Teeth

Cats have two sets of teeth, the deciduous and permanent dentitions. Deciduous incisors erupt at 2 to 3 weeks, canines at 3 to 4 weeks, and premolars at 3 to 6 weeks of age. There should be 26 deciduous teeth. Permanent incisors erupt at 3 to 4 months, canines at 4 to 5 months, premolars at 4 to 6 months, and molars at 4 to 5 months of age. There should be 30 permanent teeth. At 7 months of age, the young cat should have 30 fully erupted permanent teeth in place (Table 21-1).

There are four specific types of teeth, each serving a distinct purpose. The incisors are designed to cut, prehend, and groom. The canines are used to penetrate and grasp prey or food and also function as defensive weapons in protection. The cheek teeth (premolars and molars) assist in the ability to hold and carry, in addition to the breaking and tearing of food into smaller pieces in preparation for digestion. The so-called carnassials refer to the maxillary fourth premolar and mandibular first molar teeth, which serve a shearing function in carnivores.[66]

Tooth Formula in the Domestic Cat

The total number of teeth in the cat is greatly decreased compared with that of the dog, and the shapes of the crowns of feline teeth reflect the function of a true carnivore.[90] Accepted dental formulas for the deciduous and permanent dentition in the domestic cat are shown in Tables 21-2 and 21-3. Using the modified Triadan

TABLE 21-1 Eruption of the Deciduous and Permanent Dentitions in the Domestic Cat

	Deciduous Teeth	Permanent Teeth
Incisors	2-3 weeks	3-4 months
Canines	3-4 weeks	4-5 months
Premolars	3-6 weeks	4-6 months
Molars	No deciduous molars	4-5 months

TABLE 21-2 Formula for the Deciduous Dentition in the Domestic Cat

Deciduous	Incisors	Canines	Premolars	Total
Maxilla	3	1	3	× 2 = 26
Mandible	3	1	2	

TABLE 21-3 Formula for the Permanent Dentition in the Domestic Cat

Permanent	Incisors	Canines	Premolars	Molars	Total
Maxilla	3	1	3	1	× 2 = 30
Mandible	3	1	2	1	

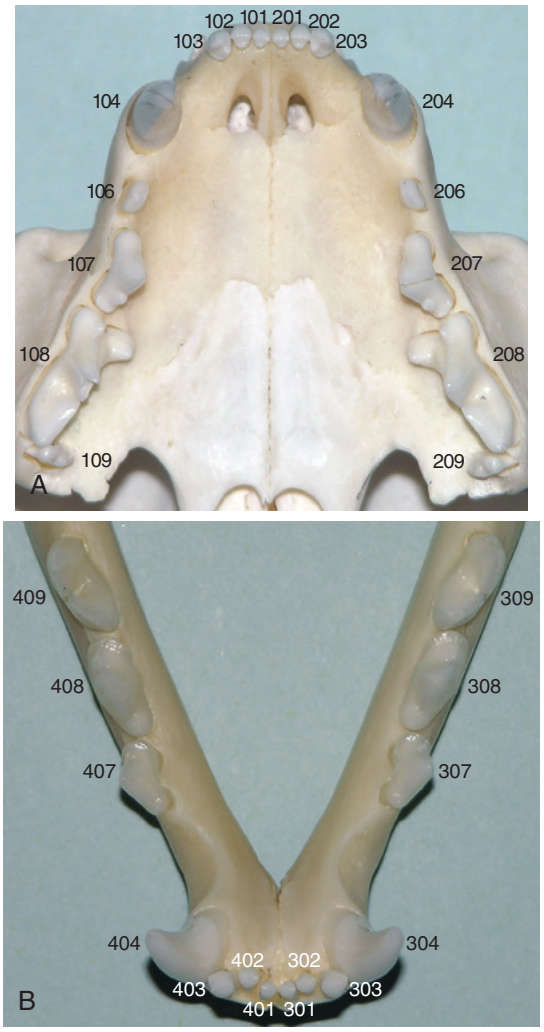


FIGURE 21-1 Modified Triadan tooth-numbering system for the maxillary **(A)** and mandibular **(B)** permanent teeth of the domestic cat. Note that there are no permanent maxillary first premolars or mandibular first and second premolars. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

tooth-numbering system, each jaw quadrant is numbered as follows: right maxillary quadrant 100 (500 when referring to deciduous teeth), left maxillary quadrant 200 (600 when referring to deciduous teeth), left mandibular quadrant 300 (700 when referring to deciduous teeth), and right mandibular quadrant 400 (800 when referring to deciduous teeth).[66]

Beginning with 01 for the first incisor (the one closest to the midline), teeth are consecutively numbered from mesial (the surface of the tooth that faces the midline of the dental arch) to distal (the surface of the tooth that faces away from the midline of the dental arch). Several premolars and molars have been evolutionarily lost in the permanent dentition of the cat. The canine (04) and the first molar (09) are present as reference teeth to allow counting forward or backward when numbering teeth. The permanent maxillary first (05) premolar and the permanent mandibular first (05) and second (06) premolars are absent in the cat. Because the maxillary fourth premolar (08) and mandibular first molar (09) are the largest cheek teeth of the upper and lower jaws, counting forward identifies the premolars between the maxillary canine and fourth premolar as the maxillary second and third premolars (teeth 06 and 07). Similarly, the premolars between the mandibular canine and first molar are identified as the mandibular third and fourth premolars (teeth 07 and 08).[66]

Taking the quadrant and tooth number into consideration, three numbers are used to identify a specific tooth. For example, the permanent right maxillary canine is tooth 104. The permanent right maxillary fourth premolar is tooth 108. The permanent left maxillary second premolar is tooth 206. The permanent left mandibular third and fourth premolars are teeth 307 and 308. The permanent right mandibular first molar is tooth 409 (Figure 21-1). The deciduous right maxillary canine is tooth 504. The deciduous right mandibular fourth premolar is tooth 808 (Figure 21-2).

Teeth

The tooth consists of a crown and one or more roots. Enamel (with >95% mineralization, the hardest tissue of the body) covers the crown, and cementum covers the

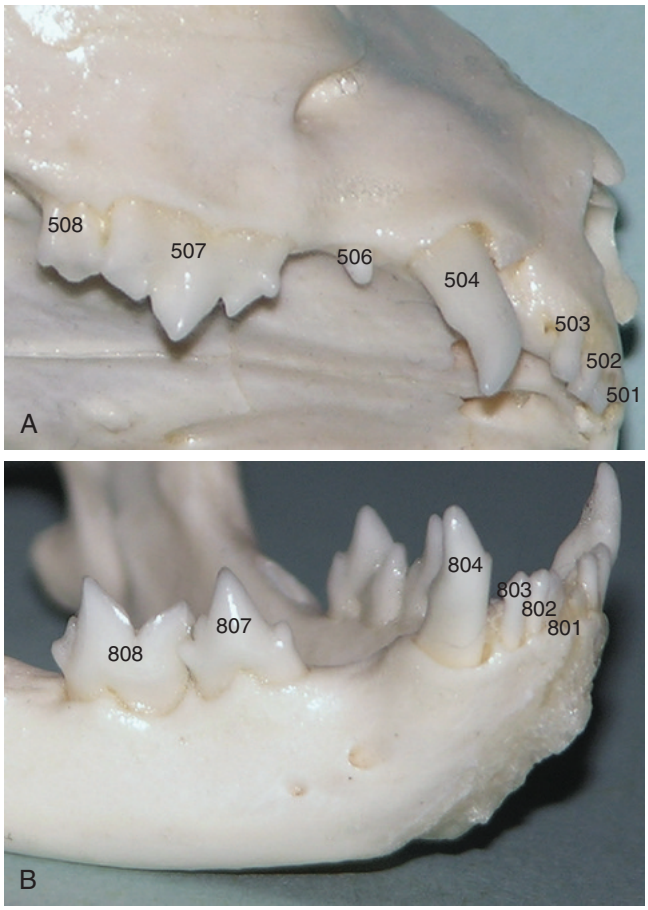


FIGURE 21-2 Modified Triadan tooth-numbering system for the maxillary **(A)** and mandibular **(B)** deciduous teeth of the domestic kitten. Note that the number of deciduous teeth differs from that of permanent teeth because there are no deciduous maxillary and mandibular first molars. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

root(s). The borderline between the anatomic crown and root(s) is the cementoenamel junction.[21] The incisors and canine teeth have one root. The maxillary second premolars and first molars have two roots that are often fused to each other, giving the appearance of only one root.[114] The mandibular third and fourth premolars and first molars and the maxillary third premolars have two roots. The maxillary fourth premolar has three roots. The furcation is where two or more roots meet at the crown.[66]

Dentin makes up the bulk of the adult tooth. It is approximately 70% mineralized and porous, and consists of thousands of dentinal tubules per square millimeter radiating outward from the pulp to the enamel in the crown and cementum in the root.[90] Odontoblasts line the periphery of the pulp cavity and produce dentin, which—in a vital tooth—is laid down throughout life. Dentinal tubules contain cytoplasmic processes of odontoblasts, fluid, and nerves extending from the pulp. Tooth pain may result from fluid movement and nerve stimulation in the area of exposed tubules. Odontoblasts adjacent to exposed dentinal tubules may respond by producing tertiary dentin to halt the progression of an external insult.[66]

The pulp cavity consists of the pulp chamber in the crown and the root canal(s) in the root(s) of the tooth. It contains the pulp, which is made up of undifferentiated mesenchymal cells, fibroblasts, odontoblasts, blood and lymph vessels, and nerves.[90] Odontoblasts line the inside of the pulp cavity at the periphery of the pulp, initially producing nonmineralized predentin, which later becomes mineralized dentin. Unlike human teeth that have only one apical foramen, the pulp of cat teeth connects with periapical tissues through several foramina in the root apex (forming the apical delta). Secondary, accessory, lateral, and furcation canals also may connect pulp tissue with the periodontal ligament.[80] Therefore entrance into the pulp cavity can be through exposed dentinal tubules, direct pulp exposure, and apical and non-apical ramifications.

The tooth "grows" toward the inside. The dentin becomes continually thicker in a vital tooth. Dentin apposition along the inside of the pulp cavity continues throughout life, unless irreversible pulpitis or pulp necrosis occurs. Therefore teeth of young adult cats have a fairly wide pulp cavity (Figure 21-3). In older cats the pulp cavity of teeth with vital pulps is usually very narrow (Figure 21-4). The narrower the pulp cavity, the thicker are the dentinal walls, and thus the stronger and more aged is the tooth.

Periodontium

The periodontium is a functional unit and consists of the gingiva, periodontal ligament, cementum, and alveolar bone.[90] The gingiva surrounds the tooth like a collar and is firmly attached to the alveolar bone and cervical portion of the tooth. The most coronal edge of the gingiva is the gingival margin. A normal space between the tooth and most coronal gingiva is called the gingival sulcus, which should not be deeper than 0.5 mm in cats. The periodontal ligament acts as shock absorber and attaches the tooth to the alveolar bone by means of Sharpey's fibers. Some fibers connect adjacent teeth by traveling through or coronal to the alveolar septum. Radiographically, the periodontal ligament space appears as a dark line surrounding the root.

The cementum covers the root(s) and is produced by cementoblasts. It is similar in mineral composition and histologic appearance to bone. Cementum width increases with age.[66] An excessive production of cementum (hypercementosis) is often seen in cat teeth, most commonly at the apical portion of the root. Alveolar bone surrounds the alveolar socket. An increased radiodensity of alveolar bone is visible adjacent to the periodontal ligament space, referred to as the *lamina dura*, which is an extension of cortical bone into the

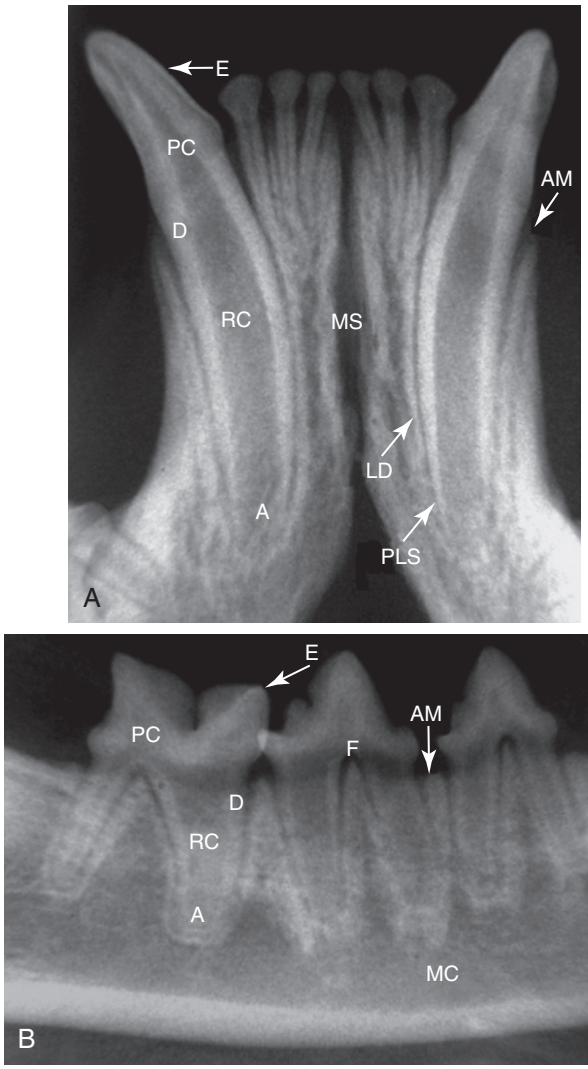


FIGURE 21-3 Radiographs of the mandibular incisors and canines **(A)** and the right mandibular cheek teeth **(B)** in a cat younger than 1 year of age. Note the thin dentinal walls, wide pulp cavities, and open root apices. *E,* Enamel; *PC,* pulp chamber; *D,* dentin; *RC,* root canal; *A,* apex; *MS,* mandibular symphysis; *AM,* alveolar margin; *LD,* lamina dura; *PLS,* periodontal ligament space; *F,* furcation; *MC,* mandibular canal. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

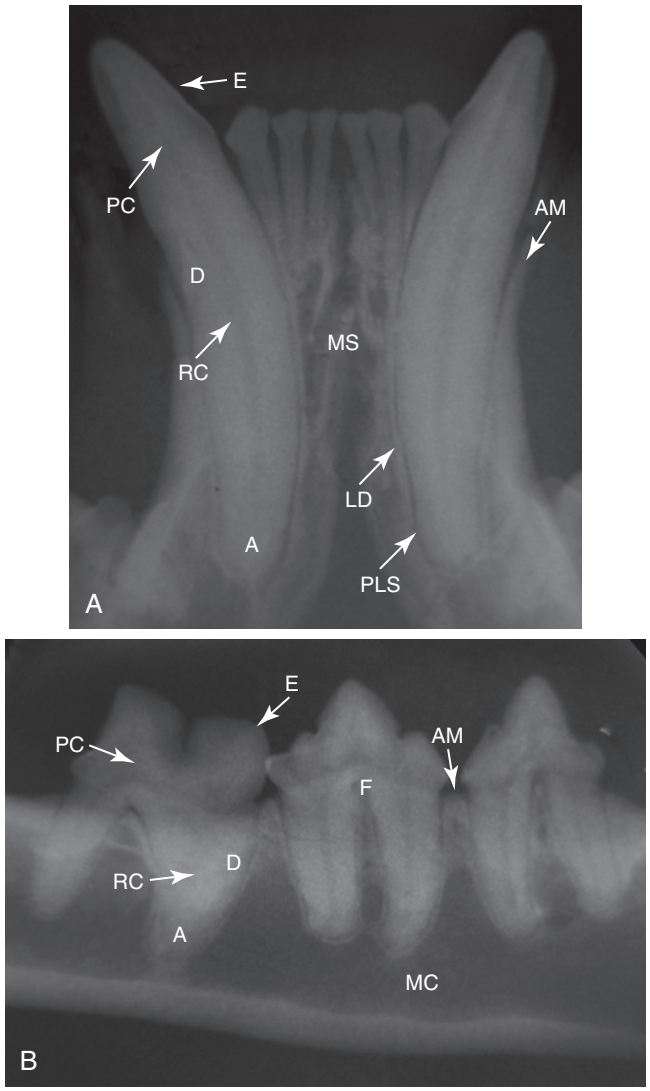


FIGURE 21-4 Radiographs of the mandibular incisors and canines **(A)** and the right mandibular cheek teeth **(B)** in a cat older than 3 years of age. Note the thicker dentinal walls, narrower pulp cavities, and closed root apices, compared with Figure 21-3. *E,* Enamel; *PC,* pulp chamber; *D,* dentin; *RC,* root canal; *A,* apex; *MS,* mandibular symphysis; *AM,* alveolar margin; *LD,* lamina dura; *PLS,* periodontal ligament space; *F,* furcation; *MC,* mandibular canal. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

alveolus. The most coronal edge of the alveolar bone is the alveolar margin.[66] Alveolar bone is constantly remodeling in response to use and the forces placed on it.

Oral Mucosa

Oral mucosa other than gingiva includes the very flexible and elastic alveolar mucosa, which covers the alveolar bone and is separated from the gingiva by the mucogingival junction; the labial and buccal mucosae, which line the inside of the lip and cheek; the loose sublingual mucosa, the mucosa covering the dorsal and ventral tongue surfaces; the mucosa of the hard palate, which is firmly attached to underlying maxillae and palatine bones; and the mucosa of the soft palate.[66] The oral mucosa is separated from the skin by the mucocutaneous junction (Figure 21-5).

Bones and Joints

Most cats are mesaticephalic; in other words, their heads are of medium proportions. Brachycephalic cats, such as the Persian, have short, wide heads. Dolichocephalic cats, such as the Siamese, have long, narrow heads. The

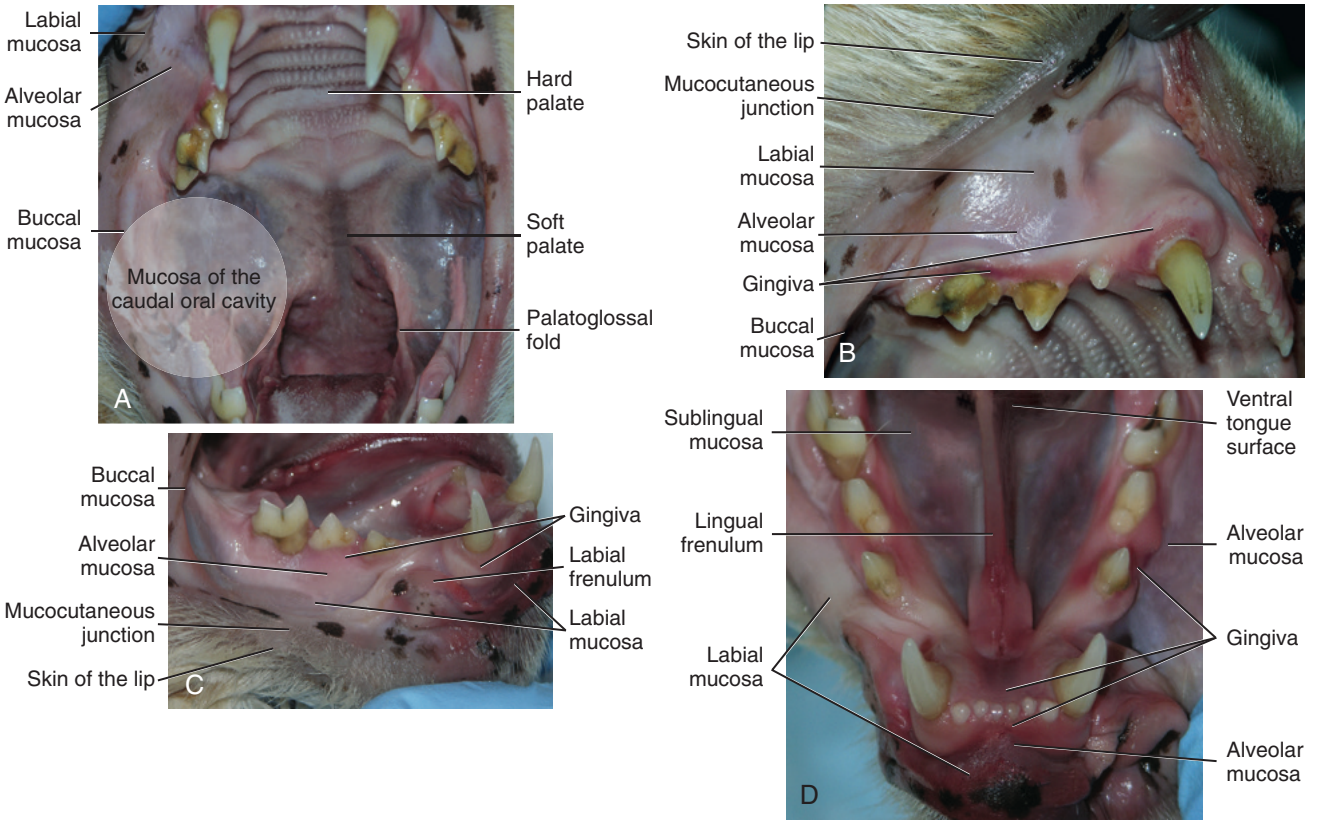


FIGURE 21-5 Oral mucosa of the roof of the mouth and caudal oral cavity **(A),** the upper jaw **(B),** the lower jaw **(C),** and the sublingual region **(D).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

upper jaw and the face consist of the paired incisive bones; maxillae; palatine, nasal, zygomatic, and temporal bones; and the unpaired vomer bone. The incisive bones carry the maxillary incisor teeth, and the maxillae carry the maxillary canines, premolars, and molars. The infraorbital canal (containing the infraorbital artery, vein, and nerve) penetrates the maxillary bone in the area of the fourth premolar and molar teeth.[66]

The lower jaw consists of the paired mandibular bones. The ventral third of each mandible includes the mandibular canal, which contains the inferior alveolar artery, vein, and nerve. Right and left mandibles are separated rostrally by a fibrocartilaginous synchondrosis (mandibular symphysis) and carry all mandibular teeth. The temporomandibular joint is formed by the condylar process of the mandible and the mandibular fossa and retroarticular process of the temporal bone (Figure 21-6). A thin fibrocartilagenous disk lies between the hyaline cartilage–covered articular surfaces. A thick band of fibrous tissue on the lateral aspect of the joint capsule forms the lateral ligament, which tightens when the jaw opens.[66]

Muscles, Cheeks, and Lips

The masticatory musculature includes the masseter, temporal, and pterygoid (medial and lateral) muscles, which close the mouth, and the digastricus muscle, which opens the mouth.[90] The lips and cheeks of cats are "tighter" and their oral vestibules less spacious than in dogs, making their labial and buccal mucosae less available for closure of large intraoral wounds. The commissure is where the upper and lower lips meet. There are three important structures within the soft tissues of the cheek that run nearly parallel over the masseter musle in a rostrocaudal direction: the dorsal and ventral buccal branches of the facial nerve and the parotid duct traversing between the two nerves and opening into the mouth at the parotid papilla in the buccal mucosa near the maxillary fourth premolar.[66]

Palate

The primary palate is made up of the rostral upper lip and the most rostral hard palate. The majority of the

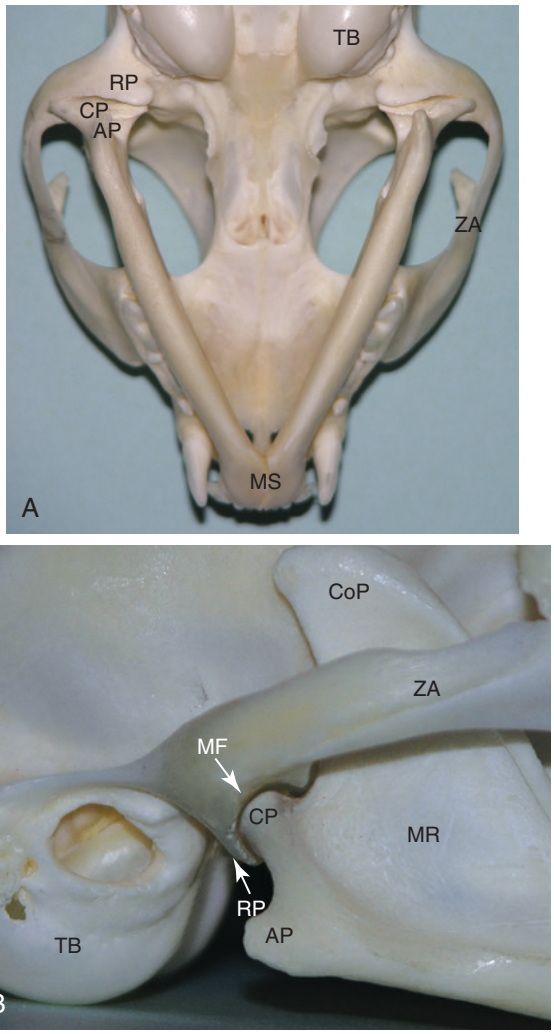


FIGURE 21-6 Ventral **(A)** and lateral **(B)** views of the feline skull, showing the temporomandibular joints and the mandibular symphysis. *CP,* Condylar process; *RP,* retroarticular process; *AP,* angular process; *TB,* tympanic bulla; *ZA,* zygomatic arch; *MS,* mandibular symphysis; *CoP,* coronoid process; *MR,* mandibular ramus. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

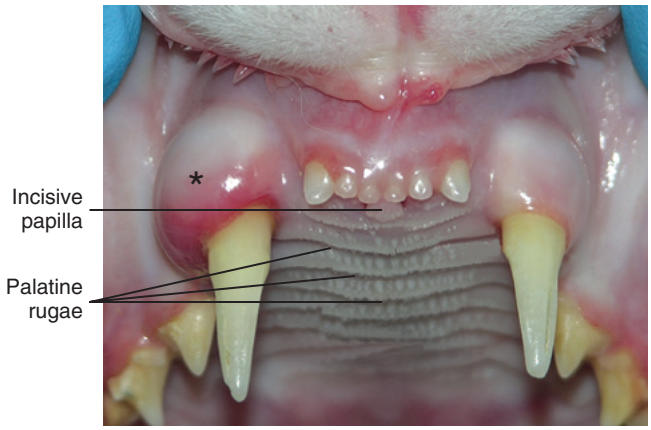


FIGURE 21-7 Note the incisive papilla just caudal to the maxillary first incisor teeth and the palatine rugae of the hard palate. The right maxillary canine tooth appears extruded and shows periodontal inflammation and severe alveolar bone expansion *(asterisk). (Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

hard palate and the soft palate constitute the secondary palate. The hard palate mucosa is non-elastic and has several transverse ridges (palatine rugae) and depressions. On the midline rostral to the first palatine ruga and just caudal to the maxillary first incisor teeth is the incisive papilla, which should not be confused with an abnormal proliferative lesion (Figure 21-7).[90] The main blood supply to the hard palate mucosa is provided by the paired major palatine arteries, which pass through the palatine canals and emerge at the major palatine foramina palatal to the level of the maxillary fourth premolar teeth about halfway toward the midline, from where they run rostrally in the palatine sulci to the palatine fissures.[66]

When the tongue is withdrawn from the mouth, palatoglossal folds can be seen that run from the body of the tongue to the rostrolateral aspect of the muscular and elastic soft palate, which receives its main blood supply from the paired minor palatine arteries. The soft palate is elevated and closes off the nasopharynx during swallowing, and it is depressed and closes off the oropharynx during nose breathing.

Tongue

The tongue has a complex muscular structure and is used to lap fluids, form food boluses, and groom the cat's fur. The body of the tongue constitutes the rostral two thirds, and the root of the tongue constitutes the caudal one third. The lateral margins of the tongue separate the dorsal and ventral surfaces.

The lingual mucosa is thick and heavily cornified dorsally but thin and less cornified ventrally. The cat's dorsal tongue surface is very rough, with firm papillae that point caudally (Figure 21-8). The lingual frenulum, which is part of the sublingual mucosa whose submucosa contains the paired sublingual veins and mandibular and sublingual gland ducts, connects the body of the tongue to the floor of the mouth. The sublingual caruncles are situated at the frenulum's rostroventral aspect and contain the orifices of mandibular and sublingual gland ducts. The lingual artery is the major blood supply to the tongue.[66]

Salivary Glands

There are four pairs of major salivary glands in cats: the parotid gland surrounding the horizontal ear canal; the mandibular gland situated in the Viborg's triangle, near the maxillary and linguofacial veins; the sublingual gland, with its monostomatic part intimately attached to the mandibular gland and its polystomatic part located

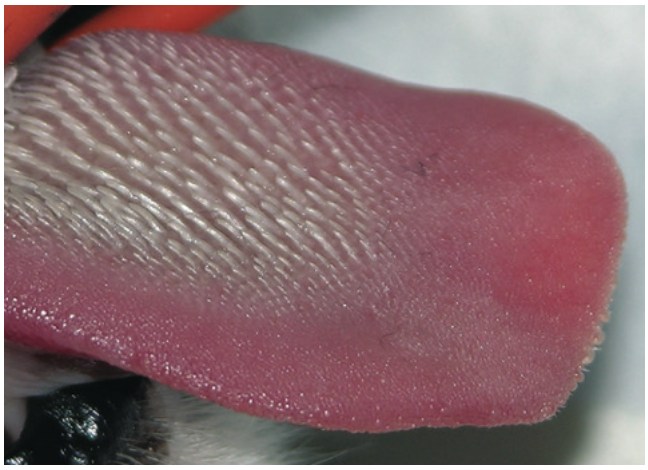


FIGURE 21-8 Caudally pointing firm papillae on the cat's rough dorsal tongue surface. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

more rostrally between the mandible and the tongue; and the zygomatic gland, located on the floor of the orbit, whose ducts open on the buccal mucosa near the maxillary first molar tooth.[90] Scattered glandular tissue is present submucosally in the lips (ventral and dorsal buccal glands). A small lingual molar gland is situated caudolingually to each mandibular first molar tooth and should not be confused with an abnormal proliferative lesion.[88]

Lymph Nodes and Tonsils

There are three lymph centers in the head (parotid, mandibular, and retropharyngeal).[66] The parotid lymph node is located at the rostral base of the ear. Several mandibular lymph nodes lie ventral to the angle of the jaw above and below the linguofacial vein. The medial retropharyngeal lymph node is an elongated, transversely compressed node and lies along the craniodorsal wall of the pharynx. The paired small palatine tonsil is attached to the lateral pharyngeal wall.

Neurovascular Structures

The maxillary and mandibular branches of the trigeminal nerve are sensory, but the mandibular branch also supplies motor function to the masticatory musculature and other muscles. The lingual nerve is a branch of the mandibular nerve and provides sensory function to the rostral two thirds of the tongue. The facial nerve provides motor function to many cutaneous facial muscles and the caudal belly of the digastricus muscle and is responsible for taste in the rostral two thirds of the tongue.

The maxillary artery provides blood supply to the upper jaw by way of the infraorbital, palatine (major and minor), and sphenopalatine arteries. The inferior alveolar artery (running in the mandibular canal) is a branch of the maxillary artery and provides blood supply to the lower jaw. It exits at the caudal, middle, and rostral mental foramina to supply the lower lips. Veins often exist concurrently with arteries and empty by way of the maxillary and linguofacial veins into the external jugular vein.[66]

Common Terminology

Rostral refers to the direction toward the tip of the nose, *caudal* to the direction toward the tail, *ventral* to the direction toward the lower jaw, and *dorsal* to the direction toward the top of the head or muzzle. *Mesial* is the surface of a tooth facing the midline of the dental arch, and *distal* is the surface of a tooth facing away from the midline of the dental arch. *Labial* is the surface of a tooth facing the lip, and *buccal* is the surface of a tooth facing the cheek. *Lingual* refers to the surface of mandibular teeth facing the tongue, and *palatal* refers to the surface of maxillary teeth facing the hard palate (Figure 21-9). *Occlusal* refers to the surface of a tooth facing an opposing dental arch, *coronal* refers to a location or direction toward the crown of a tooth, and *apical* refers to a location or direction toward the apex of a tooth's root. *Subgingival* refers to an area that is apical to the gingival margin, and *supragingival* refers to an area that is coronal to the gingival margin.[66]

ORAL EXAMINATION

Patient History and Clinical Signs

Age, breed, and sequence of development of clinical signs often are useful indicators. A full patient history is essential and should include questions about appetite; eating and drinking patterns; prehending, chewing, and swallowing; preference for soft or hard food; behavioral idiosyncrasies; access to treats and toys; vomiting, diarrhea, and weight loss; coughing and sneezing; polydipsia and polyuria; scratching, head shaking; presence of rapid lower jaw motions; previous and current medications (and responsiveness to medications); the animal's environment; and the type and frequency of home oral hygiene.[46]

The presence of halitosis, preferential chewing on one side of the mouth, inability or reluctance to open or close the mouth, dropping food from the mouth, drooling of saliva, inappetence, weight loss, sneezing, nasal discharge, pawing at the face, enophthalmos or exophthalmos, oral and maxillofacial swellings, pain on palpation of oral and maxillofacial tissues, atrophy of masticatory muscles, malocclusion, and other abnormal clinical signs should be assessed. It is often helpful for the examiner

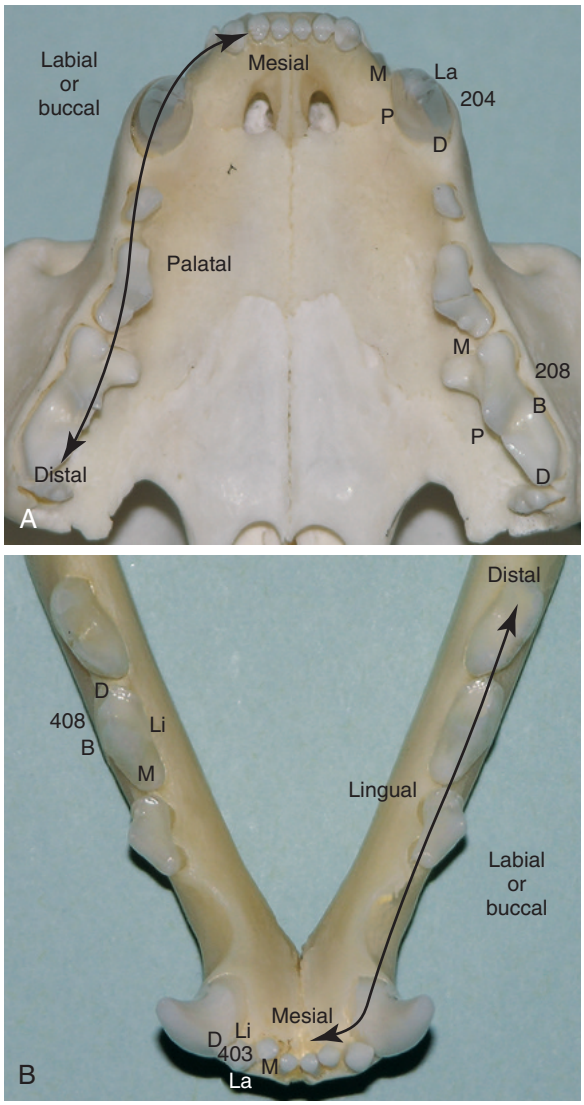


FIGURE 21-9 Directions and surfaces of maxillary **(A)** and mandibular **(B)** teeth. *M,* Mesial; *La,* labial; *B,* buccal; *D,* distal; *P,* palatal; *Li,* lingual. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

to watch the animal eat and drink if the owner reports any abnormal behavior during eating and drinking.[46]

Halitosis may be caused by oral disease (e.g., periodontal disease, stomatitis, neoplasia), nonoral diseases (e.g., uremia, respiratory or gastrointestinal disease), and the diet. Inappetence may result from pain associated with inflammation and ulceration in the oral cavity. This may progress to unwillingness or inability to drink, which in turn leads to dehydration. Pawing at the mouth and rubbing the mouth on furnishings are indications of oral or facial pain. Drooling usually results from the reluctance or inability to swallow rather than from increased salivary production. It also may be caused by the reluctance or inability to close the mouth. Saliva may be blood stained if ulceration is present in the mouth. Dysphagia (i.e., difficulty in or pain on swallowing) may result from inflamed, ulcerated, or traumatized tissues that cause local pain or from obstruction to the mechanics of swallowing by a mass lesion, neurologic disease, or palate defects. Rapid lower jaw motions ("jaw chattering") often indicate oral pain in cats with tooth resorption. Nasal discharge may be related to rhinitis, endodontic disease, neoplasia, or a palate defect.[46]

The cat may be unable or unwilling to eat or chew on the side of the mouth that has a problem. Teeth on the affected side may then show increased plaque and calculus accumulation compared with those on the healthy side. Differential diagnoses for a cat that is unable or unwilling to open the mouth include oral ulceration, temporomandibular joint ankylosis, maxillofacial fractures, tetanus, ocular disease, space-occupying retrobulbar lesion, ear disease, and neoplasia. Differential diagnoses for a cat that is unable or unwilling to close the mouth include temporomandibular joint luxation or fracture of bones forming the joint, open-mouth jaw locking, maxillary and (bilateral) mandibular fractures, and neoplasia.[46]

Extraoral Examination

The eyes, ears, nose, face, lips, jaws, masticatory muscles, lymph nodes, and salivary glands should be examined. Attention should be paid to the nostrils (one nostril is closed with a thumb while airflow from the other nostril is evaluated); any discharge from oral, nasal, and ocular orifices and sinus tracts; facial lacerations; asymmetry and facial swellings; presence of exophthalmos or enophthalmos; the ability to retropulse the eye globes (assessed by gently pushing them into their orbits); and swelling or atrophy of masticatory muscles.

The jaws, intermandibular tissues, zygomatic arches, and neck should be palpated for pain, asymmetry, discontinuity, crepitus, and emphysema. The range of mouth opening is assessed, which also provides information about abnormalities of the temporomandibular joints and muscles of mastication.[46]

Intraoral Examination

The skin and mucocutaneous areas should be examined before opening the cat's mouth. The labial and buccal mucosa is examined by lifting the cat's upper and lower lips. The oral mucosa should be moist, intact, and nonpainful on touch and may be pigmented. The color, size, location, thickness, surface characteristics, and symmetry of any oral lesions should be noted.[46] The incisors, canines, and most cheek teeth can be evaluated without opening the mouth. Opening the mouth is greatly facilitated when the cat's head is rotated dorsally. One hand holds the entire head (in the area of the zygomatic arches) and then rotates it dorsally. The other hand

FIGURE 21-10 Note that the cat already starts opening the mouth after slight dorsal rotation of its head with one hand **(A).** The index finger of the other hand opens the mouth by pushing the lower jaw ventrally. Gently forcing the thumb of the same hand into the intermandibular area will raise the tongue, allowing inspection of its ventral surface and the sublingual tissues **(B).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

opens the mouth by pushing the lower jaw ventrally (Figure 21-10). The ventral surface of the tongue and sublingual tissues can be inspected by gently forcing the thumb of the second hand into the intermandibular area. This raises the tongue. The hard palate can also be inspected.[46] Obvious lesions such as fractured teeth, moderate to severe periodontal disease, stomatitis, and oral masses can often be identified in the conscious patient. However, sedation or general anesthesia is usually required for a thorough intraoral examination.

The two most important instruments for evaluation of dental and periodontal tissues are the dental explorer and periodontal probe (Figure 21-11). The structural integrity of teeth is assessed with a dental explorer whose pointed tip can detect irregularities of the crown surface. It is also used to determine the presence of pulp

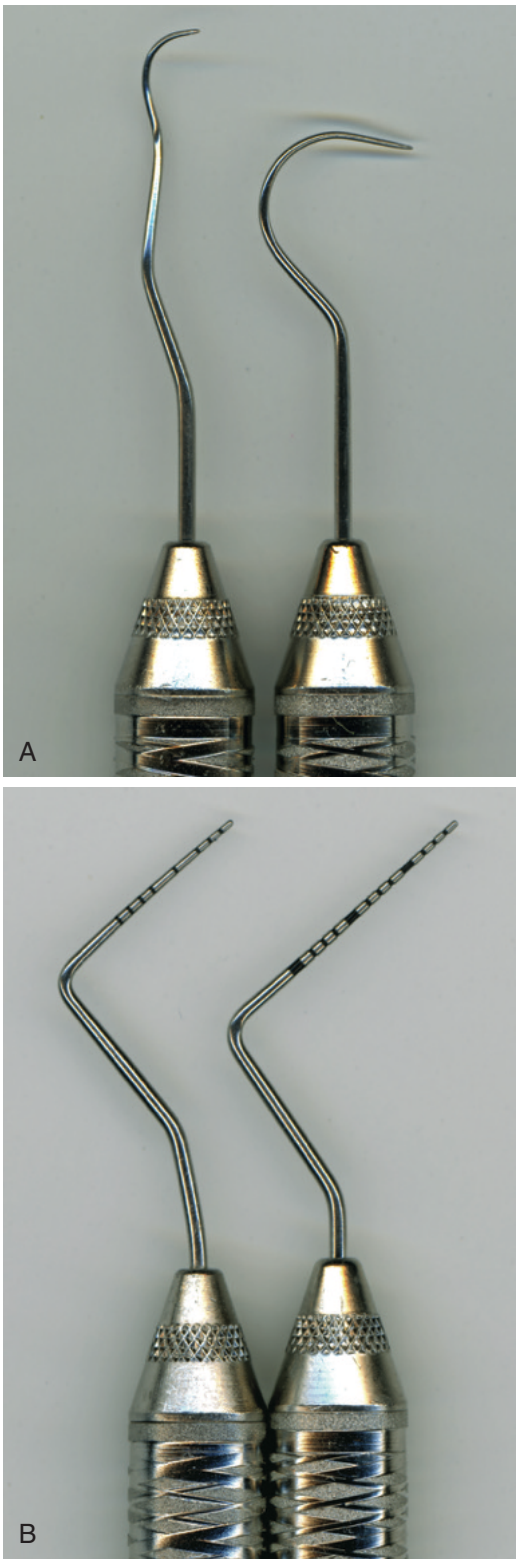


FIGURE 21-11 Dental explorers **(A)** are used for tactile exploration of the tooth's surfaces; the 11/12 ODU explorer on the left is preferred over the sphepherd's hook on the right for exploration of feline teeth. Periodontal probes **(B)** are used for measuring of gingival sulcus and periodontal pocket depths; the Williams probe on the left (with markings at 1, 2, 3, then 5, then 7, 8, 9, and 10 mm) is preferred over the CP-15 UNC on the right (with millimeter markings and a wide, black marking at 5, 10, and 15 mm) for probing of feline teeth. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

exposure in a fractured tooth. The alveolar mucosa over the roots of the teeth should be inspected and palpated for the presence of swellings and sinus tracts (the latter are often located near the mucogingival junction), which may indicate endodontic disease or neoplasia.[46] The periodontal probe is invaluable for an accurate periodontal examination. The probe is gently inserted into the gingival sulcus, and measurements are obtained at several locations around the entire circumference of each tooth. The gingival sulcus of cat teeth should not be deeper than 0.5 mm. Greater measurements indicate the presence of a periodontal pocket or, in the case of gingival enlargement, a pseudopocket. Other periodontal parameters include plaque and calculus (tartar) accumulation, gingival index, gingival recession or enlargement, total attachment loss, tooth mobility, and missing teeth. Any other abnormalities should be recorded in the dental chart, such as persistent (retained) deciduous teeth, supernumerary teeth, dental or skeletal malocclusion, circumscribed ulcers, widespread oral inflammation, palate defects, oral masses, lacerations, and other signs of trauma.[46]

Laboratory Examination

Examination for systemic disease is important to assess anesthetic risk or determine the possibility of dental and oral lesions being secondary to a systemic condition.[46] Preanesthetic blood tests should include a complete blood cell count and biochemical profile. Blood typing and cross-matching may occasionally be indicated. Urinalysis and cardiac examination are performed as necessary. Cats with acute or chronic oral inflammation (beyond gingivitis) should be tested for feline leukemia virus (FeLV), for feline immunodeficiency virus (FIV), and occasionally for feline bartonellosis.

DIAGNOSTIC IMAGING

Dental Radiography

Dental radiographs should always be obtained before tooth extraction to assess alveolar bone health and variations in root anatomy and to determine the presence of dentoalveolar ankylosis or replacement resorption of roots that could complicate the extraction procedure. They are also essential during all steps of endodontic procedures, including assessment of treatment outcome at follow-up visits. In addition to dental-related conditions, most jaw pathology can be satisfactorily assessed with dental (nonscreen) film and intraoral and extraoral imaging techniques.[28]

Needed equipment includes a dental radiography machine, dental (nonscreen) films, a chairside film processor, developer and fixer solutions, and a view box. Digital imaging uses sensor pads or phosphor plates (instead of films) that transfer the image to a computer. The digital system requires less radiation to produce an image, which may also be modified with software programs. Exposure time often is the only adjustment to be made and depends on the size of the patient and tissue thickness to be imaged.[82,84] Dental film is available in several sizes and speeds, with sizes 0, 2, and 4 and D film (ultra speed) most commonly used (Figure 21-12). The largest dental film (size 4) is very useful to evaluate diseases of the nasal cavity, orbit, zygomatic arch, mandibular ramus, temporomandibular joint, and tympanic bulla in cats. The films are inside a moisture-resistant packet and surrounded by black paper. A layer of lead foil is located at the back of the packet next to the tab opening, protecting the film from secondary radiation. A dimple is located in one corner of the film packet and also on the film and is used to distinguish images obtained from the left and right sides of the mouth on the processed radiographs. The convex (raised) surface of the dimple must face the radiographic beam during exposure. Dental rapid developer and fixer solutions are placed in small containers within a chairside film processor (from left to right: developer, water, fixer, and water).[47]

All personnel should leave the room while radiographs are exposed. If this is not possible, anyone remaining in the room should stand at least 6 feet from the radiographic cone and at a 90- to 135-degree angle to the tube head. Gauze or paper may be used to hold the films in proper position inside the mouth of an

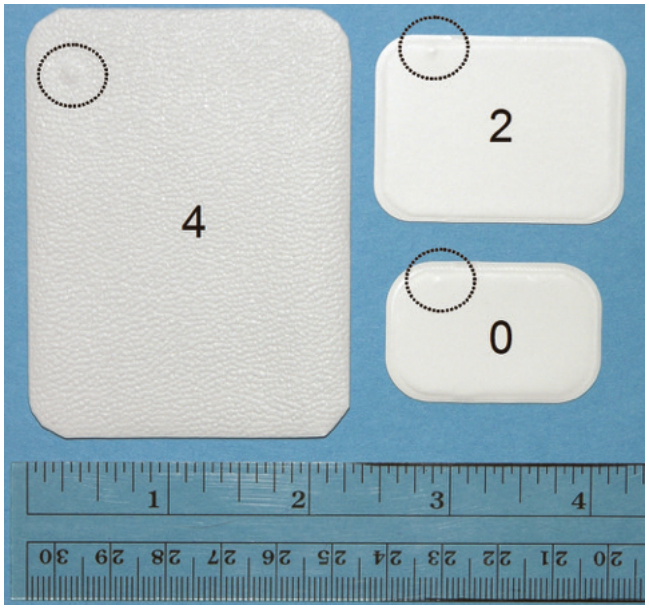


FIGURE 21-12 Sizes 0, 2, and 4 dental film; note the convex (raised) surface of the dimple *(circled)* that must face the radiographic beam during exposure. (*Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

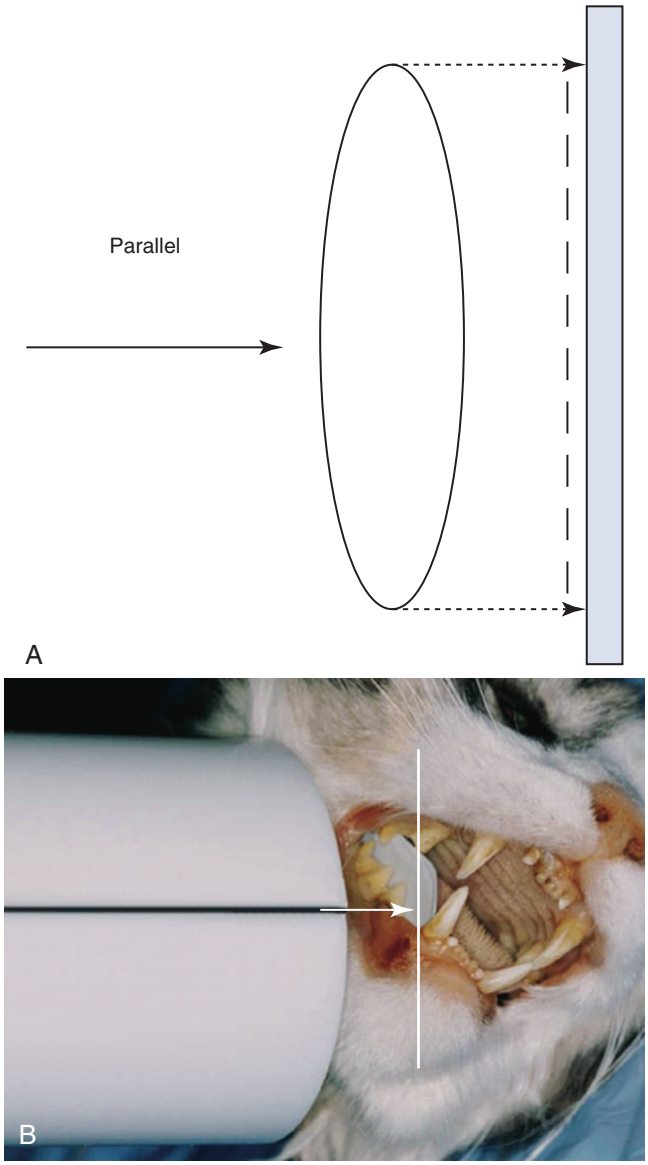


FIGURE 21-13 Parallel technique with the film placed parallel to the tooth and the radiographic beam directed perpendicular (90 degrees) to the film and tooth **(A),** shown for imaging the mandibular cheek teeth in a cat **(B).** *(***A** *copyright 2010 Dr. Alexander M. Reiter; used with permission;* **B** *from Harvey CE, Flax BM: Feline oral-dental radiographic examination and interpretation,* Vet Clin North Am Small Anim Pract *22:1279, 1992.)*

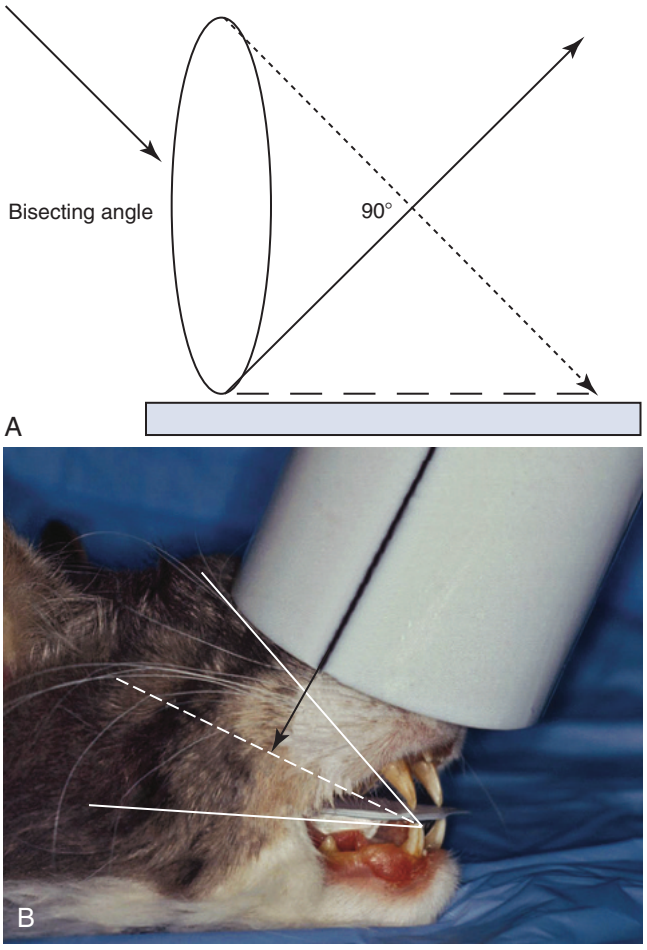


FIGURE 21-14 Bisecting angle technique with the radiographic beam directed perpendicular (90 degrees) to an imaginary line that bisects the angle formed between the long axis of the teeth and the plane of the film **(A),** shown for imaging the maxillary canine and incisor teeth in a cat **(B).** *(***A** *copyright 2010 Dr. Alexander M. Reiter; used with permission;* **B** *from Harvey CE, Flax BM: Feline oral-dental radiographic examination and interpretation,* Vet Clin North Am Small Anim Pract *22:1279, 1992.)*

intubated cat. The parallel technique is used for imaging the mandibular molars and the caudal mandibular premolars, with the film placed parallel to the teeth and the radiographic beam directed perpendicular (90 degrees) to the film and teeth (Figure 21-13).[84] The bisecting angle technique minimizes distortion when obtaining radiographs of all maxillary teeth and the mandibular canines, incisors, and rostral premolars (Figure 21-14).[42] The film is placed as close to the teeth as possible. The angle that is formed between the long axis of the teeth and the plane of the film is bisected by an imaginary line. The tube head is positioned perpendicular to this imaginary line. An extraoral technique has also been suggested for imaging the maxillary cheek teeth to avoid overlapping of the teeth with the zygomatic arch of the cat.[28,47,83]

The lid of the chairside film processor must be closed when processing dental radiographs. One hand holds the film, the other hand a film clip. Both hands are slid through the front windows of the processor. The exposed film is removed from the packet and placed in the film clip. The film is first placed into developer for about 30 seconds, then briefly rinsed in water, and placed in fixer for at least 60 seconds before viewing. After another brief water rinse, the film may be viewed using a dental view box. After initial viewing the film should be placed for

another 15 minutes in the fixer solution. This is followed by thorough rinsing under running water for 20 minutes before air drying the film. Films dried over night are stored in a labeled envelope and kept as part of the patient's medical record.[28,86]

Dental radiographs should be viewed in labial mounting (all of the radiographs in this chapter were obtained with dental film and are arranged in labial mounting), which requires that the processed film be placed on the view box with the raised dot facing the viewer.[28] It is determined whether the image is of the upper or lower jaw and of the left or right side. The only three-rooted teeth are the maxillary fourth premolars. The palatine fissure is also located in the upper jaw. The ventral mandibular cortex or mandibular canal is often visible on films of the lower jaw. Films of teeth of the left jaws are placed on the right side of the view box, and those of the right jaws on the left side of the view box. Each film should be rotated so that the crowns of the maxillary teeth face downward and those of the mandibular teeth face upward.

The enamel, dentin, cementum (visible radiographically only when thickened), alveolar margin, periodontal ligament space, lamina dura, and pulp cavity are evaluated. The mandibular canal is visible as a radiolucent tubular structure in the mandible. Mental foramina and palatine fissures may sometimes be mistaken for periapical pathology.[28,47]

Computed Tomography

Computed tomography is a useful imaging modality for the diagnosis and treatment planning of oral and maxillofacial trauma, neoplasia, and many other conditions.[3,108] It is of great value for exploration of a large volume of soft and hard tissue in a significantly shorter examination time and at a much lower cost than magnetic resonance imaging. This is particularly important when a rapid diagnosis is needed for patients with head trauma or uncertain head pathology and for those that are less than optimal anesthesia candidates. Computed tomography is of great value for detection of hard tissues, which is imperative when defining tumor margins and planning radical surgical excision. It also allows three-dimensional reconstruction, which facilitates understanding of the overall appearance of lesions, and can help guidance of a needle aspiration to establish a cytologic diagnosis.

The patient is placed on the couch in sternal recumbency with the head extended and secured in position and the forelimbs flexed caudally. Fluid lines and other extraneous structures are kept out of the gantry field to prevent artifacts. After a precontrast scan, an intravenous iodinated contrast medium is administered and a postcontrast scan is performed. Precontrast and postcontrast image series of the entire head and cranial neck should be obtained in an axial scanning mode, with slice thickness of 1 mm and interval of 2 to 3 mm for bone and slice thickness of 3 mm and interval of 3 mm for soft tissue. If lesions are located in surgically inaccessible locations, a fine needle aspirate can be obtained with an appropriate needle, which is inserted into the skin and advanced under subsequent computed tomography guidance (scan, advance, scan) to the lesion.

Soft tissue structures are evaluated on soft tissue algorithm images, and the teeth, bones, and joints of the head are evaluated on bone algorithm images (Figure 21-15). Window levels and widths are adjusted manually as needed. Maxillofacial soft tissue structures of interest

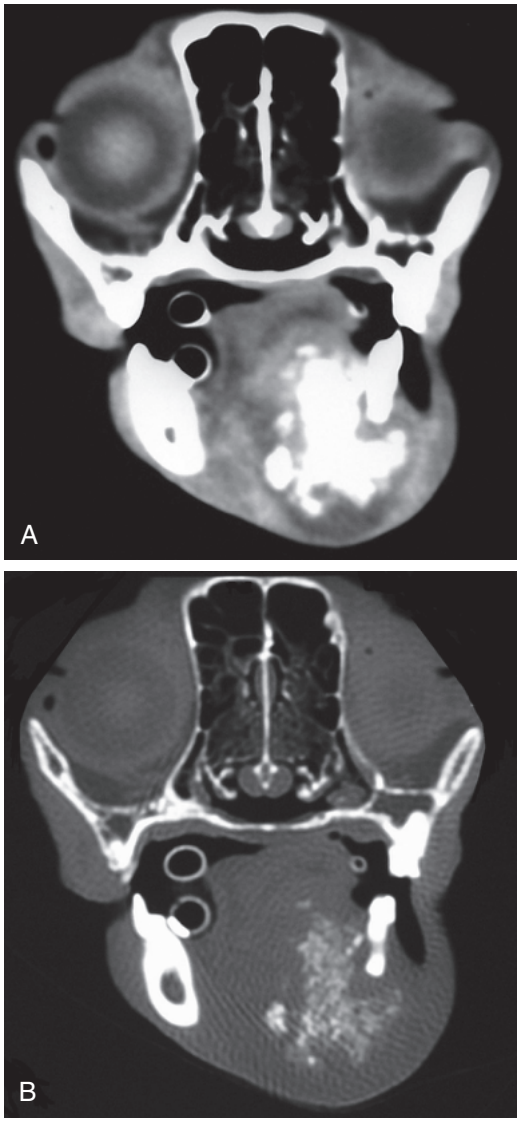


FIGURE 21-15 Computed tomography performed in a cat with left mandibular squamous cell carcinoma. Soft tissue structures are evaluated on a soft tissue algorithm image **(A),** and the teeth, bones, and joints of the head are evaluated on a bone algorithm image **(B).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

include the masticatory muscles, salivary glands, soft tissue coverings of the nasal and oral cavity, soft palate, pharynx and larynx, and head and neck lymph nodes. These soft tissues can be evaluated for their size, precontrast tissue attenuation and shape of abnormal densities, and degree and distribution of contrast enhancement. Enlarged soft tissues are consistent with edema, inflammation, or neoplasia. Abnormally small soft tissue structures are indicative of atrophy, necrosis, or fibrosis. Precontrast tissue hypoattenuation indicates increased fluid content consistent with edema. Irregular contrast enhancement is indicative of areas of increased vascularity consistent with inflammation or neoplasia, and nonenhancing cores are suggestive of necrosis or abscess. Bones and joints of the head are evaluated for any evidence of periosteal reaction or periarticular new bone formation, fractures, osteolysis, deformity, masses, and joint pathology.[37] The teeth are evaluated for structural defects, abnormal root canal widths, and changes to the periodontal attachment apparatus.

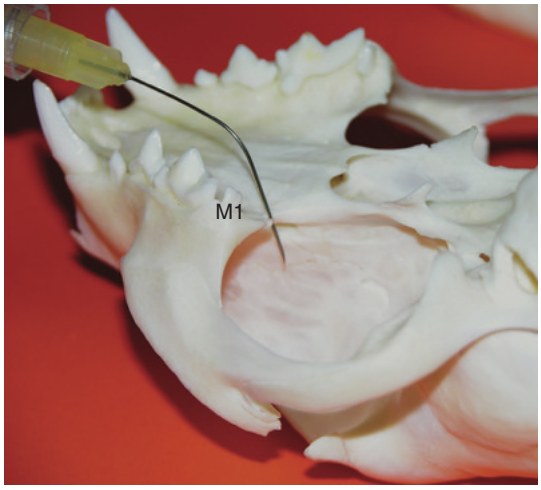


FIGURE 21-16 Maxillary nerve block demonstrated on a cat skull. Note the location of the needle in relation to the maxillary first molar tooth (M1). *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

LOCAL AND REGIONAL ANESTHESIA

Local and regional anesthesia allows reduction in the concentration of an inhalant anesthetic, which minimizes complications from hypotension, bradycardia, and hypoventilation. Patients consequently recover more quickly and with fewer complications. Furthermore, local and regional anesthesia continues to provide analgesia in the postoperative period, thus increasing patient comfort and decreasing the need for systemic administration of analgesics.[6,43,59,103]

Local anesthesia (e.g., infiltration anesthesia, use of topical anesthetic gels, and splash block) is less commonly performed in dentistry and oral surgery. *Regional anesthesia* (nerve blocks) refers to injection of a local anesthetic solution around a major nerve, utilizing 27-gauge, 1½-inch needles on 1-mL syringes (22-gauge needles when going through skin).[53,59,103] Commonly used local anesthetics in dentistry and oral surgery include bupivacaine 0.5% (effective for 6 to 10 hours) and lidocaine 2% without epinephrine (effective for less than 2 hours). The onset time for analgesia is longer with longer-acting local anesthetics (a few minutes for lidocaine, up to 30 minutes for bupivacaine). The total maximum dosage in cats is 2 mg/kg for bupivacaine and 1 mg/kg for lidocaine.[53,59] There are 5 mg of bupivacaine in 1 mL of a 0.5% solution (bupivacaine 0.5%).

The maxillary nerve block is given just caudal to the first molar tooth where the maxillary nerve enters the infraorbital canal through the maxillary foramen (Figure 21-16). Care must be taken not to inject anesthetic into the eye globe. The areas blocked include the incisive bone, maxilla and palatine bone, all maxillary teeth

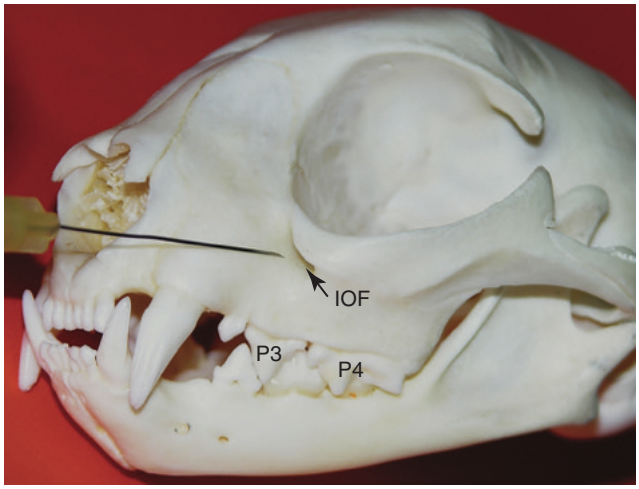


FIGURE 21-17 Infraorbital nerve block demonstrated on a cat skull. Note the location of the infraorbital foramen (IOF) in relation to the maxillary third (P3) and fourth (P4) premolars. The needle may also be advanced into the infraorbital canal to block hard and soft tissues caudal to the infraorbital foramen. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

on that side, and adjacent soft tissues. Because the infraorbital canal is very short in the cat and the maxillary nerve can easily be reached by a needle advanced through the infraorbital canal, an infraorbital approach is usually chosen to perform a maxillary nerve block. The infraorbital nerve block is given at the infraorbital foramen or inside the infraorbital canal (Figure 21-17). The areas blocked include the incisive bone and maxilla, maxillary incisors, canine, and premolars/molars (depending how far the needle is advanced into the infraorbital canal) and adjacent soft tissues. The major palatine nerve block is given through the thick palatal

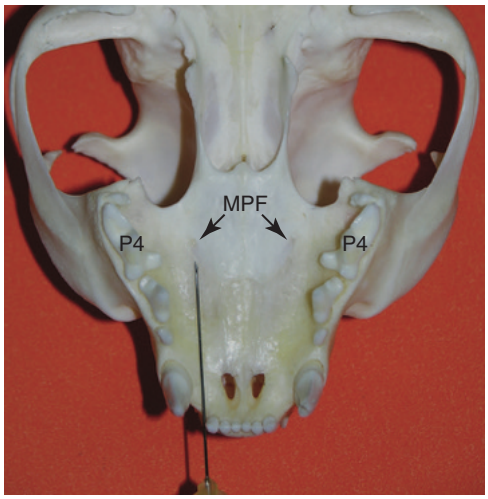


FIGURE 21-18 Major palatine nerve block demonstrated on a cat skull. Note the location of the major palatine foramina *(arrow)* in relation to the maxillary fourth premolar teeth (P4). *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

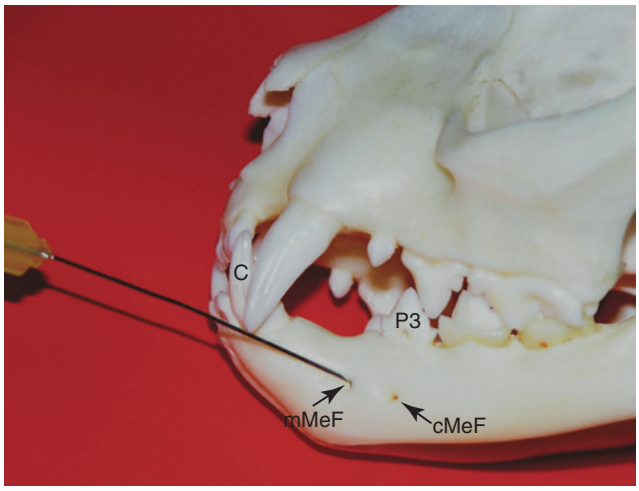


FIGURE 21-20 Middle mental nerve block demonstrated on a cat skull. Note the location of the middle mental foramen (mMeF) in relation to the mandibular canine (C) and third premolar (P3) teeth and the caudal mental foramen (cMeF). *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

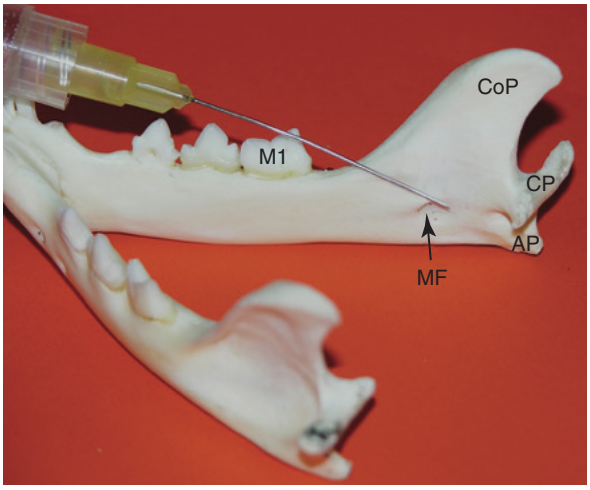


FIGURE 21-19 Inferior alveolar nerve block demonstrated on a cat skull. Note the location of the mandibular foramen (MF) in relation to the mandibular first molar tooth (M1) and the processes of the mandibular ramus. *CoP,* Coronoid process; *CP,* condylar process; *AP,* angular process. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

mucosa just rostral to the major palatine foramen (Figure 21-18). The areas blocked include the palatine shelf of the maxilla and adjacent soft tissues. The inferior alveolar nerve block can be given intraorally (at a relatively flat angle through the alveolar mucosa at the lingual surface of the mandible) (Figure 21-19) or extraorally through the skin slightly rostral to the angular process at the medial side of the mandible. The areas blocked include the mandibular body, all mandibular teeth, and adjacent soft tissues. The middle mental nerve block is given through the lateral labial frenulum at the middle mental foramen halfway between the canine and third premolar (Figure 21-20). The areas blocked include the rostral mandibular body, teeth rostral to the injection site, and adjacent soft tissues.[6,53,59,103]

PERIODONTAL DISEASE

Periodontal disease affects a majority of adult cats and involves inflammation and infection of the periodontium (gingiva, periodontal ligament, alveolar bone, and cementum) caused by plaque bacteria and the host's response to the bacterial insult. Its systemic effects have been well documented in humans (heart disease and stroke, diabetes, respiratory disease, and increased risk of premature delivery and low-birth-weight infants) and are being increasingly investigated in companion animals.[98]

Gingivitis and Periodontitis

Gingivitis is reversible, affecting gingiva only (Figure 21-21). The gingiva may detach from the tooth, creating a periodontal pocket, and a shift occurs in the gingival flora from a gram-positive aerobic to a gram-negative anaerobic spectrum. Treatment of gingivitis requires plaque control, and daily toothbrushing can resolve gingivitis. In adolescent cats a particular form of gingivitis has been recognized. This so-called juvenile hyperplastic gingivitis occurs after eruption of the permanent dentition at about 6 to 8 months of age, with the inflamed gingiva being enlarged to a degree that it can cover the crowns of the teeth (Figure 21-22). It is not known whether juvenile hyperplastic gingivitis is a precursor form of more severe oral inflammation or whether it can

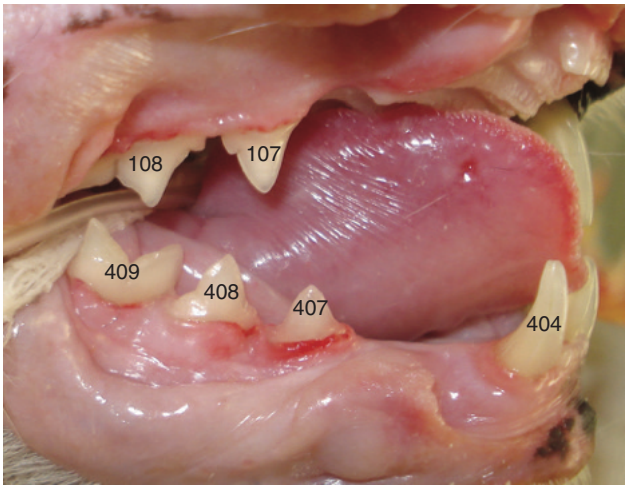


FIGURE 21-21 Gingivitis (worst at tooth 407) in a cat. The right maxillary canine and second premolar teeth are missing. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

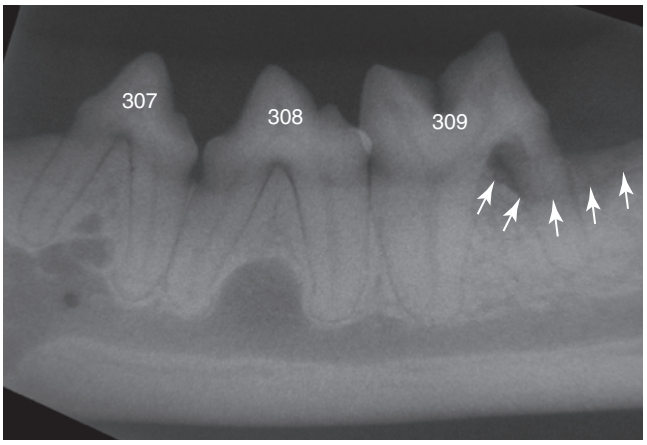


FIGURE 21-23 Dental radiograph showing the left mandibular cheek teeth in an adult cat. Note loss of alveolar bone particularly around the distal root *(arrows)* of tooth 309. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

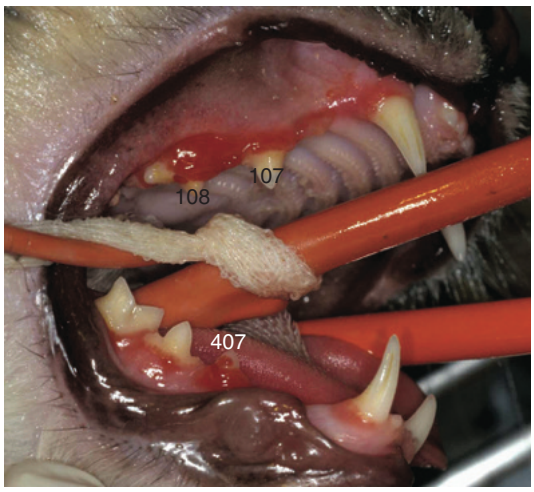


FIGURE 21-22 Juvenile hyperplastic gingivitis in an adolescent cat. Note inflamed and enlarged gingiva partially covering the crowns of teeth 107, 108, and 407. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

progress to stomatitis in the adult cat. Gingival enlargement is also caused after administration of anticonvulsants, cyclosporine, and calcium channel blockers. Treatment of gingival hyperplasia involves cessation of its cause and removal of excess gingiva. Because most cat teeth have less than 2 mm of attached gingiva, gingival surgery should be carefully executed and is often reserved for canine teeth and teeth with significant gingival enlargement.[8]

Periodontitis is the more severe form of periodontal disease, affecting all periodontal tissues and resulting in attachment loss, gingival recession, furcation exposure, periodontal pocket formation, and alveolar bone loss (Figure 21-23).[69] Bacterial infection of the pulp is possible in areas devoid of cementum and through apical and non-apical ramifications. Alveolar bone loss is usually irreversible, causing the tooth to become mobile and ultimately to exfoliate.[45] Similar to juvenile hyperplastic gingivitis, a so-called juvenile-onset periodontitis has been described in cats younger than 1 year of age.[8] The teeth of such adolescent cats often are severely mobile on digital palpation and show most other clinical and radiographic signs associated with periodontitis.

Periodontal Therapy

Closed treatment may be sufficient when periodontal pocket depths do not exceed 2 mm in cats. Professional dental cleaning is performed with power scalers, followed by the use of hand scalers to remove residual calculus in pits, fissures, and developmental grooves of the crowns supragingivally and hand curettes to clean and plane exposed root surfaces subgingivally (Figure 21-24).[64] Prevention of hypothermia is particularly important when water is used to cool power instruments or rinse debris from the mouth.[44] Hand curettes can also be used for gingival curettage that removes the inflamed and infected soft tissue lining of the periodontal pocket. Once scaling is completed, the tooth surfaces are polished with fine polishing paste and a rubber cup on a prophy angle that is attached to a low-speed handpiece. Debris and polishing paste are rinsed from the tooth surface with water from an air–water syringe.[45]

Open treatment is usually indicated when pocket depths exceed 2 mm and is performed after reflection of a mucoperiosteal flap with or without vertical releasing incisions made into gingiva and alveolar mucosa. Osseous surgery and placement of implants are possible with this flap design.[7] The flap is sutured closed with

FIGURE 21-24 Note the different working ends between a scaler *(right)* and a curette *(left)*. The scaler has a pointed tip for removal of residual calculus in pits, fissures, and developmental grooves in supragingival areas of the tooth, while the curette has a rounded tip to avoid soft tissue injury in subgingival areas of the tooth. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

synthetic absorbable monofilament material such as poliglecaprone 25 (e.g., Monocryl, Ethicon). Lateral sliding flaps and free gingival graft techniques are available for treatment of gingival clefts. Medical therapy includes the use of topical rinsing solutions (e.g., 0.2% chlorhexidine) or systemic antimicrobials (e.g., amoxicillin–clavulanic acid, clindamycin). Because of potential side effects and the possibility of bacterial resistance, systemic antimicrobials should be used only in selected cases to serve as an adjunct to local treatment.[25] Low-dose doxycycline gel (e.g., Doxirobe Gel, Pfizer Animal Health) may be inserted into cleaned periodontal pockets greater than 4 mm after root planing and gingival curettage.

Home Oral Hygiene

Plaque control is a critical component of periodontal disease prevention and in the maintenance of treatment success.[17,18,25,104] The owner is given instructions on daily tooth brushing with a soft-bristled toothbrush and pet dentifrice.[92] In addition, oral hygiene is enhanced by the use of treats, diets, and products that meet established criteria for effectiveness in mechanically or chemically controlling plaque or calculus deposition.[36,40,56,115] For a list of approved products, please visit the website of the Veterinary Oral Health Council (http://vohc.org).

TOOTH RESORPTION

Tooth resorption (previously called *feline odontoclastic resorptive lesion [FORL])* affects 25% to 75% of cats, depending on the population of cats investigated and diagnostic tools applied. The condition usually involves multiple permanent teeth and can start anywhere on the tooth's root surface.[101] Chronic dietary intake of excess vitamin D has been suggested as one potential cause of tooth resorption in cats.[99,100]

Replacement Resorption and Inflammatory Resorption

Feline teeth may appear clinically healthy, but they often show histologic and radiographic changes of periodontal and dental tissues, such as periodontal ligament degeneration, hypercementosis, and hyperosteoidosis. Narrowing of the periodontal space may result in ankylotic fusion (dentoalveolar anylosis) between the tooth and alveolar bone. These findings demonstrate events that occur before obvious tooth resorption and suggest that the very early lesion is probably noninflammatory.[41] Ankylosed roots are at risk of being incorporated into the normal bone remodeling process, resulting in gradual resorption of the root and replacement by bone (replacement resorption) (Figure 21-25).[100,101]

Resorption of enamel may occur when root resorption has progressed coronally into the crown. The enamel may then become undermined or penetrated by the resorption process. When such lesions emerge at the gingival margin, they become exposed to oral bacteria, which results in formation of inflamed granulation tissue (Figure 21-26). These defects are painful and bleed easily when probed with a dental instrument. One common feature of inflammatory root resorption is that the alveolar bone adjacent to the tooth defect is also resorbed.[100,101]

Several other peculiarities are noted in the permanent teeth of cats that could be associated with tooth resorption, including unusual thickening of alveolar bone (alveolar bone expansion), with or without periodontal pocket formation, and abnormal extrusion of canine teeth (supereruption).[65,100,101]

Etiologic Considerations

Cats with tooth resorption were shown to have significantly lower urine specific gravity and significantly higher serum concentrations of 25-hydroxyvitamin D (25OHD) compared with cats without tooth resorption.[99] These findings, together with the fact that multiple teeth are affected, indicate that tooth resorption in cats may have a systemic rather than a local cause. Cats are not able to produce vitamin D in skin,[54] and their minimum dietary vitamin D requirement may be low when

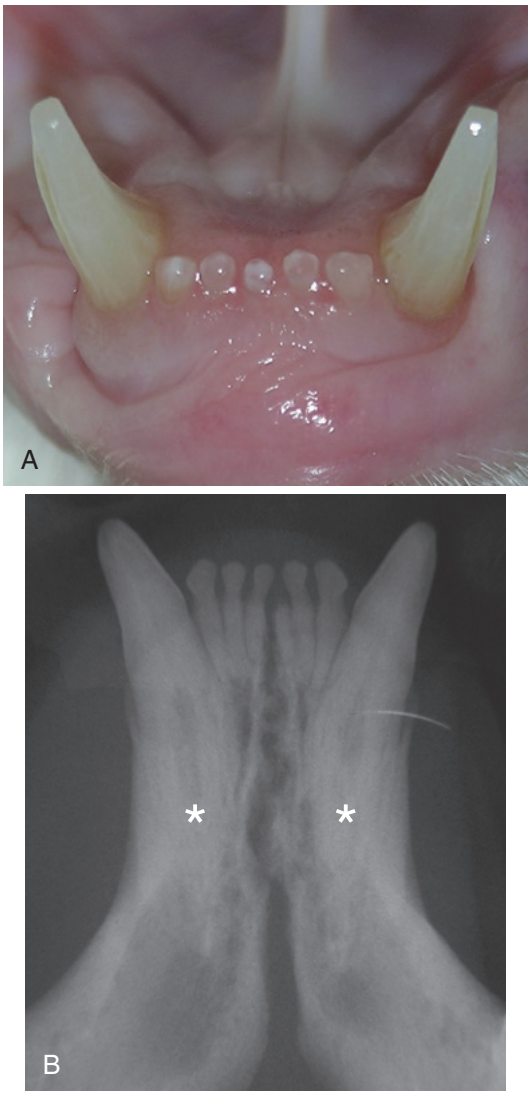


FIGURE 21-25 Replacement resorption in a cat. Clinical photograph **(A)** shows mandibular canine teeth that have mild gingivitis. Radiograph **(B)** reveals severe replacement resorption *(asterisks)* of the roots of both canines. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

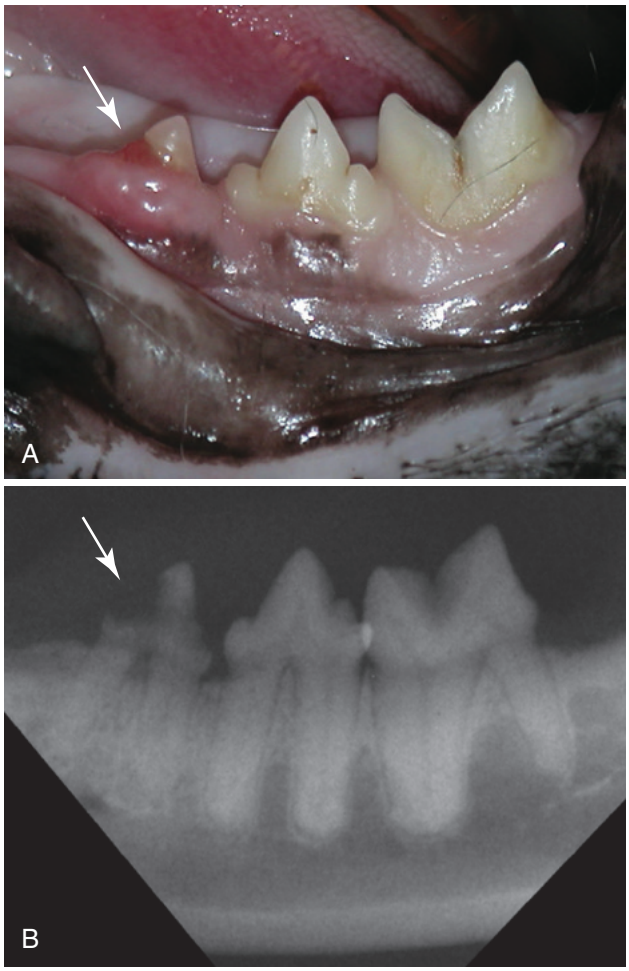


FIGURE 21-26 Inflammatory resorption in a cat. Clinical photograph **(A)** and radiograph **(B)** of the left mandibular cheek teeth in a cat, showing an inflammatory resorption *(arrows)* coronal to the gingival attachment of the left mandibular third premolar tooth. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

compared with that of other species.[78] Commercial cat foods often contain vitamin D in excess of the maximal allowance.[77] Because a direct linear relationship exists between 25OHD serum concentrations and dietary intake of vitamin D,[79] cats with higher 25OHD serum concentrations must have ingested larger amounts of vitamin D or vitamin D metabolites. Significantly decreased urine specific gravity in cats with tooth resorption[99] also indicates that this condition might not just be a local oral disease but is probably associated with pathology in other areas of the body, such as abnormal mineralization of kidneys resulting from excessive dietary intake of vitamin D.[99,100] Recent studies also demonstrated that the nuclear vitamin D receptor is implicated in the pathophysiology of tooth resorption in cats.[13,14]

Numerous studies demonstrate the effects of excess vitamin D and vitamin D metabolites on the periodontium in experimental animals.[100] These changes in periodontal tissues resemble histologic features of teeth from cats with tooth resorption and include periodontal ligament degeneration, hypercementosis, hyperosteoidosis, narrowing of the periodontal ligament space, dentoalveolar ankylosis, and resorption of dental hard tissues. Loss of biological width (the distance between the bottom of the gingival sulcus and the alveolar margin) and coronal displacement of transseptal fibers have also been reported in these experimental animals, which may provide explanations for two other phenomena commonly seen in the mouth of cats (i.e., thickening of alveolar bone and extrusion of canine teeth).[65,100]

Clinical Signs

Tooth resorption is rarely seen in cats younger than 2 years of age, and clinically obvious disease may not be noted before the cat is 4 to 6 years of age. An increase in prevalence is seen with increasing age. There is no obvious predisposition with regard to gender, breed, or neuter status. The most commonly affected teeth include the mandibular third premolars; however, any tooth can be affected. Multiple teeth—in some cases the entire dention—are likely to be affected throughout a cat's life.[99,101]

Many affected cats will not show clinical signs. Some cats present with oral discomfort, lethargy, anorexia, dehydration, and weight loss. Halitosis, plaque and calculus accumulation, gingivitis, and gingival enlargement in areas of crown defects may be noted. Nasal discharge and sneezing are occasionally observed when there is severe resorption of maxillary teeth. Repetitive lower jaw motions may be seen during eating, drinking, and grooming or on palpation of oral and dental tissues.[101] Alveolar bone expansion (Figure 21-27) and extrusion of canine teeth (Figure 21-28) can frequently be observed in cats with tooth resorption.[100]

When tooth resorption progresses from the root into the crown and becomes exposed to the oral environment, an inflammatory component will join the initially noninflammatory process, filling the defect with inflamed granulation tissue. Resorption coronal to the gingival attachment is palpable by means of a dental explorer and, if large enough, visible as a red spot on the crown surface.[101] Affected crowns often break off, leaving resorbing root remnants in the alveolar bone. Retained root remnants can irritate the surrounding tissues, resulting in abscessation and local osteomyelitis with or without sinus tracts in gingiva, alveolar mucosa, or skin. A bulge may be seen in areas where gingiva has completely covered remnants of resorbing dental tissue.[101]

Exposed dentin surface—although covered by inflamed granulation tissue—is sensitive to mechanical and thermal stimuli. Therefore tooth resorption emerging at the gingival margin is considered to be painful. In the absence of pulpitis and periapical inflammation, however, tooth resorption apical to the gingival attachment is thought to be asymptomatic.

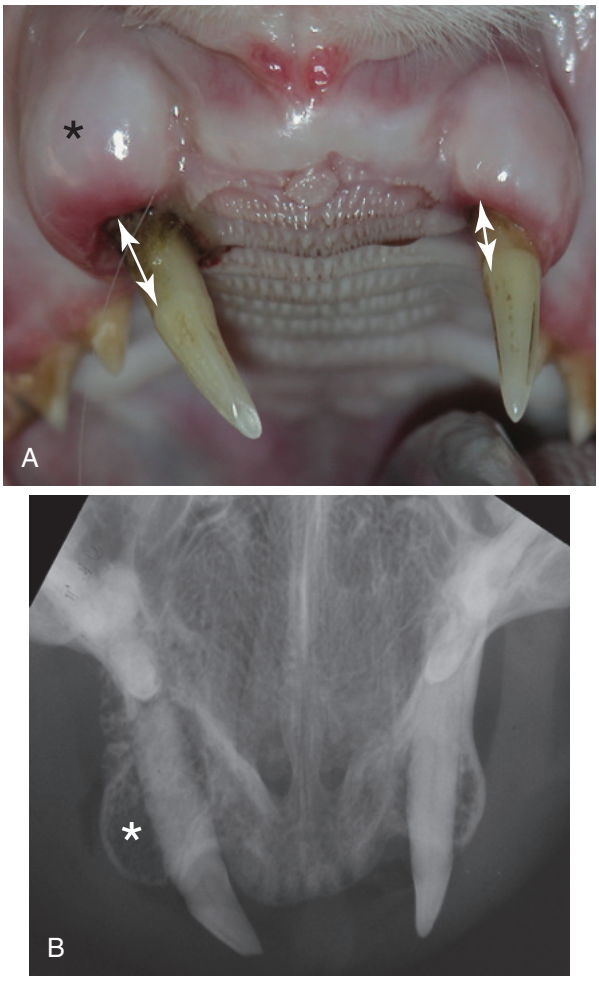


FIGURE 21-27 Clinical photograph **(A)** and radiograph **(B)** of the rostral upper jaw in a cat, showing alveolar bone expansion—more severe on the right *(asterisk)*—and extrusion of both maxillary canine teeth *(double-ended arrows* indicate exposure of root surface). The crown of the right maxillary canine is displaced palatally, and there are retained root remnants in areas of missing maxillary incisors. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

Radiographic Signs

On the basis of the radiographic appearance of the root(s) of affected teeth, two presentations are distinguished. In type 1 lesions, unaffected root areas are surrounded by a radiographically visible periodontal space.[27] Notched radiolucencies with sharp or scalloped margins are usually found in cervical root or crown areas of the tooth, where they are exposed to inflammatory stimuli of the oral environment. Pathognomonic of inflammatory resorption is that the alveolar bone adjacent to the tooth defect is also resorbed.[100] However, pulpal involvement associated with these lesions does not appear to be associated with development of radiographically detectable periapical lucencies.[68] Tooth resorption that emerges at the gingival margin often appears small clinically but may exhibit advanced replacement resorption of the root(s) with disappearance of the lamina dura, often giving the tooth a diffusely moth-eaten or striated appearance. Ankylosed roots and those with replacement resorption have been categorized radiographically as type 2 lesions.[27] It is important to understand that both types of resorption can be present on a single tooth. The Nomenclature Committee of the American Veterinary Dental College (http://

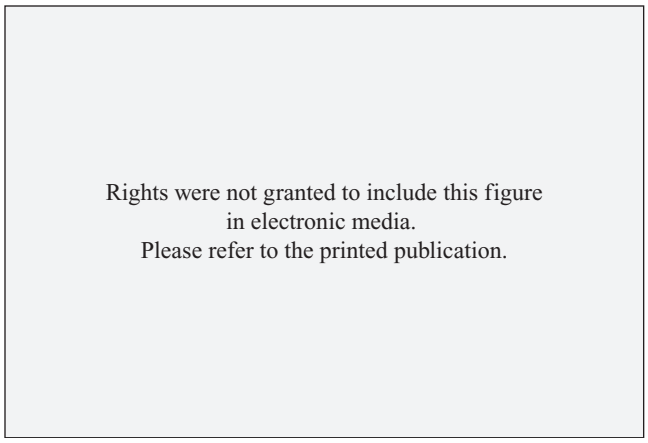


FIGURE 21-28 Mouth of a cat, showing vascular granulation tissue filling areas of resorption at the mesiobuccal aspect of tooth 108 and buccal aspect of tooth 409. The maxillary and mandibular third premolars are missing. There is a bulge with inflamed gingiva *(asterisk)* in the area of the missing third premolar, indicating the presence of retained root fragments. The right maxillary and mandibular canines (teeth 104 and 404) appear to be extruded *(double-ended arrows* indicating exposure of root surface). *(From Reiter AM, Mendoza KA: Feline odontoclastic resorptive lesions. An unsolved enigma in veterinary dentistry,* Vet Clin North Am Small Anim Pract *32:791, 2002.)*

avdc.org) proposed a staging system from 1 to 5 (with 4a, b, and c) for the classification of tooth resorption (Box 21-1).

Histologic Features

Histologic studies provide compelling evidence that the very early tooth resorption in cats is noninflammatory.[41] Clinically and radiographically normal teeth of cats with obvious resorption of other teeth showed a loss of the physiologic periodontal ligament architecture, a narrowing of the periodontal ligament space (caused by hypercementosis along the root surface, hyperosteoidosis along the alveolar bone surface, or mineralization within the periodontal ligament), fusion of the tooth root with alveolar bone (dentoalveolar ankylosis), and areas of resorption of cementum and dentin.[41]

Teeth with dentoalveolar ankylosis are at risk of being incorporated into the normal bone remodeling process and are ultimately resorbed and replaced by new bone (replacement resorption). When this process occurs close to the gingival attachment, the defect may emerge at the gingival margin, and the histologic picture may change to that of an inflammatory resorption; pathognomonic of which is that the adjacent alveolar bone often is resorbed as well.[100] Attempts at repair may be noted by production of bone or cementum-like material; however, tooth resorption in cats usually progresses until the roots are completely resorbed or the crown breaks off, leaving root remnants behind.[101]

BOX 21-1
Classification of Tooth Resorption Proposed by the American Veterinary Dental College

Stage 1

Mild dental hard tissue loss (cementum or cementum and enamel)

Stage 2

Moderate dental hard tissue loss (cementum or cementum and enamel with loss of dentin that does not extend to the pulp cavity)

Stage 3

Deep dental hard tissue loss (cementum or cementum and enamel with loss of dentin that extends to the pulp cavity); most of the tooth retains its integrity

Stage 4

Extensive dental hard tissue loss (cementum or cementum and enamel with loss of dentin that extends to the pulp cavity); most of the tooth has lost its integrity
- 4a: Crown and root are equally affected
- 4b: Crown is more severely affected than the root
- 4c: Root is more severely affected than the crown

Stage 5

Remnants of dental hard tissue are visible only as irregular radiopacities, and gingival covering is complete

Treatment

Topical fluoride treatment has never been evaluated for prevention of tooth resorption in cats, and it is highly doubtful whether fluoride application on the crowns of teeth has any effect on resorption of roots apical to the gingival attachment.[101] Systemic alendronate therapy has been suggested on the basis of results of a very small sample of cats[75]; however, studies in mice provide evidence that dentoalveolar ankylosis and extensive tooth resorption actually result from bisphosphonate administration.[116,117] Restorative therapy also does not address pathology located apical to the gingival attachment and has repeatedly been shown to fail over both the short and long term.[101] If increased vitamin D activity ever proves to be the causative factor of tooth resorption in cats, feeding a diet less rich in vitamin D would be recommended.

Extraction and crown amputation with intentional root retention are the current treatment options. Feline teeth are best extracted using an open technique. A

mucoperiosteal flap is raised, alveolectomy is performed, multirooted teeth are sectioned, and teeth or crown-root segments are elevated and extracted.[12,106] Retained root remnants are removed in a similar fashion. Root remnants under intact and healthy gingiva and without endodontic or periapical pathology on dental radiographs may be left where they are. Ankylosed teeth and those with replacement resorption of their roots often make complete extraction impossible. Crown amputation with intentional retention of resorbing root tissue (discussed later in this chapter) is a viable treatment option for such teeth.[26]

DENTOALVEOLAR TRAUMA

Rapid tooth wear can result in chronic irritation of the pulp or even pulp exposure. However, abrasion and attrition are fairly uncommon in cats. Tooth fracture can be either uncomplicated (without pulp exposure) or complicated (with pulp exposure).[98] Fracture of canine teeth is common in cats after motor-vehicle trauma, falls from heights, kicks, and hits. If dentin is exposed in an uncomplicated fracture, a pathway can still exist for stimuli to pass through the dentinal tubules to the pulp, resulting in formation of tertiary dentin or endodontic disease. Pulp exposure in complicated fractures will always result in endodontic disease (pulpitis and pulp necrosis). Extension of endodontic disease into the periapical tissues will cause apical periodontitis or granuloma or abscess formation, often manifesting in facial swelling and formation of sinus tracts. Localized or widespread infection of the bone and bone marrow (osteomyelitis) can arise from an endodontic infection.[98] Tooth resorption starting on external root surfaces and progressing into root or crown dentin is often the cause of fracture of feline teeth. Tooth displacement injuries (luxation and avulsion) can be seen in cats whose canine teeth are affected by alveolar bone expansion and supereruption.

Clinical Signs and Diagnosis

Reluctance to eat hard food may be noted in the patient with dentoalveolar trauma. The teeth on the affected side may then show increased plaque and calculus accumulation and gingival inflammation. Regional lymphadenopathy and fever may be present with an acute apical abscess. Endodontic disease may result in crown discoloration (pink, red, purple, gray, or brown), which can be interpreted as indicative of pulp necrosis.[98] The integrity of the dental crowns is evaluated with a dental explorer, the fine and pointed tip of which may catch in an open pulp chamber. Recent pulp exposures reveal red tissue at or bleeding from the fracture site (Figure 21-29), whereas old pulp exposures show black debris and necrotic pulp tissue. Endodontically diseased maxillary canine or cheek teeth may result in maxillofacial swelling and formation of extraoral or intraoral sinus tracts that often have a history of responsiveness to antibiotics and recurrence when antibiotic therapy is discontinued. Sinus tracts can be traced with a gutta-percha cone (root canal filling material), and a radiograph is obtained to locate their source.[98]

FIGURE 21-29 Upper jaw of a cat, showing complicated fracture of the right maxillary canine tooth *(arrow)*. Note the bleeding from exposed pulp tissue after evaluation of the fracture site with a dental explorer. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

Treatment

Vital pulp therapy is primarily performed on teeth with acute complicated crown fractures (of less than 2 days' duration in animals older than 18 months of age and of less than 2 weeks' duration in animals younger than 18 months of age) to preserve pulp vitality and increase the strength of the tooth by allowing continued dentin formation.[85] Intentional crown reduction with vital pulp therapy may be performed in cats with unilateral mandibulectomies when medial drift of the remaining mandible results in the mandibular canine tooth puncturing the palate on closure of the mouth. Instruments and materials in contact with vital pulp must be sterile to prevent iatrogenic bacterial infection. Intentional crown reduction is followed by partial pulpectomy, direct pulp capping, and restoration. Dental radiographs are obtained in 6 months to confirm pulp vitality and then once annually.

If the pulp is exposed for longer periods of time or has become necrotic, standard root canal therapy is performed and includes accessing the pulp cavity; débriding, shaping, disinfecting, and obturating the root canal; and restoring access and fracture sites (Figure 21-30).[52,81]

FIGURE 21-30 Radiograph obtained following standard root canal therapy of the right maxillary canine tooth shown in Figure 21-29. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

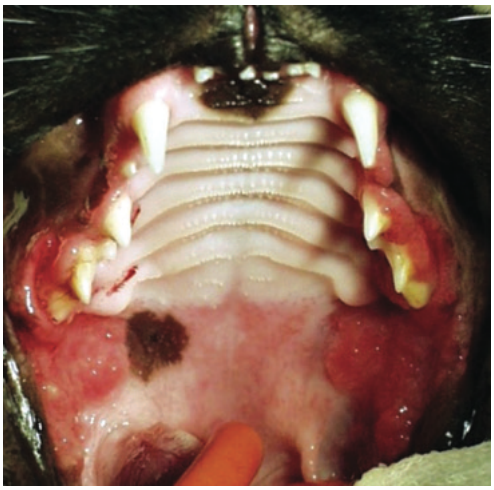


FIGURE 21-31 Cat with inflammation of the gingiva, alveolar mucosa, labial and buccal mucosa, and mucosa of the caudal oral cavity lateral to the palatoglossal folds. Note that the hard palate mucosa is usually not inflamed in cats with stomatitis. *(From Harvey CE: Stomatitis. In Cote E, editor:* Clinical veterinary advisor, *ed 1, St Louis, 2007, Mosby, p 1039.)*

Perioperative dental radiography is essential, and an armamentarium of instruments and materials are required to perform the various steps of root canal therapy. Surgical root canal therapy is performed when standard root canal therapy has failed and includes access through oral mucosa (maxillary canine) or skin (mandibular canine), alveolectomy, apicoectomy, and retrograde filling. With either technique, the treated tooth should be reexamined radiographically in 6 months and then once annually.[4,39] Luxated and avulsed teeth have lost their blood supply and should be extracted in cats rather then repositioned or replanted.

STOMATITIS

Stomatitis is recognized mainly in adult cats and characterized by persistent inflammation of the oral mucosa. One investigation found that 88% of cats with stomatitis were shedding both feline calicivirus (FCV) and feline herpesvirus-1 (FHV-1) in saliva, which suggests that these two viruses may play a role in feline stomatitis.[70] Evidence for a cause-and-effect relationship between *Bartonella* and feline stomatitis has not been provided.[24,91]

Clinical Signs and Diagnosis

Cats with stomatitis often have a long history of inappetence, weight loss, pawing at the face, and oral pain. Clinical signs usually include focal or diffuse oral inflammation involving the gingiva, alveolar mucosa, labial and buccal mucosa, sublingual mucosa, and the area of or lateral to the palatoglossal folds (Figure 21-31).[71] In severe cases the inflamed tissues become proliferative and ulcerated and bleed spontaneously. Various degrees of dental and periodontal disease may be present (tooth resorption, gingival recession, periodontal pockets, mobile or missing teeth). Mandibular lymphadenopathy; oral, nasal, and ocular discharge; and focal ulceration of the lips may also be present.

A complete blood count, biochemical profile, and urinalysis are performed to identify concurrent or contributory diseases. An increase in total protein usually is due to elevated gamma globulin concentrations. Leukocytosis caused by mild to moderate neutrophilia may be present. Serologic evaluation for FeLV antigen and FIV antibody should be performed. Testing for *Bartonella* infection is controversial. A biopsy specimen should be obtained to rule out neoplasia or other causes of oral inflammation. Histopathology typically shows ulceration with subepithelial lymphocytic–plasmacytic infiltration, which may reflect a chronic response to the presence of an overwhelming bacterial load rather than being an indicator of the primary cause of the condition.[71]

Treatment

Stomatitis presents a therapeutic challenge, and management is often frustrating for both the veterinarian and owner. Many cases are refractory to treatment. A multimodal treatment approach is imperative in patients with stomatitis, often requiring a combination of medical and surgical therapies for resolution of clinical signs and occasional placement of an esophageal feeding tube for nutritional management. Plaque control is achieved

with professional dental cleaning, topical and systemic antimicrobial therapy, and tooth extraction. Systemic antibiotic therapy (e.g., amoxicillin–clavulanic acid and clindamycin) often provides only short-term clinical benefit or can be ineffective in the initial management of inflammation. Topical 0.12% chlorhexidine products may be used for adjunctive therapy in the initial management.[71]

Glucocorticosteroids are often required to decrease inflammation, reduce pain, and stimulate appetite. Administration of oral prednisolone (starting at 1 to 2 mg/kg orally every 12 hours initially for 1 week, followed by tapering it to the lowest effective dose over a period of 4 to 8 weeks) can be challenging in the patient experiencing pain. Therefore some cats may initially benefit from subcutaneous injections of methylprednisolone (4 mg/kg) that, after a few weeks, is followed by oral administration of prednisolone.[71] The presence of lymphocytes in affected tissues suggests that antilymphocyte drugs such as cyclosporines may be useful (starting at 2.5 mg/kg of Neoral [Novartis] solution orally every 12 hours; given for 6 weeks before judging effectiveness; monitoring of trough drug levels [should be 250 to 500 ng/mL], kidney values, and other blood parameters).[112] Clinical improvement was reported in cats with stomatitis that were given bovine lactoferrin (bacteriocidal immunomodulator that may inhibit adhesion of periodontopathogens; 250 mg orally once daily).[1] Low-dose doxycycline (antiinflammatory, anticollagenolytic, and antimetalloproteinolytic effects; 1 mg/kg orally once daily) and feline interferon omega (Virbagen Omega, Virbac; 5 MU are diluted and divided as necessary to submucosally inject all inflamed areas; the remaining 5 MU are injected into a 100-mL bag of sodium chloride and frozen in ten 10-mL aliquots; client gives 1 mL orally every 24 hours for 100 days; the 10 mL fraction in use is refrigerated and the other aliquots are kept frozen until needed) have also been suggested as medical treatment options for cats with stomatitis.[109,120]

Tooth extraction appears to be the best long-term therapeutic strategy because it removes the surfaces that are available for plaque retention.[50] Teeth with periodontitis or resorption and retained roots must be extracted. Plaque seems to play a role in perpetuating stomatitis even if teeth are located relatively distant from the actual site of inflammation (e.g., in cases of stomatitis of the caudal oral cavity). Therefore reasonably healthy teeth may be extracted in cats with severe stomatitis that do not respond to medication. Extraction of all teeth caudal to the canine teeth is often sufficient. If inflammation also occurs adjacent to the canines and incisors, a full-mouth extraction procedure may be necessary. Débridement of friable and inflamed soft tissue and bone before wound closure with an absorbable monofilament suture material (e.g., poliglecaprone 25) will aid in resolution of inflammation. The response to tooth extraction ranges from complete resolution of inflammation (60%), minimal residual inflammation, and no oral pain (20%); to initial improvement requiring continued medical therapy to control clinical signs (13%); to no improvement (7%). Cats tolerate extractions, even full-mouth extractions, very well and can eat moist and even dry food without teeth.[50]

Laser surgery may be used as an adjunct in patients with refractory stomatitis not responding to extractions and medical therapy.[67] The CO_2 laser is used in excision and ablation modes. Fibrosis formation is enhanced when lased areas are left to heal by second intention. Follow-up oral examination typically shows granulation tissue and striations of fibrous tissue spanning the previously treated areas. Laser treatments are repeated in intervals of several weeks to months, increasing the amount of fibrous tissue and decreasing interspersed areas of continued inflammation. The patient should be seen for reexaminations every few weeks to monitor improvement, obtain body weight measurements, and slowly taper oral glucocorticosteroids. Sublingual and oropharyngeal tissues around the endotracheal tube can often become swollen from intubation and handling. Dexamethasone (0.25 mg/kg intravenously) may be administered to minimize swelling that could affect breathing after extubation.[67]

TOOTH EXTRACTION

Tooth extraction is most frequently performed in cats with periodontal disease, tooth resorption, stomatitis, and traumatized teeth. Other indications include roots retained in the jaws; persistent deciduous teeth; teeth causing malocclusion; unerupted teeth; teeth near jaw fracture lines, in areas of osteomyelitis, and osteonecrosis or surrounded by oral neoplasia; and client preference.[94] The client must have given permission for extraction of any tooth before the procedure is undertaken. To prevent complications such as local or systemic infection,[97] the entire tooth must be removed, without leaving any root structure in the alveolus.

Instruments and Mechanics

Dental luxators have sharp, flat-tipped blades that can penetrate into the periodontal space. Dental elevators have less sharp, more curved blades that fit the shape of the tooth. Luxating elevators often combine the benefits of the two basic designs. They are grasped with the butt of the handle seated in the palm, and the index finger is extended along the blade to act as a stop in case the instrument slips. Smaller luxating elevators, root tip picks, root tip forceps, bone curettes, periosteal elevators, and extraction forceps are available for use in cats (Figure 21-32).[94]

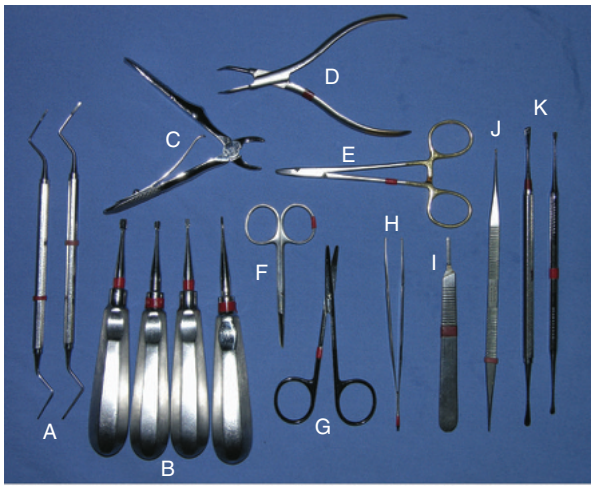


FIGURE 21-32 Set of smaller-sized instruments for extraction of feline teeth, including root fragment elevators *(A)*, winged luxating elevators *(B)*, extraction forceps *(C)*, root fragment forceps *(D)*, needle holder *(E)*, suture scissors *(F)*, curved Metzenbaum scissors *(G)*, Adson thumb forceps *(H)*, scalpel handle *(I)*, spoon curette *(J)*, and periosteal elevators *(K)*. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

Teeth are secured to the alveolar bone of the incisive bone, maxilla, and mandible by the gingiva and periodontal ligament. The roots of the incisors and canine teeth in cats are slightly curved and flattened oval in cross-section, thus providing antirotational retention. The maximum circumference of canine teeth is not at the cementoenamel junction or the alveolar margin but rather at some distance apical to them, thus locking the roots into the jaw. The roots of the premolars and molars diverge, which also aids in retention. The maxillary fourth premolars in cats have three roots. The cheek teeth of many cats often have bulbous root apices as a result of hypercementosis.[94]

Closed Extraction

A no. 15 scalpel blade is inserted into the gingival sulcus, and the gingival attachment is incised around the tooth. The blade of a luxating elevator is then worked vertically into the space between the tooth and alveolar bone, and the handle is rotated along its long axis to create gentle and steady pressure on the tooth. This wedging force will widen the periodontal ligament space until the instrument can be inserted further apically. Rotational pressure with the instrument is then applied and maintained for at least 10 seconds to cause the periodontal ligament fibers to tear. The luxating elevator should be moved around the entire tooth, while also progressing toward the root apex. Extraction forceps should be used only when the tooth is already mobile and applied as far apically as possible to reduce the chances of tooth fracture. The tooth should be examined visually and by means of digital palpation, verifying that the entire root was extracted. The alveolus is then débrided and lavaged, sharp bony edges are smoothed, and the extraction site is sutured closed with a synthetic absorbable monofilament (e.g., 5-0 poliglecaprone 25) in a simple interrupted pattern. A blood clot should remain in the alveolus to allow for proper healing.[22,94]

Multirooted teeth must be sectioned before extraction to prevent root fracture. This provides multiple single-rooted crown-root segments, the extraction of which is no more difficult than that of multiple single-rooted teeth. Sectioning is performed with a fissure bur in a water-cooled high-speed handpiece, starting from the furcation through the tooth crown. Two-rooted teeth are separated into one mesial and one distal single-rooted crown-root segment. Three-rooted teeth are separated into three one-rooted crown-root segments. The luxating instrument can also be placed perpendicular to the tooth between the crown-root segments to lever them out of their alveoli.[22,94]

Open Extraction

When firmly seated deciduous canine teeth, large and periodontally intact permanent teeth, or multiple permanent teeth in one jaw quadrant need to be extracted, a mucoperiosteal flap is raised with one or two releasing incisions that extend from the gingival margin beyond the mucogingival junction into alveolar mucosa. Round or pear-shaped carbide burs attached to a water-cooled high-speed handpiece are used to remove alveolar bone at the vestibular tooth surfaces by as much as one third to two thirds of the length of the root(s). Sectioning of multirooted teeth, extraction of crown-root segments, and débridement of the alveoli are performed as for the closed extraction technique.[22,94]

The flap margins are trimmed with fine gingival scissors or curved Metzenbaum scissors. A scalpel blade is used on the connective tissue side to incise the periosteum in a distomesial direction across the base of the flap. The flap will advance as the inelastic periosteal layer is cut. The back of a scalpel blade can also be used to "strum" and weaken the periosteal layer without cutting into or through the flap, followed by blunt dissection with a scissors. Alternatively, a small incision can be made in the periosteum with a scalpel blade. Then the tips of a closed Metzenbaum scissors are inserted through the opening and opened to undermine the periosteal layer mesially and distally, carefully avoiding injury to adjacent neurovascular structures. The flap is sutured to the palatal or lingual gingiva with synthetic absorbable monofilament in a simple interrupted pattern (Figure 21-33).[12,108]

Root remnants with sinus tracts, roots fractured during the extraction procedure, and roots remaining after mandibulectomies and maxillectomies should be removed to prevent infection and inflammation of the

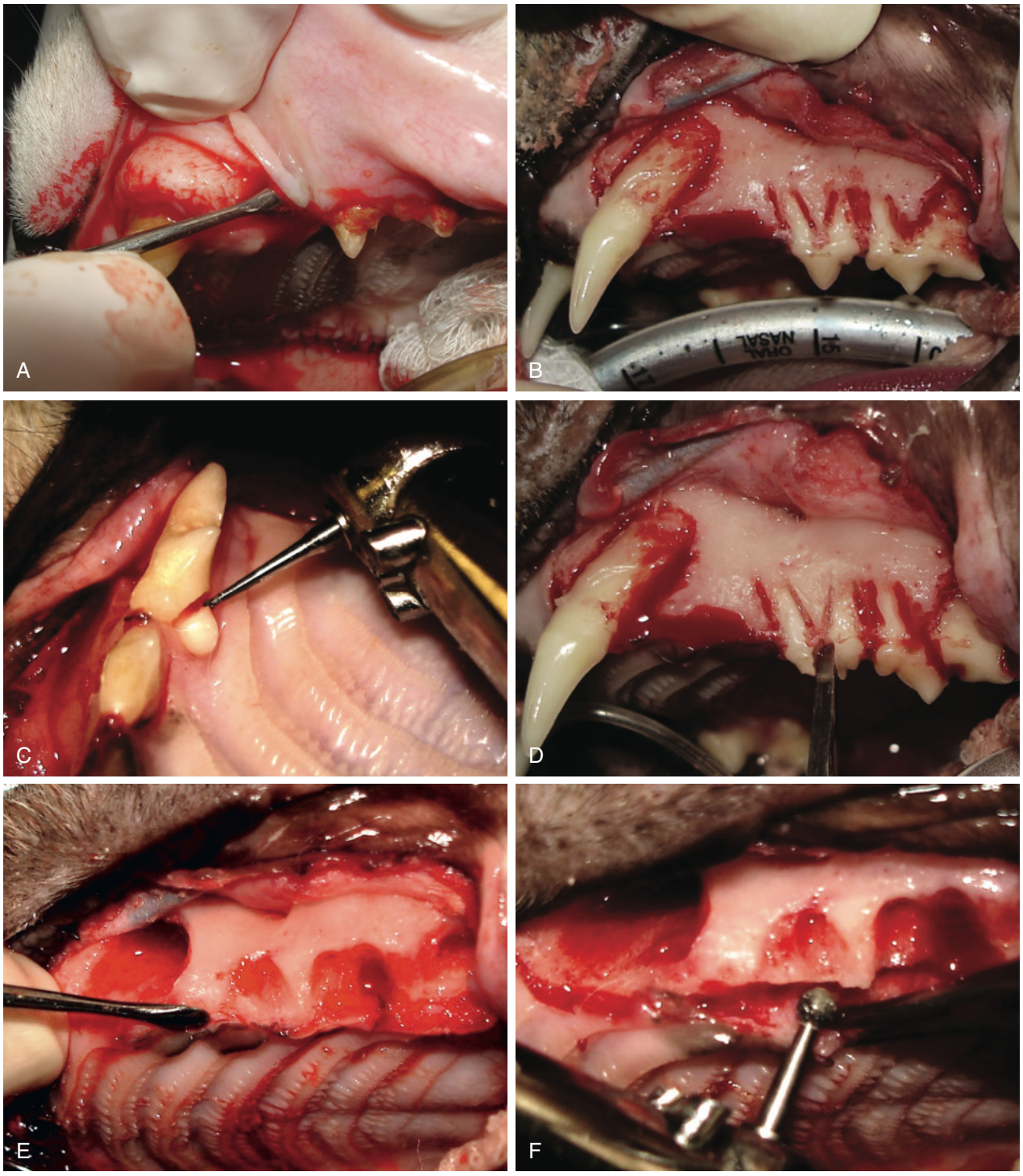


FIGURE 21-33 Clinical photographs showing extraction of multiple maxillary teeth in a cat. A periosteal elevator is used to elevate a mucoperiosteal flap **(A).** This is followed by alveolectomy with a round carbide bur **(B)** and sectioning of teeth with the same bur or a fissure carbide bur **(C** and **D).** Following elevation and removal of all teeth and crown-root segments, the palatal gingiva is elevated as an envelope flap **(E)** to allow for alveoloplasty of exposed alveolar margins with a diamond grit-coated round bur **(F).**

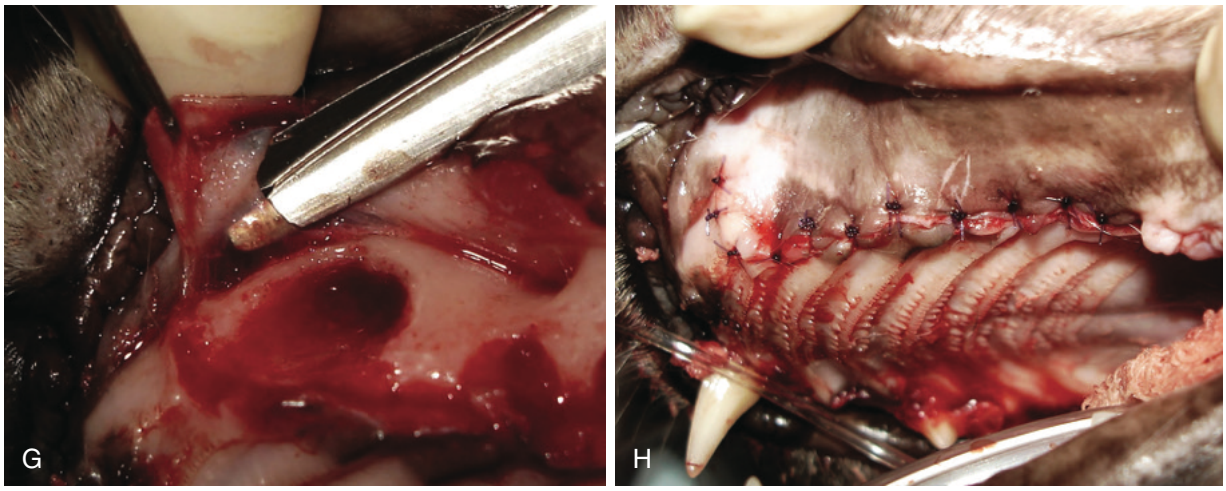


FIGURE 21-33, cont'd A small incision is made in the periosteum with a scalpel blade, and closed Metzenbaum scissors are inserted through the opening to bluntly undermine the periosteal layer mesially, labially, buccally, and distally **(G).** The extraction sites are rinsed before wound closure with a tension-free flap **(H).** *(From Blazejewski S, Lewis JR, Reiter AM: Mucoperiosteal flap for extraction of multiple teeth in the maxillary quadrant of the cat,* J Vet Dent *23:200, 2006; used with permission.)*

bone. Special root tip elevators, picks, and extraction forceps are available. Creation of a mucoperiosteal flap and partial alveolectomy will facilitate removal of a root fragment. If a root fragment cannot be retrieved, the surgical site should be evaluated periodically by means of clinical and radiographic follow-up examination. Retrieval of root fragments from the nasal cavity or infraorbital or mandibular canal after their accidental repulsion into these spaces may be made through soft tissue and bone away from the extraction site.[94]

Crown amputation with intentional retention of resorbing root tissue can be performed on teeth that show radiographic dentoalveolar ankylosis and root replacement resorption. It is contraindicated for mobile teeth with periodontitis, endodontic disease, and periapical pathology and not recommended when closed or open extraction can be accomplished.[94] The gingival attachment is incised, a mucoperiosteal flap with or without releasing incisions is made, and the crown is amputated with a round or fissure bur attached to a water-cooled high-speed handpiece at the level of the cervical root portion of the tooth. The resorbing root is further reduced with a round diamond grit–coated bur to about 1 to 2 mm below the level of the alveolar margin to allow for alveolar bone to grow over it. The gingiva is then sutured closed over the wound (Figure 21-34). Postoperative radiographs must be obtained for future monitoring (Figure 21-35).[26]

EOSINOPHILIC GRANULOMA COMPLEX

Eosinophilic granuloma complex entails a group of lesions that can affect the oral cavity, lips, and skin. There is no breed predisposition. Lesions have been recognized in several cats of multicat households, and experimental transmission was demonstrated from one area of a cat to another. Therefore an infectious or allergic etiology has been suggested, with lesions resulting from a hypersensitivity reaction caused by fleas or mosquitos, food, and contact or environmental allergies.[46] Eosinophilic granulomas manifest in the mouth, often at the mucosa of the hard and soft palate, dorsal tongue surface, and sublingual region. The surface of oral lesions may be speckled with small dense white areas (Figure 21-36). The eosinophilic ulcer ("rodent ulcer") is usually seen in the rostral portion of the upper lip, well-demarcated with raised edges that surround a pink-yellow ulcerated surface (Figure 21-37). Both lesions are more commonly found in young female cats and characterized by eosinophilic infiltrates on histopathology. One major differential diagnosis is squamous cell carcinoma, and biopsy should be performed before treatment.[46]

Treatment of eosinphilic lesions consists of glucocorticosteroid therapy (1 to 2 mg/kg prednisolone orally every 12 hours initially for 1 week, followed by tapering it to the lowest effective dose over a period of 4 to 8 weeks). Injectable drugs (4 mg/kg methylprednisolone subcutaneously) may also be attempted 2 to 3 times, several weeks apart. Intralesional injection of triamcinolone is sometimes helpful.[46] Oral cyclosporine may be an effective alternative to steroids.[112] Secondary infection may be treated with amoxicillin–clavulanic acid at 14 mg/kg orally every 12 hours for 2 to 3 weeks. Surgical excision and laser therapy have also been suggested for single oral lesions. In the case of flea infestation, a flea control program should be started. A strict elimination diet should be attempted when an adverse food reaction is suspected as an underlying cause.

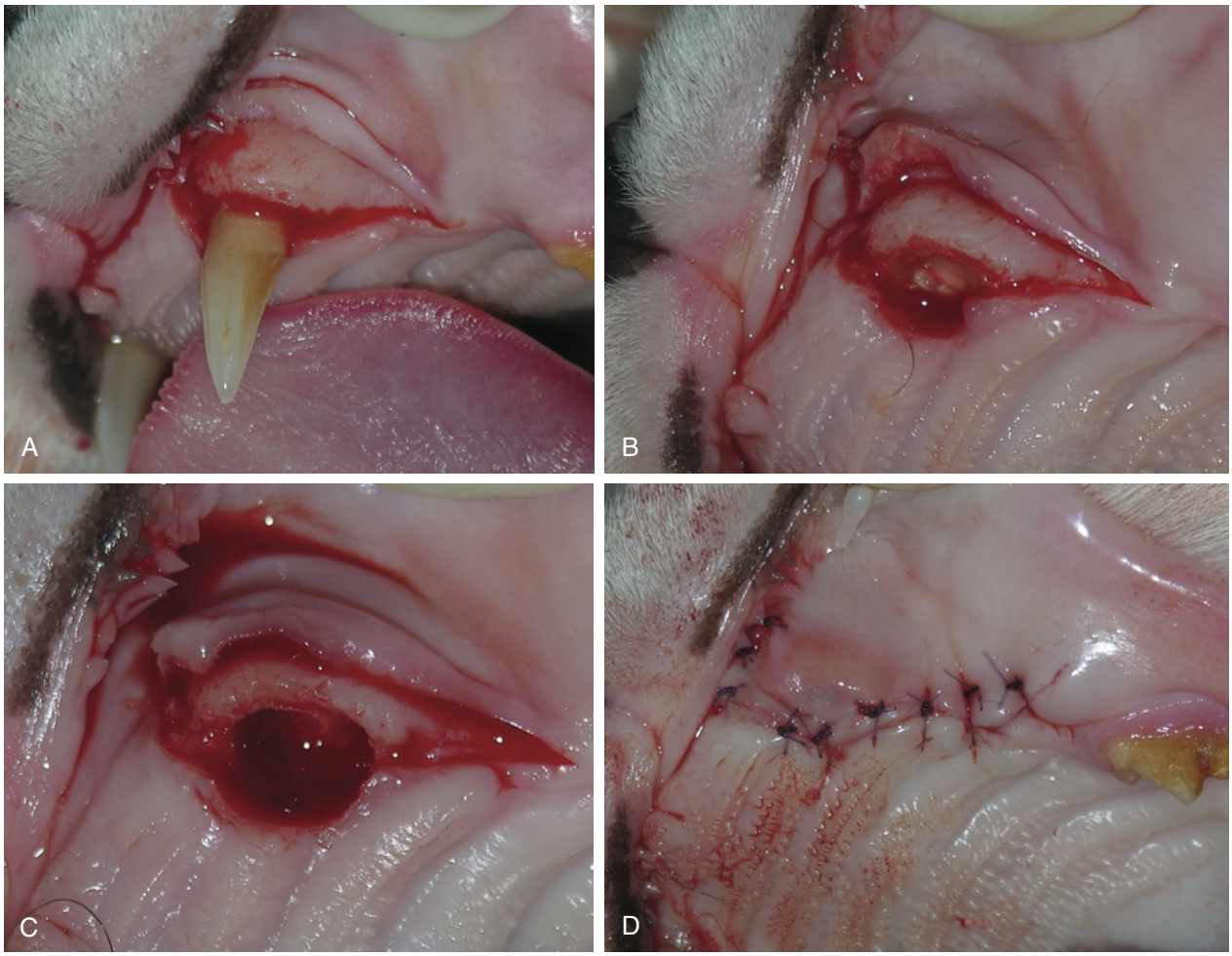


FIGURE 21-34 Clinical photographs showing crown amputation of the left maxillary canine tooth with intentional retention of resorbing root tissue. A mucoperiosteal flap is raised **(A).** The crown is amputated with a dental bur at the level of the cervical root portion of the tooth **(B).** The resorbing root is further reduced with a dental bur to about 1 or 2 mm below the level of the alveolar margin **(C).** The gingiva is sutured closed over the wound **(D).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

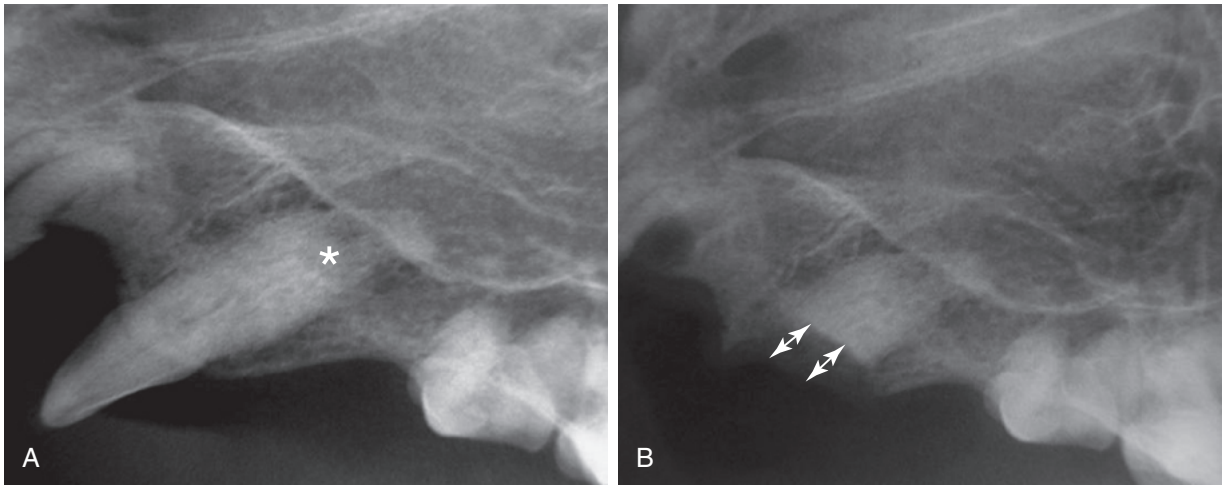


FIGURE 21-35 Preoperative radiograph **(A)** of the left maxillary canine tooth from Figure 21-34, showing root replacement resorption *(asterisk)*. Postoperative radiograph **(B)** following crown amputation and intentional retention of root tissue, showing reduction of the resorbing root about 1 or 2 mm below the level of the alveolar margin *(double-ended arrows)*. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

FIGURE 21-36 Eosinophilic granuloma of the hard palate mucosa in a cat. Note the mucosal surface speckled with small dense white areas. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

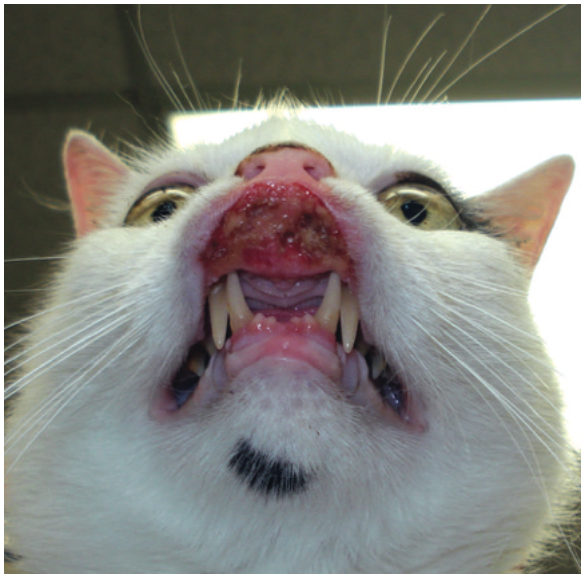


FIGURE 21-37 Eosinophilic ulcer in the rostral portion of the upper lip in a cat. Note the well-demarcated lesion with raised edges that surround a pink-yellow ulcerated surface. (*Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

FELINE OROFACIAL PAIN SYNDROME

Feline orofacial pain syndrome (FOPS) is considered to be an episodic neuropathic pain disorder caused by a dysfunction of central or ganglion processing of sensory trigeminal information. Affected cats usually exhibit exaggerated licking, unusual chewing movements, and pawing at the mouth. More severe cases have acute oral pain (with pain-free intervals) confined to one side of the mouth and face (or worse on one side). Mutilation of the tongue, lips, and labial and buccal mucosa may also be seen. The disease has predominantly been seen in Burmese cats in the United Kingdom, suggesting an inherited disorder, and can affect cats at any age. Many cats showed first signs of FOPS at the time of eruption of the permanent dentition, often redeveloping the syndrome as they mature. The discomfort is reported to be triggered by movements of the mouth, including those associated with eating, drinking, and grooming. Cats may be anorexic and unwilling to eat. The disease is often recurrent and unremitting, and some cats are euthanized as a consequence of the condition.[105]

Sensitization of trigeminal nerve endings from tooth eruption and oral disease and environmental stress appear to be important precipitating factors in the etiology of the disease, suggesting that the disease may be a pain disorder analogous to trigeminal neuralgia and glossodynia (burning mouth syndrome) in humans. Diagnosis is by elimination of other causes of oral pain or trigeminal nerve dysfunction. Oral disease must be treated appropriately, and social incompatibility in a multicat household should be identified. Antiepileptic drugs with analgesic effects (e.g., phenobarbital, diazepam, carbamazepine, gabapentin) appear to be better pain relievers in FOPS than traditional analgesics (e.g., opioids, antiinflammatory drugs). Periodic monitoring of liver function and drug serum concentrations is recommended for cats treated with antiepileptic drugs.[105]

PALATE DEFECTS

Congenital lip and palate defects are rarely encountered in cats. Palate defects acquired after birth usually are located in the hard palate and result from chronic infection (e.g., severe periodontal disease), trauma (e.g., high-rise syndrome, electrical cord and gunshot injury, dog bites, foreign body penetration, and pressure wounds secondary to a maloccluding tooth), neoplasia, and surgical or radiation therapy. Such oronasal defects do not heal because of the continuous passage of air and food, leading to chronic rhinitis and nasal discharge.[96]

The choice of repair technique depends on the location and size of the defect and the amount of tissue available for flap procedures. There may be considerable bleeding during hard palate surgery, but digital pressure with gauze sponges is often sufficient to control hemorrhage. The best chance of success is with the first attempt at repair. Teeth at the surgical site and those that could traumatize flaps should be extracted. Electrocautery for hemostasis must be avoided. The flaps should be larger

than the defect they will cover. The blood supply to the flaps must be maintained, and flaps should be handled as carefully as possible. Rather than using tissue forceps, the veterinarian should make stay sutures at the flap edges for tissue manipulation. Connective tissue surfaces or cut edges should be sutured together, and a two-layer closure should be employed if practical. Longer-lasting synthetic absorbable monofilament suture material (e.g., 4-0 polydioxanone [PDS]) and simple interrupted or mattress sutures are recommended. Suture lines should not be located over a void if possible, and closure must be accomplished without tension.[96,102]

Congenital Palate Defects

Cleft lip appears as a defect of the lip (harelip) and most rostral hard palate. Cleft lips rarely result in clinical signs beyond mild rhinitis, and repair may be performed for cosmetic reasons. The most rostral palate and the floor of the nasal vestibule are reconstructed. This is accomplished by creating overlapping double flaps and advancement, rotation, or transposition flaps of both oral and nasal tissue or flaps that are harvested from oral soft tissue only. Reconstructive cutaneous surgery completes the repair.[96]

Cleft palate is almost always in the midline and usually associated with a midline soft palate abnormality. Soft palate defects without hard palate defects may occur in the midline or are unilateral. Clinical signs and history of patients with cleft palate include failure to create negative pressure for nursing, nasal discharge, coughing, gagging, sneezing, nasal reflux, tonsillitis, rhinitis, aspiration pneumonia, poor weight gain, and general unthriftiness. Management requires nursing care by the owner, which includes tube feeding to avoid aspiration pneumonia.[96,102]

Surgical correction is performed in 3- to 4-month-old cats, preferably using the overlapping flap technique because there is less tension on the suture line (which is not located directly over the defect) and the area of opposing connective tissues is larger, which results in a stronger scar. It provides more reliable results compared with the medially positioned flap technique. Incisions are made in the mucoperiosteum to the bone (full-thickness flaps) at the medial margin of the defect on one side (envelope flap) and along the dental arch about 1 to 2 mm palatal to the teeth to the rostral and caudal margins of the defect on the other side (overlapping flap). The tissues are undermined with a periosteal elevator, ensuring that the major palatine arteries are not transected. The overlapped flap is folded on itself, turned, and sutured under the envelope flap so that the connective tissue surfaces are in contact. The sutures are placed in a horizontal mattress pattern. Granulation and epithelialization of exposed tissues are completed in 3 to 4 weeks.[96,102]

Midline soft palate defects are corrected by making incisions along the medial margins of the defect to the level of the caudal end of the tonsils. The palatal tissue is separated with a Metzenbaum scissors to form a dorsal (nasopharyngeal) and ventral (oropharyngeal) flap on each side. The two dorsal and the two ventral flaps are sutured separately in a simple interrupted pattern to the midpoint or caudal end of the tonsils.[96,102]

Acquired Palate Defects

An oronasal fistula may result from loss of incisive and maxillary bone associated with severe periodontal disease or tooth extraction, typically in the area of a maxillary canine tooth. An acute oronasal fistula following tooth extraction is diagnosed by direct visualization of the nasal cavity and bleeding from the ipsilateral nostril. Clinical signs of a chronic oronasal fistula include sneezing and ipsilateral nasal discharge, and a defect that communicates with the nasal cavity in the area of a missing tooth may be noted on oral examination. Elevating and positioning a labial-based mucoperiosteal flap over the defect repairs the oronasal fistula.[96,102]

Traumatic cleft palate is an acute midline soft or hard tissue defect of the hard palate (Figure 21-38) typically associated with high-rise syndrome[95] and less often with road-traffic trauma in cats. Although these clefts may sometimes heal spontaneously in 2 to 4 weeks with conservative management, the benefit of surgical management with medially positioned flaps outweighs the risk of developing a persistent oronasal communication. An acute traumatic cleft palate is managed by débriding the torn palatal tissue edges, undermining the palatal mucoperiosteum on either side of the defect (carefully avoiding transection of the major palatine arteries), approximating the displaced bony structures with digital pressure, and apposing and suturing of the two palatal flaps in a simple interrupted or mattress pattern. Tension on the suture line can be minimized by creating relieving incisions along the dental arches about 1 to 2 mm palatal to the teeth, allowing the flaps to be moved medially into apposition with each other (Figure 21-39). The exposed bone next to the teeth is left to granulate and epithelialize. If the palatal defect is extensive, inter-quadrant fixation is performed by securing a twisted wire between the maxillary canines (or other maxillary teeth if the crowns of the canines are missing) and covering the wire with bis-acryl composite.[96,102]

The modified split palatal U-flap is useful for large caudal defects.[96,102] The epithelial margins of the defect are débrided with a scalpel blade. One flap of slightly longer and another of slightly shorter length are created. The shorter flap is rotated through 90 degrees and transposed to cover the defect. Its medial aspect is sutured to

FIGURE 21-38 Clinical photograph **(A)** and radiograph **(B)** showing a traumatic cleft palate in a cat as a result of falling from a height. Note the wide separation of left and right incisive and maxillary bones *(double-ended arrows)* and the fractured left maxillary canine tooth *(arrow)*. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

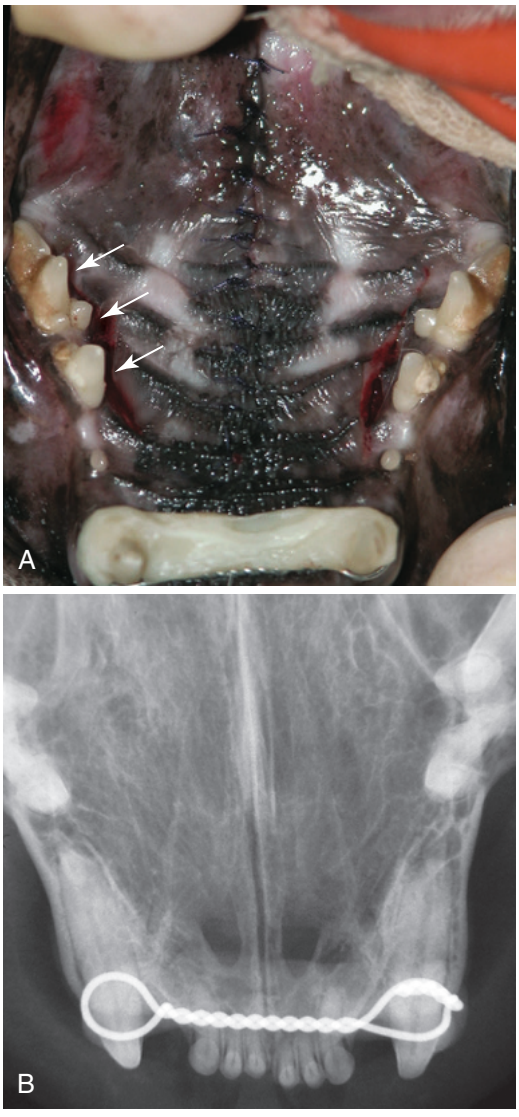


FIGURE 21-39 Clinical photograph **(A)** and radiograph **(B)** showing repair of the traumatic cleft palate in Figure 21-38, accomplished by means of approximation and suturing of medially positioned flaps after creation of bilateral releasing incisions *(arrows)* into palatal mucoperiosteum along the dental arches. Note interquadrant fixation (twisted wire covered with composite resin) between the maxillary canine teeth. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

the caudal aspect of the palatal defect. The longer flap is rotated through 90 degrees and transposed rostral to shorter flap. Its medial aspect is sutured to the lateral edge of the shorther flap. The denuded rostral aspect of the palate from which the flaps were harvested is left to granulate and epithelialize.[72,96,102]

Other techniques for repair of large palate defects include combinations of overlapping flaps and buccal- or labial-based pedicle or axial pattern flaps, which are created and sutured across the defect 4 to 6 weeks after extraction of several teeth. These flaps are supplied by major palatine or infraorbital blood vessels. The use of auricular cartilage grafts underneath flaps has also been described.[20] An alternative for repair of defects in the rostral or midportion of the hard palate is the use of a tongue flap. The edges of the dorsal aspect of the tongue are excised and apposed to the débrided edges of the palatal defect. The tongue is separated from the palate several weeks later, leaving enough tongue tissue with the palate to close the defect without tension. Another alternative is to create a permanent or removable silicone or acrylic obturator.[110]

OROFACIAL SOFT TISSUE INJURY

Penetration of the oral cavity may result from animal bites or, less commonly, foreign bodies; linear foreign bodies (such as dental floss) can get caught around the tongue and saw through to the lingual frenulum. Penetrating wounds can be deep and contaminated and are often located in the sublingual area, palate, tonsils, floor of the orbit, or pharyngeal walls. Management of these injuries requires surgical exploration; cleansing; and, if appropriate, suturing. Trauma to the mandibular or sublingual salivary gland ducts with subsequent sublingual mucocele (ranula) formation is rare in the cat. Lacerations of the cheek or lip are débrided and sutured for apposition of the mucosa and skin.

Lip avulsion is a degloving injury frequently associated with road-traffic trauma or when someone steps on the lip of a usually young cat. The lower lip is more frequently involved than the upper lip.[73] The wound is débrided, and the lip is repositioned. Simple interrupted sutures are made in areas with sufficient remaining gingiva and alveolar mucosa. Large horizontal mattress sutures can be passed around the tooth crowns. Securing the connective tissue side of the degloved lower lip to intermandibular tissues and the mandibular symphysis will decrease dead space and will reduce the likelihood of seroma formation (Figure 21-40).

Electric-cord injury occurs most often in young cats that chew on power cords.[60] Life-threatening airway compromise can result from pulmonary edema, which is caused by smoke inhalation or electrical exposure. Initially, the patient is managed conservatively (lavage with lactated Ringer's solution), and the injured tissues are left to necrose so that the maximum amount of tissue is retained. It can take several days before the extent of

FIGURE 21-40 Kitten with lower lip avulsion. Note the exposed surface of the mandibles **(A).** Securing the connective tissue side of the degloved lower lip to intermandibular tissues and the mandibular symphysis will decrease dead space and reduce the likelihood of seroma formation **(B).** Large horizontal mattress sutures can be passed around the tooth crowns **(C).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

FIGURE 21-41 Kitten presenting for the 1-week reexamination after electric-cord injury. Note that a rostral portion of the lingual body has been lost *(asterisk)*. There are multiple incompletely healed electric burns on the hard palate, alveolar mucosa of the left maxilla, and mucocutaneous junction areas of the lower lips *(arrows)*. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

local injury is clearly defined. Necrosis of the lips, cheeks, tongue, and hard palate is common (Figure 21-41); more extensive electric burns cause necrosis of dental pulp tissue and maxillary, palatal, or mandibular bones. Once the necrotic tissue is evident, surgical débridement is initiated, which should be conservative to the level of bleeding tissue, allowing time for definitive demarcation of devitalized tissue. Formation of osteonecrosis or oronasal fistula requires further surgery.[60] Possible causes for chemical burns are corrosive chemicals (the cat's skin should also be evaluated) or gastric reflux. The lesions are acute-onset ulcers covered by necrotic debris; initial therapy is lavage with lactated Ringer's solution, followed by conservative management.

Multiple factors influence tissue destruction in cats with gunshot trauma, including projectile mass, velocity, flight instability, and secondary projectiles formed by the primary projectile. Projectiles damage tissue by means of laceration and crushing, shock waves, and cavitation. Bones are shattered, and soft tissue damage can occur well beyond the visible injury as a result of progressive vascular compromise. Control of bleeding and maintenance of airway are initial considerations, followed by careful débridement, removal of projectiles and projectile fragments, and wound closure. Larger wounds may be only temporarily sutured closed to allow tissue swelling to decrease and sloughing of necrotic tissue to take place. Treating the patient conservatively for a few days allows determination of viable tissues available for definitive repair at a later time.

JAW FRACTURES

After stabilization of life-threatening injuries, jaw fractures are evaluated by inspection and palpation of mandibular and maxillary bones and the temporomandibular joints. The head is examined for asymmetry and discontinuity, exophthalmos or enophthalmos, lip avulsions, and facial wounds, and the oral cavity is inspected for mucosal lacerations, fractured and displaced teeth, malocclusion, hematomas, and hemorrhage.

Most mandibular and maxillary fractures can be satisfactorily assessed with size 2 and 4 dental radiographic film. The largest dental radiographic film can also be used in the cat to evaluate injuries to the zygomatic arch, mandibular ramus, and temporomandibular joint and tympanic bulla. Computed tomography is indicated for caudal mandibular fractures, maxillary fractures, and temporomandibular joint injury that cannot be assessed adequately with radiography. Imaging studies of intracranial structures should be considered in any patient with moderate to severe head trauma on presentation, failure to improve, or deterioration of clinical signs.

Mandibular Fractures

Mandibular fractures in cats are typically located in the area of the mandibular symphysis (symphyseal separation or parasymphyseal fracture) or the mandibular ramus (fracture of the condylar process or coronoid process). The midportion of the mandibular body is less often fractured in cats. However, iatrogenic mandibular fracture occurs after extraction of teeth, particularly in the area of the mandibular canines. Unilateral mandibular fractures often result in the lower jaw being deviated toward the side of injury, causing malocclusion. Bilateral mandibular fractures may result in a dropped lower jaw appearance. An oblique mandibular body fracture, with the fracture line running in a rostroventral direction, is relatively stable, insofar as the masticatory muscle forces may hold the fracture segments in apposition (favorable fracture). A mandibular body fracture with the fracture line running in a caudoventral direction is unstable because the muscular forces will lead to displacement of the fracture segments (unfavorable fracture).[63]

Mandibular ramus fractures are relatively stable because the surrounding muscle mass often prevents gross displacement of the fracture segments. Some say that condylar process fractures should be treated with condylectomy. Others suggest letting them heal as pain-free and functional nonunion, but immature and young adult cats with such injuries are at risk to develop temporomandibular joint ankylosis.

Maxillary Fractures

Fractures of the upper jaw are less frequent in cats. Epistaxis, facial swelling, subcutaneous emphysema, pain, and asymmetry are the usual clinical findings. Some cats with head trauma present with an acute traumatic cleft palate, zygomatic arch fracture, or a unilateral separation of the temporal bone from the parietal bone (the latter may often go unnoticed). Combined fractures of the zygomatic arch and the mandibular ramus can result in excess callus formation and ankylotic fusion in young animals, resulting in inability to open the mouth.

Minimally displaced upper jaw fractures may not require surgical repair other than suturing of torn soft tissues. Severely comminuted, depressed, and grossly unstable fractures require surgical intervention. Airway obstruction caused by displaced bones, swelling, or blood can be life-threatening. Cats with respiratory compromise should be placed in an oxygen cage, and the nostrils should be cleaned of blood and discharge and kept unobstructed.

Jaw Fracture Repair

Surgical treatment is aimed at repairing hard and soft tissue injuries, establishing normal masticatory function and providing acceptable cosmesis. Initially, the mouth is flushed with dilute chlorhexidine (0.12%), and the fracture sites are carefully débrided to remove blood clots, food particles, foreign material, small bone fragments, and necrotic tissue. Severely mobile teeth, teeth with advanced periodontitis or periapical disease, and those that interfere with reduction of the jaw fracture should be extracted. If teeth with fracture lines extending along the periodontal ligament space toward the root apex are retained, they should be carefully monitored for evidence of periodontal or endodontic pathology, and appropriate treatment must be instituted as soon as either is recognized. Soft tissue lacerations are sutured or closed after orthopedic repair. Most mandibular and some maxillary fractures are open to the oral cavity, and antibiotic therapy may be considered in selected cases to prevent infection.

Tape or nylon muzzles[55,118] can be used as temporary first-aid treatment while awaiting definitive repair for most mandibular fractures and represent a means of additional support in active patients in which the healing mandible may be subjected to excessive forces. Muzzles may be the sole means of stabilization for mandibular fractures in young cats, minimally displaced mandibular ramus fractures, and pathologic mandibular fractures when the owner declines surgical repair. However, they are contraindicated for maxillary fractures (airway compromise) and maybe also for temporomandibular joint injury (joint immobility may promote temporomandibular joint ankylosis). The tape muzzle is applied snugly enough to maintain the dental interlock but loosely enough (leaving a gap of about 0.5 to 1 cm between the incisal edges of the maxillary and mandibular incisors) to permit the tongue to protrude and lap water and semiliquid food (Figure 21-42).[55,118] Occlusal alignment and stabilization of midbody and caudal mandibular fractures may also be achieved with bis-acryl composite bridges between the maxillary and mandibular canines (or other teeth) (Figure 21-43).[9] Similar to the muzzling technique, a small gap between the maxillary and mandibular incisors should provide space for the tongue to protrude. If the distance between maxillary and mandibular incisors is too wide, the cat may experience difficulty in swallowing food. Other complications of maxillomandibular fixation techniques include dermatitis (only for muzzling), dyspnea, and aspiration pneumonia.[9,63]

Mandibular symphyseal separation or parasymphyseal fractures are repaired with circumferential wiring.[63] A stab incision is made in the chin at the ventral midline. An 18-gauge needle is inserted between bone and soft tissues to exit into the mouth distal to the canine teeth. A 20- to 22-gauge orthopedic wire is passed through the needle. The needle is removed and reinserted on the other side, and the oral wire end is passed through the needle opening. The needle is again removed, the symphysis is held in proper alignment, and the wire ends are twisted below the chin until the lower jaw is stable. The twisted wire is trimmed, and the 0.5- to 1-cm portion of twisted wire is bent caudally so that the skin covers

FIGURE 21-42 Cat with mandibular fracture and adhesive tape muzzle in place. Note the three parts of the muzzle: *(1)* loop encircling the upper and lower jaws, *(2)* loop ventral to the ears and around the neck, and *(3)* an additional middle layer running over the forehead. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

FIGURE 21-43 Cat with mandibular fracture and bis-acryl composite bridges *(asterisks)* between the maxillary and mandibular canines. Note the space between the incisal edges of the maxillary and mandibular incisors to permit the tongue to protrude and lap water and soft food. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

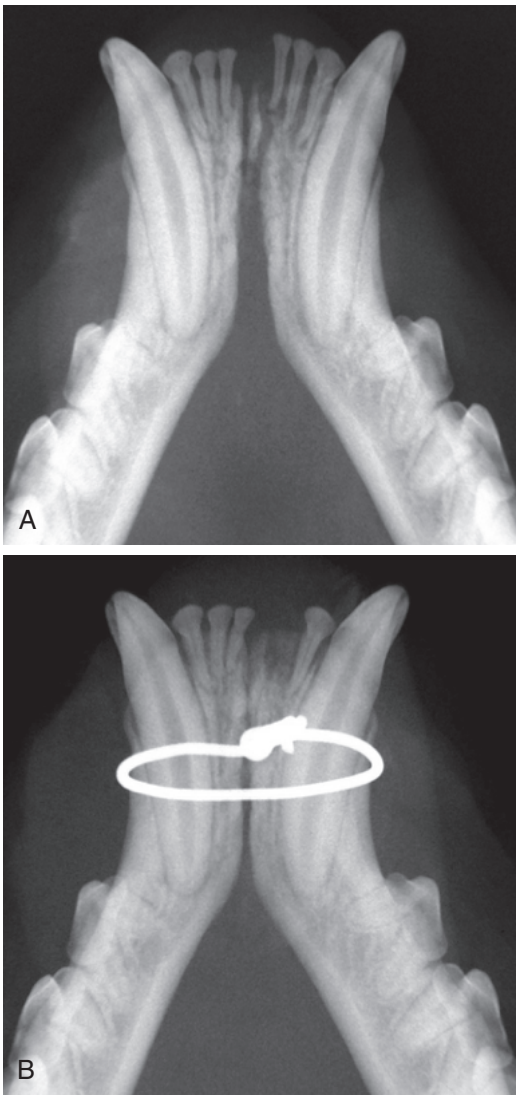


FIGURE 21-44 Dental radiographs of a cat with separation of the mandibular symphysis before treatment **(A)** and after circumferential wiring **(B).** Note that two mobile incisor teeth had been extracted. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

it. The wire is removed in about 4 weeks by cutting it intraorally and pulling it out from below the chin (Figure 21-44). Leaving the wire in place for extended periods or overtightening the wire bears the risk of necrosis and resorption of bone around the canine tooth roots. A twisted intraoral wire can be applied between the crowns of the mandibular canine teeth to give additional stabilization.[61] A figure-of-eight wire pattern around the mandibular canine teeth is not recommended because twisting of the wire ends can result in linguoverted canine teeth and long-term malocclusion.

Effective alignment of fracture segments is achieved with interdental wiring techniques, making use of the tooth crowns as anchoring points and providing additional retention surface for splint materials.[53,63] Interdental wiring should never be a stand-alone treatment, but rather should always be followed by intraoral splinting with resin. The teeth should be cleaned with hand or ultrasonic scalers and their surface slightly roughened with course pumice before maxillofacial repair. The Stout multiple-loop wiring technique includes at least two teeth in each fracture segment into the wiring procedure. The size of the orthopedic wire used in cats may range from 24 to 28 gauge. Wire slippage from the teeth can be prevented by using a 20- or 22-gauge needle and placing the wire subgingivally between the teeth. Alternatively, drops of composite can be placed at the gingival third of the mesial and distal crown surfaces of the teeth to create overhangs that allow the wire to remain in position. Loops are situated on the buccal side of the interdental spaces of the maxillary teeth and lingual (or buccal—depending on evaluation of occlusion) sides of the interdental spaces of the mandibular teeth. The wire can be twisted in areas of missing teeth, and looping is continued with the next teeth in line. Once sufficient teeth have been looped, the "static" wire end is threaded through all loops so that both wire ends can be twisted in a pull-and-twist fashion. Finally, all loops are twisted (slight ventral pull for mandibular teeth and dorsal pull for maxillary teeth) and bent interdentally. The modified Risdon wiring technique uses a wire whose middle portion is initially anchored to one tooth. The two wire ends are twisted along the dental arch and anchored again to another tooth. The twisted wire is sutured to gingiva at several locations between the two anchor

teeth, which effectively aligns displaced fracture segments before placement of an intraoral resin splint.

Bis-acryl composite is used to fabricate intraoral resin splints. The cleaned teeth are acid etched (to improve attachment of the resin) and air dried. The resin is applied with an applicator gun (syringe with mixing tip) primarily to the lingual surface of mandibular teeth and the labial and buccal surface of maxillary teeth, preferably coronal to the mucogingival junction.[62] Once the material has set, the splint is trimmed and shaped with acrylic burs on low-speed handpieces, allowing for closure of the mouth, and finally polished (Figure 21-45).[53] Because food particles may become trapped between the splint and oral tissues, home oral hygiene is instituted (repeated flushing with dilute chlorhexidine and regular tooth and splint brushing). The splint is removed by interdental sectioning with a bur and detaching the material in segments, using an extraction forceps or luxating elevator. After splint removal, the teeth are cleaned and polished. Gingival inflammation from splint and wire trauma usually subsides within a few days.

Other less commonly employed techniques include osseous wiring, external fixation, and bone plating.[11] Regardless of whether a noninvasive or invasive technique is used to repair a jaw fracture, the occlusion should be assessed and radiographs of the surgical sites obtained before extubation. The cat is discharged on adequate pain control, an Elizabethan collar, and proper feeding instructions. Repair devices are removed after radiographic confirmation of fracture healing, usually 3 (immature and adolescent cats) to 7 weeks postoperatively. Minor occlusal discrepancies after device removal can be corrected by odontoplasty. If malocclusion is severe and prevents closure of the mouth, extraction of one or more teeth will be necessary to restore acceptable masticatory function. Affected jaws and teeth should be reevaluated in 6 and 12 months to determine appropriate healing and ensure periodontal and endodontic health of teeth near jaw fracture lines. Severe jaw fractures in kittens can disturb normal skeletal growth and development of the teeth, resulting in facial deformities and dental abnormalities in the growing cat.

TEMPOROMANDIBULAR JOINT DISORDERS

There are three temporomandibular joint disorders relevant to the cat: temporomandibular joint luxation, open-mouth jaw locking, and temporomandibular joint ankylosis. Luxation of the temporomandibular joint is often confused with open-mouth jaw locking. Both

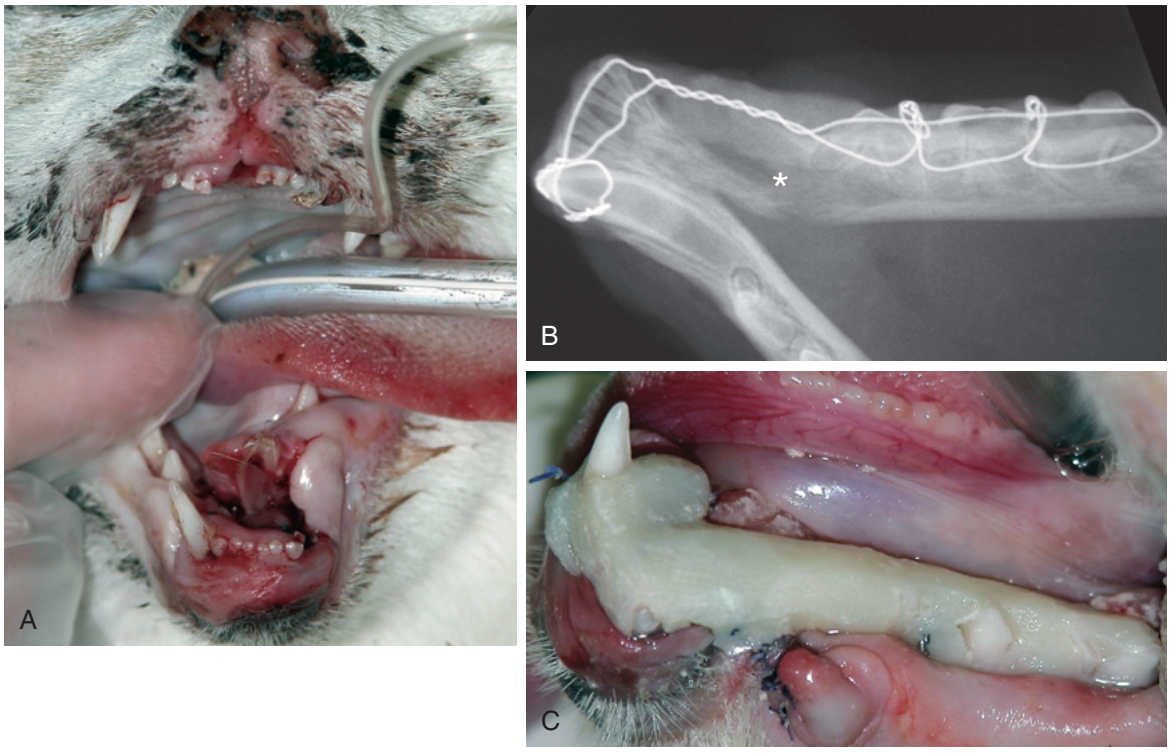


FIGURE 21-45 Clinical photographs and radiograph of cat with severe head trauma. There are maxillary and mandibular fractures **(A).** Jaw fracture repair in the area of the injured and extracted left mandibular canine tooth involved interdental wiring using the Stout multiple-loop technique and twisting *(asterisk)* of the wire ends in edentulous areas **(B)** and intraoral splinting using bis-acryl composite resin **(C).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

conditions usually present with inability to close the mouth, but their etiologies, pathophysiologies and treatments are completely different. A definitive diagnosis can be made on the basis of clinical examination and radiography (dorsoventral view). Knowing which condition is present is paramount when formulating a treatment plan. Although temporomandibular joint luxation often may be resolved with a wooden dowel (e.g., a pencil) placed between the maxillary and mandibular carnassial teeth and then closing the jaws, the same treatment will cause further trauma and pain to the cat with open-mouth jaw locking. It should be noted that any trauma to the temporomandibular joint in young cats can lead to joint ankylosis.

Temporomandibular Joint Luxation

Luxation typically occurs as a result of trauma. With rostrodorsal luxation the mandibular condyle moves rostrally and dorsally.[58] As a result, the lower jaw shifts laterorostrally to the contralateral side. Malocclusion will be a presenting clinical sign, resulting in the inability of the animal to close its mouth fully owing to abnormal contact between the maxillary and mandibular teeth. Very well-developed retroarticular processes resist caudal displacement of the mandibular condyle. Consequently, fracture of this structure may be obligatory for caudal luxation to occur (which is rare).

A dorsoventral radiographic view best demonstrates rostrodorsal temporomandibular joint luxation, usually showing an increased width of the joint space and a rostral displacement of the mandibular condyle (Figure 21-46). Lateral oblique views are also useful in establishing a diagnosis. Reduction of rostrodorsal temporomandibular joint luxation in the cat is obtained by placing a pencil between the maxillary fourth premolar and mandibular first molar teeth on the affected side only (pencil acts as a fulcrum) and closing the lower jaw against the pencil while simultaneously easing the jaw caudally. The reduction is often unstable, and a tape muzzle for 2 to 4 weeks may be indicated to prevent the cat from opening the mouth wide, thus reducing the likelihood of recurring displacement. Chronic luxation is treated by condylectomy.[29]

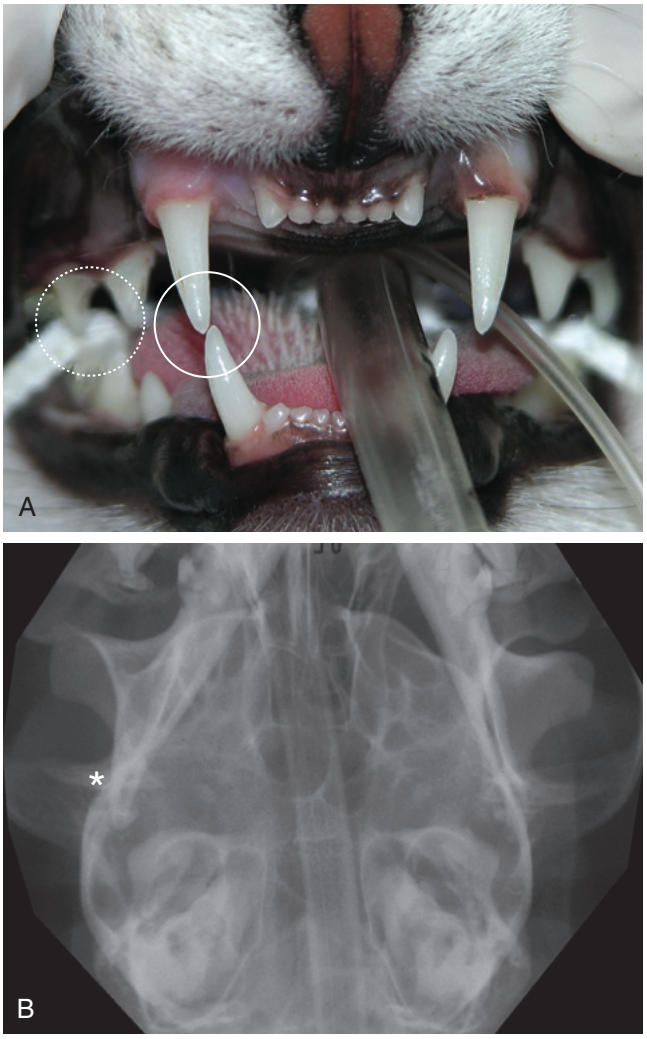
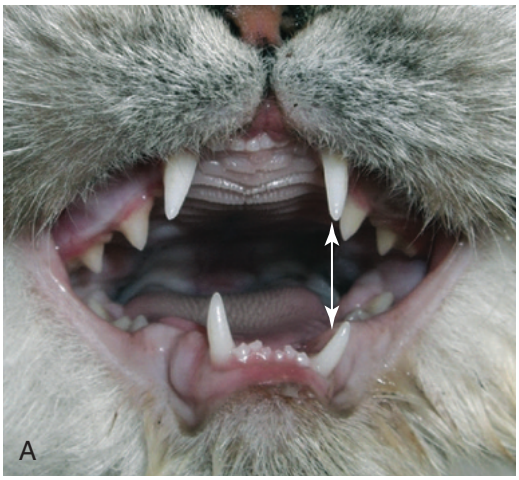


FIGURE 21-46 Cat with rostrodorsal luxation of the left temporomandibular joint. Note inability to fully close the mouth because of contact between maxillary and mandibular canines *(full circle)* and cheek teeth *(interrupted circle)* after shifting of the lower jaw towards the unaffected side **(A).** Dorsoventral radiographic view shows the condylar process *(asterisk)* of the left mandible being displaced rostrally **(B).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

Open-Mouth Jaw Locking

Dysplasia of the bony or soft tissues of the temporomandibular joint is congenital or acquired during life and has primarily been reported in Persian cats.[93] It may result in increased laxity of the temporomandibular joint capsule and open-mouth jaw locking. Yawning often precipitates an event. The coronoid process of the mandible can flare laterally, locking onto or ventrolateral to the zygomatic arch. In contrast to rostrodorsal temporomandibular joint luxation, there is no contact between maxillary and mandibular teeth, and the cat presents with its mouth wide open (Figure 21-47). The addition of computed tomography is of academic interest and may not be necessary for establishing a diagnosis (Figure 21-48).[93,108]

An ipsilateral protuberance on the ventrolateral aspect of the zygomatic arch may be palpable. Locking occurs on the opposite side of the dysplastic joint. However, both joints can be affected (warranting bilateral surgery), and manual locking of the apparently unaffected side should be attempted under chemical restraint before surgical treatment. Open-mouth jaw locking can also occur without temporomandibular joint dysplasia as a result of traumatic events that caused



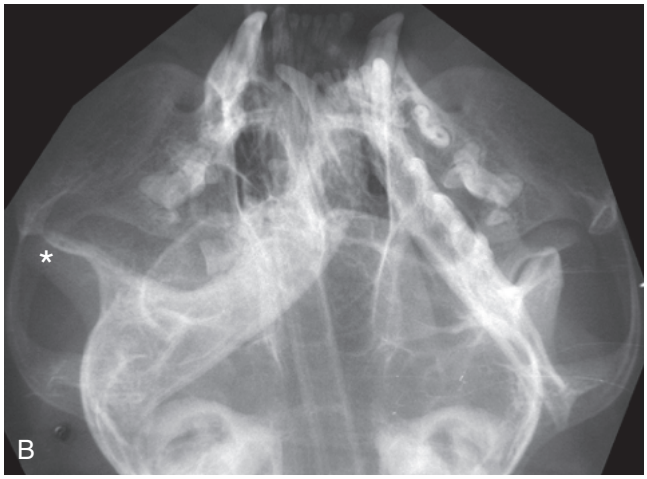


FIGURE 21-47 Cat with open-mouth jaw locking on the left side. Note shifting of the lower jaw toward the affected side (with the left mandibular dental arch farther ventral compared with that on the right) and inability to close the mouth, which is held wide open *(double-ended arrow)* without any contact between maxillary and mandibular teeth **(A).** Dorsoventral radiographic view shows the coronoid process *(asterisk)* of the left mandible being locked ventrolateral to the zygomatic arch **(B).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

FIGURE 21-48 Computed tomography (three-dimensional reconstruction) performed in a cat with open-mouth jaw locking, demonstrating the coronoid process of the left mandible being locked ventrolateral to the zygomatic arch *(arrow). (From Reiter AM: Symphysiotomy, symphysiectomy and intermandibular arthrodesis in a cat with open-mouth jaw locking: case report and literature review,* J Vet Dent *21:147, 2004; used with permission.)*

flattening of or excessive callus formation at the zygomatic arch, malunion fracture of the mandibular body, and increased mandibular symphyseal laxity.[93]

Acute treatment of open-mouth jaw locking consists of opening the mouth further (sedation may be needed) to release the coronoid process from the ventrolateral aspect of the zygomatic arch and then closing the mouth. Tape muzzling is a temporary solution. Definitive surgical treatment involves partial coronoidectomy, partial zygomectomy, or preferably a combination of both.[93] A curvilinear incision is made parallel to the zygomatic arch, muscle attachments are dissected from the bone with a periosteal elevator, and the coronoid process locked ventrolateral to it is identified. A segment of the zygomatic arch is removed with a rongeur. The same instrument is then used to remove a portion of the coronoid process, followed by closure of the surgical site. It is helpful to grab the coronoid process, once identified, with a small towel clamp so that it can be readily found after partial zygomectomy.[93]

Temporomandibular Joint Ankylosis

Progressive inability to open the mouth usually occurs as a complication after trauma to the temporomandibular joint. True or intracapsular ankylosis is fusion of hard tissues within the temporomandibular joint capsule. Radiographic features are loss of temporomandibular joint space, irregular mandibular condyle contour, and extensive new bone formation. Treatment consists of condylectomy and excision of all associated callus (which often extends extracapsularly).[2,74,89] Transposing adjacent muscle tissue or packing fat transplants into the space between the cut bony surfaces may be helpful in avoiding or reducing reankylosis. Postoperative care includes physical therapy (repeated mouth opening several times a day) and use of glucocorticosteroids (that slow down healing capacity of connective tissue such as bone). Oral prednisolone is given at 1 to 2 mg/kg daily divided in two doses for 1 week and then tapered to 0.25 to 0.5 mg/kg once a day over a 4-week period. Injection of repository triamcinolone into each surgery site can be used if oral prednisolone is not satisfactory.

Excessive callus formation during healing of fractures of the zygomatic arch and mandibular ramus can also lead to progressive inability to open the mouth without temporomandibular joint involvement. Such

false or extracapsular ankylosis may also be a sequela of extensive new bone formation associated with otitis media. Surgical treatment depends on the nature and location of the ankylotic lesion and often requires resection of zygomatic arch, coronoid process, condylar process, and excessive new bone.

ORAL AND MAXILLOFACIAL TUMORS

Oral and maxillofacial tumors may be benign (noninvasive or invasive with no metastasis) or malignant (invasive and with metastasis) and may be of dental (odontogenic; epithelial, mesenchymal, or mixed) or nondental origin.[102] Geriatric cats are generally predisposed to oral and maxillofacial tumors, but there are certain tumors that typically occur in adolescent and young adult cats (e.g., inductive fibroameloblastoma typically in the rostral maxilla of cats younger than 2 years old). Odontogenic tumors can occur at any age, but tumors in young cats are more likely to be of odontogenic origin.

Clinical complaints may be absent with benign tumors, but dysphagia, drooling, bloody oral discharge, halitosis, and weight loss are often reported with malignant tumors. There may be an obvious proliferative mass or swelling of the mandible or maxilla. Daily home oral hygiene by the owner and professional oral examination at every patient visit by the veterinarian is imperative in early tumor detection.

Benign Lesions

Benign oral and maxillofacial tumors are less common in cats, but osteoma, lipoma, peripheral odontogenic fibroma, giant cell epulis, ameloblastoma, inductive fibroameloblastoma (feline inductive odontogenic tumor), amyloid-producing odontogenic tumor, and plasmacytoma are occasionally seen.[32,34,35] *Epulis* (plural, *epulides)* is a nonspecific, clinical term referring to a local, exophytic growth on the gingiva that could present nonneoplastic or neoplastic disease (benign or malignant). Therefore its use is discouraged without the addition of descriptive adjectives. The nature and origin of so-called multiple feline epulides are controversial. Some consider these gingival proliferations to be benign neoplasms[16,19]; others suggest that they arise from the periosteum and represent inflammatory lesions (reacting to plaque, calculus, and other irritation).[33]

Malignant Lesions

The predominant malignant oral and maxillofacial tumor in cats is squamous cell carcinoma (SCC),[111] which—if occurring on the lower jaw—often presents as mandibular swelling (with bone invasion and "sunburst" formation) (Figure 21-49), but often without significant intraoral soft tissue proliferation. If occurring on the upper jaw (there often is a history of a nonhealing tooth extraction site), SCC usually is nonprotuberant, with severe bone invasion into the maxilla, orbit, and zygomatic arch. SCC tends to be more proliferative and ulcerated when located on the lips, cheeks, tongue, and sublingual region. Lingual and sublingual SCC often extends into the caudal body or the root of the tongue, making it firm and non-elastic on palpation. Metastasis to regional lymph nodes is common, and distant metastasis may occur late in the disease process. The average age of onset is 10 years, and occurrence of SCC in cats has been associated with exposure to flea collars, high intake of canned food, regular ingestion of canned tuna, and environmental tobacco smoke.[10,107] History and clinical signs include mobile teeth, nonhealing extraction sites, swelling of the mandible or maxilla, oral ulceration and bleeding, halitosis, and dysphagia if

FIGURE 21-49 Cat with mandibular squamous cell carcinoma. Swelling of the lower jaw without significant intraoral soft tissue proliferation is commonly seen with this type of tumor **(A).** Radiograph of the left mandible showing bone destruction and sunburst effect, and the third premolar tooth is missing **(B).** *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

the mass is large enough to affect masticatory function. Fibrosarcoma, osteosarcoma, hemangiosarcoma, and lymphosarcoma are less common oral and maxillofacial tumors, and malignant melanoma is very rare in the mouths of cats.[102]

Differential Diagnoses

Many differential diagnoses can mimic oral and maxillofacial tumors. Normal anatomy should be distinguished from pathology (e.g., incisive papilla caudal to maxillary incisors, lingual molar gland caudolingual to the mandibular first molar teeth). If the suspicious lesion is located directly on the midline or bilateral, an anatomy textbook should be consulted and normal structures ruled out before performing a biopsy.

Other non-neoplastic differential diagnoses include scar tissue (usually on oral mucosa along bite planes or the tongue), eosinophilic lesions (granuloma and ulcer), healing wounds (granulation tissue), inflammatory lesions (e.g., ulcers), foreign bodies, apical abscess, cellulitis, osteomyelitis, gingival hyperplasia (abnormal increase in the number of normal cells in a normal arrangement that results clinically in gingival enlargement), dentigerous cyst (arising in an area of a tooth that has not erupted), odontomas (conglomerate of disorganized normal tissue cells), edema, and sialoceles (extravasation of saliva into submucosal or subcutaneous tissues as a result of trauma to salivary ducts or gland capsule).[38]

Staging, Oral Examination, and Biopsy

Thoracic radiographs should be obtained of any patient in which oral and maxillofacial cancer is suspected. Abdominal ultrasound may be added in selected cases. Regional lymph node enlargement indicates either tumor metastasis or reactivity related to oral inflammation. Enlarged lymph nodes should be evaluated by fine-needle aspiration or excisional biopsy. A negative lymph node biopsy does not preclude the possibility of regional metastasis, which may occur along perineural or vascular routes, or metastasis to other, less accessible lymph nodes.[51]

Oral examination focuses on the location, size, extent, and surface characteristics of the lesion, which may be smooth, irregular, pigmented, inflamed, ulcerated, bleeding, or necrotic. Teeth may be displaced or missing. Some cats have difficulty opening (when rostral movement of the coronoid process of the mandible is inhibited or the temporomandibular joint is involved) or fully closing the mouth (when opposing teeth bite into the intraoral tumor), and appetite and activity level may be affected. Decreased ability to retropulse the eye globes is often noted in the case of maxillary, retroorbital, and caudal pharyngeal masses. Radiography of the jaws and head (using standard film or sizes 2 and 4 dental film) will further define the extent of oral and maxillofacial tumors. Computed tomography is particularly helpful in cats with maxillary and caudal mandibular tumors and for the assessment of regional lymph nodes.

Suspect lesions should be sampled for examination.[102] A biopsy is preferably obtained from an area that can be included in the definitive resection. If cytologic or histologic results do not match the clinical findings, a second, deeper, and larger specimen is obtained. Cytologic techniques are often performed with a 22-gauge needle by means of a needle biopsy ("woodpecker method") or needle aspiration. Impression smears and scrapings may be of value only if obtained from the cut surface of a tumor. Instruments for histologic sampling include rongeurs, disposable open-ended skin biopsy punches, and cold scalpel blades for incisional or excisional biopsy. Multiple samples should be obtained. Hemostasis is achieved by digital pressure, and biopsy sites of more deeply invading tumors are sutured. For adequate fixation the specimen is placed in 10% buffered formalin at a ratio of one part tissue to 10 parts fixative.[102]

Laboratory workup before definitive surgery should include complete blood cell count and biochemical profile. Urinalysis, blood typing and cross-matching, coagulation profiles, and buccal mucosa bleeding time are performed in selected cases. The client must be informed about intraoperative and postoperative complications, follow-up care, long-term function, quality of life, and prognosis.

Treatment

Marginal resection with small amounts of unaffected surrounding tissue is restricted to small and benign oral and maxillofacial tumors. Radical surgery (mandibulectomy, maxillectomy, glossectomy, and wide lip and cheek resection) of invasive and malignant tumors should include at least 1 cm of apparently healthy tissue (including skin) surrounding the neoplastic lesion.[113] The use of electrocautery along wound edges that will be sutured is to be avoided. Wound closure depends on tissues available for creation of flaps (mucosa, skin, local, and distant). Combined therapy (surgery plus radiotherapy or chemotherapy or both) may be indicated, particularly for tumors with regional or distant metastasis.[76] When surgical excision is not an option, efforts should be made to decrease the rate of growth (radiotherapy, chemotherapy) and provide relief from discomfort (extraction of teeth impinging on the tumor, administration of pain medications).* Expression of cyclooxygenase (COX) in feline oral SCC has been

*References 15, 30, 31, 49, 57, 76, 119.

determined,[23,48] and the use of COX inhibitors such as piroxicam and meloxicam for cancer palliation may thus provide a survival advantage. Concurrent use of corticosteroids should be avoided, and gastric protectants such as misoprostol should be considered.

The relatively small size of the head of the cat, the proximity of the upper jaw to the nasal cavity and orbit, and the rather short and tight upper lips (limiting the amount of soft tissue available for wound closure) make radical maxillectomy far more challenging in the cat than in the dog. Therefore maxillectomy in the cat is often reserved to small and rostrally located tumors of the upper jaw. Mid and caudal maxillary malignancies could appear small on clinical examination, but they have a tendency to invade the nasal cavity, orbit, and zygomatic arch. In addition to that, surgical efficiency is critical when performing maxillectomies because bleeding may not be controlled effectively until the affected piece of jaw is removed. Bone should initially be scored with power instruments (rotating burs; sagittal and oscillating saws) or an osteotome and mallet, followed by the use of leverage with an appropriate instrument to break the remaining bony attachments. This approach prevents injury to nasal mucosa and allows for safe ligation of vessels within the infraorbital (or mandibular, in the case of partial mandibulectomy) canals. Diffuse bleeding from nasal mucosa may respond to wound irrigation with 0.05 to 0.1 mL/kg of a mixture of 0.25 mL phenylephrine 1% and 50 mL lidocaine 2%. When there is insufficient lip and cheek mucoperiosteum available for wound closure, distant flaps will be necessary to close the maxillectomy site.

Unilateral and bilateral rostral mandibulectomy just distal to the canine teeth provides good function and cosmesis in cats.[87] Bilateral resection caudal to this level or unilateral mandibular body resection results in loss of the mandibular symphysis, "floating" of the remaining mandibular sections, and progressively greater problems with tongue retention, eating, and grooming. In the case of unilateral total mandibulectomy,[113] the mandibular symphysis is separated with a scalpel blade. Incisions are made well away from the tumor in the oral mucosa and skin, and the mandible is undermined by blunt dissection. The lateral attachments of the tongue are separated, and mandibular and sublingual salivary ducts are ligated when transected. This frees the mandible for further dissection of the masseter and pterygoid muscles from their attachments. The inferior alveolar artery and vein entering and exiting the mandibular canal through the mandibular foramen at the medial aspect of the mandible are ligated and transected. The temporomandibular joint capsule is incised, temporal muscle attachments on the coronoid process are dissected free, and the mandible is lifted out. The incision is closed with synthetic absorbable monofilament sutures, apposing connective tissue and oral mucosal edges (Figure 21-50). After more involved unilateral mandibulectomy procedures, two complications should be addressed, preferably at the time of resective surgery. The opposite mandible will swing over toward the midline, which may result in the remaining mandibular canine tooth to impinge on the palate when the mouth is closed; to avoid this, the tooth is extracted or its crown surgically reduced, followed by vital pulp therapy. The tongue also may lose its ventrolateral support and hang out of the mouth, resulting in drooling and chronic dermatitis. This can be prevented by ipsilateral, rostral advancement of the lip commissure to form a fold that contains the tongue (commissuroplasty).

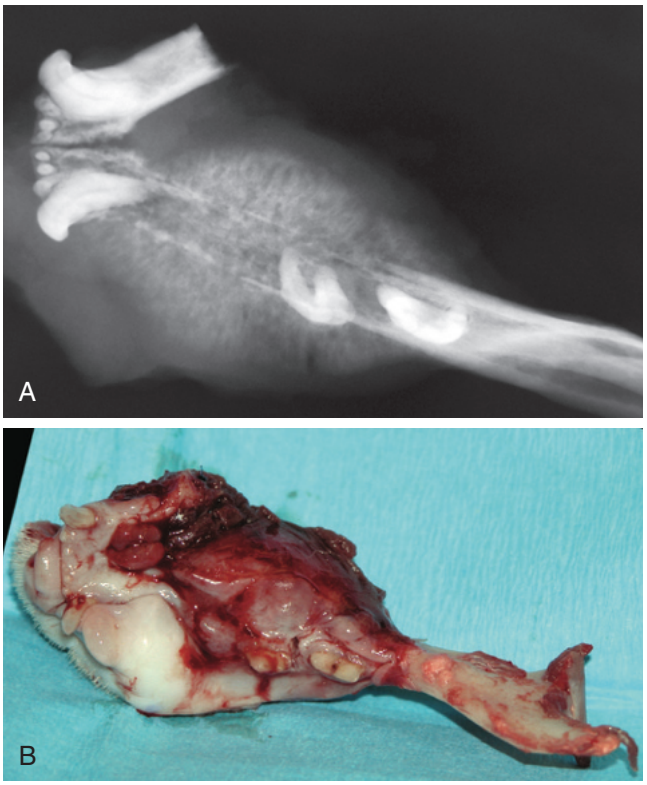


FIGURE 21-50 Radiograph **(A)** and clinical photograph of resected specimen **(B)** of cat in Figure 21-49 undergoing left total and right partial mandibulectomy. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

Wound dehiscence 2 to 3 days after surgery usually results from tension on suture lines or compromised vascularity of flaps. Freshly dehisced flaps are resutured after further undermining to eliminate tension. Closure of chronic oronasal defects should be performed after complete healing of surrounding soft tissues has occurred. Postoperative pain is controlled with a combination of centrally acting opioids and nonsteroidal antiinflammatory medications. Injectable or oral opioids are supplemented until fentanyl from a transdermal patch achieves an adequate level in the blood.[5] Antibiotic treatment is not required after oral and maxillofacial

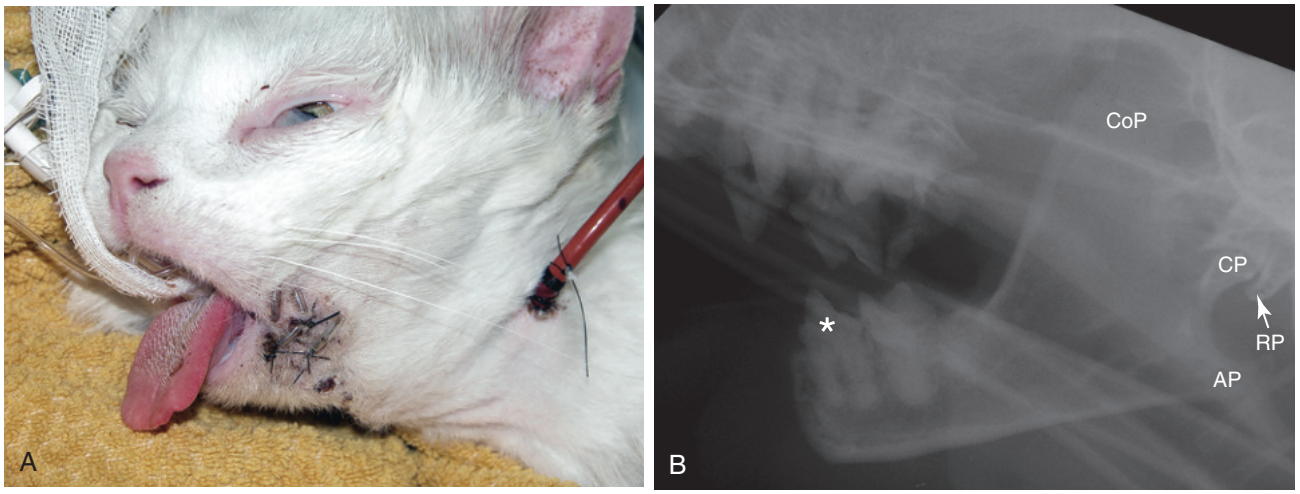


FIGURE 21-51 Clinical photograph of cat in Figure 21-49 2 weeks after left total and right partial mandibulectomy, left commissuroplasty (tension-relieving sutures still in place), and esophageal feeding tube placement **(A).** Radiograph **(B)** revealing extent of mandibular resection just rostral to the right mandibular fourth premolar tooth *(asterisk). CoP,* Coronoid process; *CP,* condylar process; *RP,* retroarticular process; *AP,* angular process. *(Copyright 2010 Dr. Alexander M. Reiter; used with permission.)*

surgeries in the otherwise healthy cat. Broad-spectrum antibiotics are given perioperatively in debilitated and immunosuppressed patients and those suffering from organ disease, endocrine disorders, cardiovascular disease, severely contaminated wounds, and systemic infections.

Water is offered once the animal has recovered from anesthesia. Soft food is offered 12 to 24 hours after surgery and maintained for about 2 weeks.[102] The cat may require several days to adapt to the changed circumstances in its mouth before being willing to eat normally. An esophageal feeding tube will provide proper nutrition during the immediate postoperative period. Chlorhexidine digluconate solution or gel (0.12%) is administered into the mouth for 2 to 3 weeks. An Elizabethan collar may be used to prevent disruption of the surgical sites. Reexaminations (including palpation of head and neck lymph nodes) are scheduled at 2 weeks (removal of skin sutures) and 2, 6, and 12 months postoperatively and then once annually (Figure 21-51). After the histopathologic results arrive, collaboration with an oncologist is helpful to discuss the need for further treatment (surgery, radiation therapy, and chemotherapy). Thoracic radiographs are repeated as necessary to monitor for distant metastasis.

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