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Oral disorders of exotic rodents
Loïc F.J. Legendre, DVM, Diplomate AVDC, EVDC

Northwest Veterinary Dental Services Ltd., 4037 Sunset Boulevard,
North Vancouver, BC, V7R 3Y7 Canada

The word “rodent” comes from the Latin verb rodere meaning “to gnaw”; thus, all rodents share the important characteristic of possessing two pairs of continuously growing incisors with which they gnaw. All of them also have a monophyodont dentition (no primary teeth). There are more than 1700 species of rodents [1,2]. In an order this large, variations in habitat (desert to tropical jungle), size (a few grams to more than 50 kg), and diets (omnivorous to specialized herbivorous), have resulted in a wide variation in their dental anatomy.

Anatomy

The dental formulas of rodents vary, but in general they possess four incisors, no canine teeth, few premolars and 8 to 12 molars. Caviidae (guinea pigs), Chinchillidae (chinchilla), Hydrochoeridae (capybara), and Castoridae (beavers) share the following dental formula:

\[ 1/1 \ 0/0 \ 1/1 \ 3/3 = 20 \]

Muridae (Old World rats and mice) have the following dental formula:

\[ 1/1 \ 0/0 \ 0/0 \ 3/3 = 16 \]

Sciuridae (squirrels) have the following dental formula [2]:

\[ 1/1 \ 0/0 \ 1-2/1 \ 3/3 = 20-22 \]
The incisors continue to grow throughout the life of the animal. These are classified as elodont or aradicular hypsodont teeth [3] (long crown and no anatomical root) and they possess an open-rooted system [1].

Based on dentition, rodents can be divided into two groups. The larger group consists of animals who have elodont incisors and brachyodont (short crowns and anatomically-formed roots) premolars and molars (Fig. 1). The smaller group is made up of animals whose teeth are all elodont. The first group eats diets that are fairly high in caloric energy; they are not particularly abrasive, and, consequently, these rodents possess low crowned, well-rooted premolars and molars. Guinea pigs, chinchillas, capybaras, Patagonian cavies, and springhaas are in the latter group and are described as herbivorous rodents [4]. Their teeth have adapted to a more voluminous abrasive diet and have large chewing surfaces. Their cheek teeth continue to grow to compensate for the wear that occurs during prolonged chewing. Voles are an intermediate group that shows variation in crown length between species. Tooth roots either form, but not until skeletal maturity, or do not form; the species who have entirely elodont dentition are able to live in a harsher environment where the vegetation is tougher [4].

Throughout the order, incisors grow at a rapid rate; 55 to 65 mm per year of growth was reported for chinchillas [5]; higher rates are often found in smaller species. Incisors are normally worn down as fast as they grow by gnawing on plants, gathering food and bedding, burrowing, or gaining access to food [4]. Their incisors also differ from other teeth; the enamel is deposited unevenly on their surfaces [1]. The superficial layer of enamel is commonly pigmented, except in guinea pigs. Enamel is primarily present on the labial surface, less so on the mesial and distal surfaces, and is absent on the lingual surface (see references [1,4–6]). This distribution is believed to be responsible, in part, for the chisel-like appearance of their crowns. Chewing
and gnawing activities seem to be important determinants of the incisor’s shape.

Clinical signs and diagnosis of oral diseases

Crossley [7,8] described the common signs of oral diseases in rodents, in general, and in chinchillas, in particular. Box 1 shows a list of presenting signs that are associated with oral disease. Box 2 shows a list of physical examination findings that are indicative of oral problems. The presenting signs are often vague and disease is usually far advanced by the time the patient is presented to a veterinary facility. History and palpation should steer the clinician in the right direction. To establish a definite diagnosis, however, a detailed look at the dentition is necessary. Unfortunately, the oral opening is proportionally narrower than in carnivores and the cheek teeth are caudally positioned, which makes thorough dental examination difficult. Even with good restraint and a dental endoscope (eg, an otoscope or better yet; a Welch Allyn (Skaneateles Falls, NY) illuminated nasal speculum), a thorough examination of the oral cavity is nearly impossible in the conscious patient. A comprehensive oral examination requires anesthesia, an oral speculum (Rodent mouth gag, JR1rg; Jorgensen Laboratories, Loveland, Colorado) (Fig. 2), cheek dilators (JR1rds and JR1rdl; Jorgensen Laboratories) (Fig. 3), light, mirrors, magnification, and radiography [2,7]. Because of the inherent difficulty in performing a thorough dental examination in rodents, historically, many conditions were missed which resulted in poor treatment outcome. Much of the information on dental pathology was gathered from postmortem examinations of these animals. The high incidence of structural changes that are found in the teeth and jaws indicates that radiography is essential for treatment planning. The minute size of some patients makes intraoral film placement, as used in cats, dogs,
Box 2. Findings during physical examination that are indicative of oral problems

- Weight loss/emaciation
- Slobbering/drooling
- Perioral saliva staining
- Perioral skin disease
- Staining of forelimbs
- Palpable swelling on the lingual edge of ventral mandible
- Discomfort on cheek teeth palpation
- Restricted jaw movement
- Inability to fully close mouth
- Overgrown incisor teeth
- Abnormal incisor wear pattern
- Spikes on cheek teeth
- Food impaction between cheek teeth
- Ocular discharge
- Conjunctivitis
- Exophthalmos
- Purulent ocular/nasal discharge
- Facial abscessation
- Submandibular/cervical lymphadenopathy
- Systemic disease
- Death

...and people, impractical. In contrast, extraoral views are easy to obtain and yield a rewarding amount of information.

Dental radiograph units are much easier to manipulate than the bulky, regular machines; multiple views at different angles can be obtained quickly without needing to repeatedly move the patient. It is possible to use a conventional machine if no dental unit is available. Dental films are nonscreen and yield the fine detail that is necessary to diagnose periodontal pathology. They come in self-contained flexible packages that encourage intraoral placement and bisecting-angle views when appropriate; this allows visualization of dental structures with minimal superimposition of other structures [9,10]. Cassettes with high definition intensifying screens, particularly those that are designed for single emulsion film (mammography cassettes) can also be used but will only provide sufficient definition in larger rodents, such as guinea pigs. Intraoral views often are not practical because of the small size of the patients and their oral anatomy; extraoral views often are desirable. Three extraoral views are standard: lateral, dorso-ventral, and rostro-caudal. Lateral and rostro-caudal views are usually the most informative [1]. The lateral view shows crown and root length, curvature of the incisors, and alignment of the occlusal surfaces (Fig. 4). Rostro-caudal
views show root and crown length, angle of the occlusal surfaces, presence of spikes, and state of the temporomandibular joint (TMJ) (Figs. 5, 6). The knowledge of normal anatomy and species variations is mandatory. Crossley [2,11] established that, in a normal chinchilla, the occlusal surfaces are horizontal, the radius of curvature of the upper incisors is less than half that of the lower incisors, the roots of the maxillary cheek teeth do not bisect a line that extends from the hilus of the tympanic bullae to the top of the maxillary

Fig. 2. Oral speculum which is inserted between the incisors to open the mouth.

Fig. 3. Cheek dilators come in two sizes. The spatulated parts are inserted into the mouth and the spring action spreads the cheeks apart, which allows visual access of the premolars and molars.
incisors, and the roots of the mandibular cheek teeth do not extend to, nor displace, the ventral border of the mandible (Fig. 7). Normal guinea pigs display cheek teeth with equal crown lengths, from mesial to distal. They form an open “V” at a 30° angle to the horizontal, and they should be worn perpendicular to the buccal/lingual-palatal tooth surfaces. The lateral radiographic appearance of mandibular cheek teeth is similar to those of the chinchilla although the angulation of the occlusal plane prevents this from being seen clearly in guinea pigs. The maxillary cheek teeth show no large lucency apical to their roots. The TMJs are semilunar in appearance and distinct on well-aligned rostro-caudal views (see Fig. 5). Rostro-caudal views also demonstrate the marked curvature of the cheek teeth that results in the angled occlusal surfaces in the guinea pig. The alignment of the maxillary and mandibular incisors is always difficult to rate on a radiograph because the mandible displays an extended range of rostro-caudal motion. Factors, other than mandible position, that influence the relationship of maxillary and mandibular incisors with each other are: brachygnathia/dolicognathia (short/long jaw), brachycephalia/dolicocephalia, degree of mouth opening, and crown lengths. Anterior cross bite is definitely present when it is unilateral (one side of the incisor relationship being normal and the other being reversed). A CT scan greatly enhances the examination of the maxillary and TMJ regions but it is still only available at a few institutions.

**Systemic diseases with oral manifestations**

Guinea pigs are unable to metabolize their own vitamin C, and, therefore, suffer from scurvy if they are fed a deficient diet. Scurvy manifests itself by periodontal disease, gingival hemorrhages, and loosening of teeth [1]. Treatment and prevention consist of feeding fruits and vegetables that are rich in Vitamin C. If the patient is debilitated, tube feeding, fluids, antibiotics, and vitamin supplements may be required [12].
Excessive selenium intake interferes with the metabolism of collagen in a similar manner to Vitamin C deficiency, and causes weakening of the periodontal ligament fibers, and, ultimately, tooth instability and eruption problems [2]. Correcting the diet is usually curative, if the problem is recognized before significant secondary changes occur.

Primary periodontal disease is uncommon in rodents, although introducing *Actinomyces viscosus* in laboratory rats can induce it. Treatment of primary periodontal disease is similar to what is recommended in other species (ie, dental cleaning, root planing, polishing). The size of the patient is the limiting factor to a thorough prophylactic treatment. Chlorhexidine solution is helpful to retard plaque accumulation and control periodontal disease. Periodontal disease can be secondary to displaced teeth; this can allow impaction of food to take place, malocclusion, or abrasions because of hard objects that are encountered in the environment. Hamsters suffer from a stomatitis secondary to cheek pouch impaction that is corrected by cleaning the pouch and applying antibiotic ointment to its mucosal lining [12].

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Fig. 5. Rostro-caudal radiograph of a guinea pig skull. The black dots point out the curvature of the maxillary and mandibular cheek teeth and delineate the TMJ. The white dots show the angulation of the occlusal table. *(From Legendre LFJ. Malocclusion in guinea pigs, chinchillas and rabbits. Can Vet J 2002;43:385–90; with permission.)*
In rats, a corona virus infection of the salivary glands results in a sialocryoadenitis. Clinical signs are swelling under the mandible and neck. The disease is usually self-limiting but may require treatment if other signs, such as reduced food intake, appear. The infection may rapidly spread through a colony. Strict hygiene protocols are essential with isolation of infected groups of animals. Guinea pigs’ salivary glands may get infected with cytomegalovirus but this rarely becomes clinical [12].
Oral trauma

Oral fractures vary widely in presentation, as they do in dogs and cats. They range from a simple mandibular symphyseal separation to a complex compound maxillary fracture that involve the teeth. Repair follows the same principles as for dogs and cats. Acrylic splints and wires can be used to stabilize the fragments and allow early return to self-feeding [13]. Size, difference in anatomy, and difficulty in management result in a poor prognosis with some of these procedures; euthanasia may be the most humane option. The surgeon needs to face the challenge of anesthesia. It is always an arduous endeavor to anesthetize a rodent, particularly when working in the oral cavity because maintenance by use of a face mask is not possible. The small size of most rodents necessitates a different approach which includes the following: (1) Minimization of stress because it affects their anesthetic responses. It can result in ketosis in guinea pigs. (2) Endotracheal tubes are rarely an option, and a variety of small masks and nose cones are required to administer oxygen. (3) The patient is susceptible to hypoglycemia. If a procedure is anticipated to last for longer than 30 minutes, supplemental 5% concentration of dextrose should be mixed with fluids and injected intravenously, intraorally, intraperitoneally, or subcutaneously (SC). Rats, gerbils, mice, hamsters, guinea pigs, and chinchillas do not vomit, which obviates preanesthetic fasting. Care is necessary, however, as pressure on the abdomen can result in regurgitation, particularly in guinea pigs. Guinea pigs and chinchillas often retain food in their oral cavity or pharynx, either as the result of chewing and swallowing problems or simply because they were disturbed while eating and have held the food since that time. The risk of aspiration in these species can be reduced by a short period of fasting before anesthesia, but, conversely, prolonged food deprivation must be avoided because it induces hepatic dysfunction [14]. (4) The patient loses and gains heat from the environment quickly, therefore, close monitoring is essential. Heated surgical surfaces, hot water bags, or bubble wraps are mandatory to control heat loss, but great care is also required to avoid hyperthermia and burns. (5) Much of our modern technology is not functional on such a small patient. The anesthetist must rely on cardiopulmonary function, reflexes, and body temperature. (6) Hypovolemia is often overlooked in a small patient and should be controlled by injecting saline solution at a rate 5 mL/kg/h to 10 mL/kg/h during the procedure. (7) Salivary and respiratory secretions always interfere with dentistry and are decreased by using anticholinergics. Secretions are particularly thick in guinea pigs so atropine should be given intravenously or SC at a dose of 0.05 mg/kg [14].

Many protocols are available to induce and maintain anesthesia but it is not within the scope of this article to cover them [14]. It is safer to use a balanced anesthesia approach using a small dose of injectable drugs to induce sedation or light anesthesia and provide analgesia and to control the depth of anesthesia using volatile agents.
Analgesia is as challenging and as important as anesthesia. Postoperative pain was shown to reduce food and water intake in rats, mice, and guinea pigs [15]. Concurrently, healing is slowed and return to normal is delayed. Principles that are used in dogs and cats, such as pre-emptive and multimodal analgesia, apply here but have not been extensively studied. Much of the data available is empirical. Nevertheless, recent articles contain tables with dosage guides for various species [15]. For dental surgery, opioids followed by nonsteroidal anti-inflammatory drugs (NSAIDs) are recommended. For simple occlusal adjustment using an atraumatic method that applies no more than physiologic forces to the teeth and does not approach the pulp, no postoperative analgesia should be required; however, being atraumatic is difficult to achieve so it is wise to routinely use NSAIDs, alone or combined with an opioid.

**Dental diseases**

Dental disease is made up of the same entities that are encountered in other mammals: caries, fractures, and periodontal disease.

Caries is a tooth destructive demineralizing process that is initiated by acidic bacterial waste products. It is associated with accumulation of dental plaque on tooth surfaces and the availability of easily digested carbohydrates, such as starch and sugars. Caries lesions in rodents who have brachyodont cheek teeth are similar to the lesions that are seen in humans. Rats have been used as research models for human caries [16]. Caries seems to be much less common in wild animals compared with animals that are kept in captivity or humans [17]. This is mostly due to the difference in diets, the anatomy of the teeth, and the pH of the saliva [17,18]. Pets who are fed diets that are high in sucrose and refined starch are at a higher risk for getting this disease. Although the pathology is identical to the one seen in man, conservative treatment is rarely undertaken because of the minute size of the patients. When lesions are extensive or symptomatic in anelodont teeth, extraction is indicated. When elodont teeth are affected (e.g., guinea pigs, chinchillas), coronal reduction, occlusal correction, and provision of a more natural diet may be effective in controlling the problem if the teeth are still erupting and functional [19].

Resorptive lesions have been recognized in such species as man, chimpanzee, marmoset, cat, dog, rabbit, rat, and chinchilla (Fig. 8) [18,20]. They are most commonly reported in cats but are frequently seen in pet rodents, as well and may be induced by inflammation. Periodontal inflammation stimulates odontoclastic resorption which creates lacunae in the tooth. Granulation tissue moves in an attempt to contain the damage. In some cases, repair takes place but lost dentin is not replaced. A mixture of bone-like and cementum-like tissue is deposited into the defect, which results in gross ankylosis of the tooth to the supporting bone [19].
Most commonly, incisors are damaged by gnawing on hard food or on hard objects, such as cage wires or cage bars. A fractured incisor without pulp chamber exposure will resolve on its own by growing back into occlusion. One only needs to monitor and trim the opposite tooth until its functional wear resumes. Conversely, if the pulp is exposed, then dental treatment is necessary. A radiograph of the affected tooth is obtained to verify that a diagonal or vertical fracture line is not extending deep into the root. The infected superficial tissue is carefully removed and a calcium hydroxide paste is placed on the pulp. An intermediate filling material, such as IRM (Caulk Co., Milford, DE), or a glass ionomer, is placed on top of the calcium hydroxide paste for protection. Harder restorative materials, like composite resins or amalgam, are not recommended because they will prevent normal wear of the treated tooth and may cause excessive wear on the opposite incisor [1,20]. The patient needs antibiotics and analgesics for a few days posttreatment. While the affected incisor is growing back, its opposite requires regular trimming to prevent formation of a malocclusion. The treatment is complete after the incisors are back in occlusion and the restoration has worn away to expose healed dentine. Complications arise if the affected tooth fails to grow back, is deformed and causes a malocclusion, or pulp necrosis and abscessation occur; treatment consists of trimmings at regular intervals or extraction of the affected incisor and the opposite tooth.

Periodontal disease in brachyodont cheek teeth is similar to that which is seen in humans and is treated similarly by scaling, root planning and curettage, or extraction, followed by diligent home care and regular recheck visits. Continuously-growing teeth are more susceptible to periodontal loosening and infection. An established periodontal abscess rapidly migrates.
to the periapical area, particularly in teeth that have periodontal food impaction. Grossly, the presentation is a facial abscess. The source of the abscess is often missed on oral examination. Because the swelling is on the side of the face, it is often assumed that a cheek tooth is responsible, when, in fact, endodontic abscessation of damaged incisors is the most common cause; the root apices of mandibular incisors extend to the level of the premolars in guinea pigs and chinchillas, and to beyond the third molar tooth in many other species including rats, mice, hamsters, gerbils, and prairie dogs [20]. Careful examination and radiographs are required to determine whether a periodontal abscess, endodontic abscess, foreign body, or external wound is responsible. These facial abscesses are difficult to treat. This is, in part, because of the failure to recognize the cause and the fact that proper drainage is necessary and entails extraction of all of the affected teeth. Because of the caseous nature of purulent discharge in most rodents, it is important to thoroughly curette the affected area, or to do en block resection, and to keep the wound open to heal by secondary intention [20]. The technique of packing the site with a poultice of calcium hydroxide paste as described for rabbit abscesses [21] should be used with caution because there are reports of serious adverse complications (see the article on rabbits elsewhere in this issue). Another method to deal with facial abscesses is to clean the area as best as possible and place antibiotic impregnated polymethyl methacrylate beads in the defect, before suturing it closed. The beads are left in place for a minimum of 2 months. If there are no signs of abscession, they can be removed. Further discussion on bead fabrication and antibiotics of choice is available in the literature [21].

Occasionally, the lower incisors get trapped in wire mesh and suffer from an intrusive luxation. The germinal pulpal tissue is damaged and the teeth will fall out 6 to 8 weeks posttrauma (David Crossley, B Vet Med, MRCVS, personal communication, 2002).

Orthodontics

Malocclusion is the most common oral disorder of rodents, whether it results from the abnormal growth of incisors only, as for most rodents, or is caused by the abnormal growth of all teeth, as for the herbivorous group. Elongation of incisors is due to three main causes: decreased amount of gnawing because of a poor diet or lack of a suitable substrate, trauma that results in misalignment, and faulty genetics that result in dolicognathia or brachygnathia. Trimmings at regular intervals may control all three causes. Modifying the diet to include more abrasive foods and allowing the patient to gnaw can cure the first problem. Cure of the latter two conditions is not possible; treatment is achieved by removing the pair or pairs of incisors that are not occluding properly. Incisor extraction seems to have little effect on the feeding behavior of captive pets. They possess prehensile lips and easily
manipulate the food that is offered to them. In the wild, incisors are indispensable to obtain food; this surgery should only be contemplated on pets and captive specimens.

Recently, it was recognized that captive prairie dogs, who were kept on a “soft” diet were developing a new syndrome. Reduced incisor wear results in elongation of the crown and root. The apical intrusion causes increased pressure on the germinal tissues which become distorted and then disrupted. The end result is a progressively reduced growth rate, and, eventually, arrested eruption. Grossly, the maxillary incisors are affected first. Because the wear rate is initially unaltered, the crowns become shorter and shorter until the distal surfaces of the incisors are subgingival instead of being 2 mm to 5 mm supragingival. The patient may or may not show signs of decreased feeding, depending upon the type of diet. The most common presentation is nasal obstruction. Radiographs show signs of apical dysplasia with the walls of the roots plicating (Fig. 9). Continued apical deposition of dysplastic tooth structure at the apices of the maxillary incisors is likely responsible for the formation of a space-occupying mass. With time, this mass enlarges and obstructs the nasal cavity (David Crossley, B Vet Med, MRCVS, personal communication, 2002). The mandibular incisors are similarly affected; however, the apical changes usually consist of continuous intrusive growth of deformed tooth structure. After eruption ceases, no cure is available. Prevention consists of feeding captive prairie dogs coarse grass and soil-contaminated roots to cause up to 1 mm of wear per day, which is normal for this species. Surgical removal of the deformed apical tissues is rarely practical, because of their extent.

Fig. 9. Radiograph of a prairie dog skull. The apical part of the root is plicated and malformed. This denotes apical dysplasia. Note that in this species the apex of the mandibular incisors is distal to the last molar. (Courtesy of D.A. Crossley, B Vet Med, MRCVS, Manchester, UK.)
Incisor treatment

Incisor trimming can be accomplished with the patient awake or anesthetized [20]. If awake, the patient should be restrained comfortably. In the author’s experience, wrapping it in a blanket and holding it upside down, works well. A tongue depressor is placed caudal to the incisors, in the diastema space, to protect the soft tissues, while cutting. Nail clippers or cutters are not recommended because they can create diagonal fractures [20,22]. These fractures can expose the pulp chamber which requires endodontic treatment to correct it, however, the exposure may not be visible which results in the lesion going untreated. The instrument of choice for incisor trimming is a cutting or diamond burr that is mounted on a high-speed dental hand-piece [20,22]. Incisor crowns are delicately reduced, taking care to maintain or recreate the natural bevel. The pulp canal usually stops close to the gingival margin in normal teeth, but may be subgingival in teeth that have been erupting slower than normal, or supragingival in those that have erupted faster than normal. If one is planning to remove a large portion of the crown, it is always advisable to obtain a radiograph to verify where the pulp canal ends.

Treatment for incisor malocclusion often requires incisor extraction. Detailed descriptions of the procedure can be found in earlier texts (see references [1,20,22,23]). Treatment is a surgical process that is performed under general anesthesia, with proper instruments, adequate light, and plenty of patience. After obtaining a radiograph to examine the anatomy and to confirm that extraction is required, an intrasulcular cut is made using a #15, 15C, 11, or even 12, scalpel blade. This cut severs the sulcular epithelium and opens the periodontal ligament space. This makes it easier to introduce a luxator around the tooth to loosen it. Because incisors are sharply curved, specialized instruments are necessary. Luxators EX15 and EX16 (Cislak Manufacturing, Glenview, Illinois) or Crossley rabbit incisor luxator J41cr (Jorgensen Laboratories) are recommended (Fig. 10). A 20-gauge hypodermic needle can also be used to sever periodontal ligament fibers [22]. The luxating technique is the same as for any other tooth. The luxator should be introduced in the periodontal ligament space, wedged, and held at a constant pressure for 20 to 30 seconds. Then change to the opposite side of the tooth, repeat the procedure, introduce the luxator deeper, and start again until the tooth is mobile. Attachment is strongest on the medial and lateral sides, as well as inside the curvature of the tooth [23]. It is important not to wiggle the tooth; constant pressure tears the ligament efficiently, whereas wiggling causes the ligament to do what it was designed to do (ie, resist-short term forces). When the ligament is completely ruptured, the tooth is intruded and twisted to destroy the germinal tissues and then gently pulled out of the alveolus following its curvature (Fig. 11). Even when being careful, several complications can arise; root fracture is the most common, especially with beginners. The patients are small and a delicate touch is required. Dentists who are familiar with dogs and cats
have a tendency to apply too much force. A fractured root can rarely be retrieved. The tooth usually grows back and the procedure can be repeated at a later date. If the tooth does not reappear in the mouth within 6 to 10 weeks, it is important to obtain a radiograph because dysplastic apical growth may be occurring, rather than continued normal growth. If the root fragment is, or becomes, infected, a surgical approach is required to remove it [23,24]. If the tooth regrows abnormally, surgical extraction is again required. Profuse hemorrhage is rare unless the alveolar bone is also fractured during the extraction. It is normal for minimal bleeding to occur; this can be controlled by applying digital pressure for a short time. A suture
to close the alveolar opening will also control the bleeding (Fig. 12). Extraction of the tooth without the apical pulpal tissue has the same result as breaking the root, unless the apical region is curetted at the time of extraction to damage the germinal tissues. The tooth usually regrows and the procedure is repeated in 6 to 8 weeks [24]. The owner should be advised about the differences between human anelodont and rodent elodont teeth before attempting to remove incisors and should be warned that the surgery may have to be repeated.

Fig. 11. Extracted maxillary incisors of a guinea pig. Not the pulpal tissue inside the apex of the root.

Fig. 12. Lips and oral cavity of a guinea pig. Two sutures that close the extraction sites of the maxillary incisors are visible. Captive guinea pigs function well without incisors.
In the herbivorous rodents, malocclusion is more often caused by the cheek teeth than the incisors [20]. Three causes have also been suggested for cheek tooth elongation/malocclusion: anisognathia, abnormal incisor relationship, or the decreased amount of chewing that is required for processed foods (see references [20,22,24]). Anisognathia is the norm for most mammals. In some of these rodents, the mandibular occlusal surfaces are close together which gives the appearance of excessive or reversed anisognathia; however, the jaw relationship is generally correct. This dental abnormality, which is the result of tooth elongation and increased curvature, prevents complete occlusal contact of the mandibular and maxillary teeth during the course of mastication and further reduces tooth wear [22]. Reduced and uneven tooth wear does not prevent continued tooth growth, so the crowns of the cheek teeth elongate. The patient’s mouth is continually held open and is unable to prehend and process food efficiently. The reverse situation may occur occasionally; incisor malocclusion is the primary problem that prevents the mouth from closing properly which results in elongated cheek teeth. Because guinea pigs have angled occlusal planes and convergent dental arcades, there is a mesial shift of the mandible as the cheek teeth elongate; a spur is often seen on the fourth mandibular premolars and on the third maxillary molars which no longer occlude [22].

Cheek tooth elongation and mesial shifting of the mandible will alter the relationship of the incisors; this results in a secondary incisor malocclusion. The maxillary incisors will tend to curve sharply backward toward, and even into, the palate, whereas the mandibular incisors grow labially and lift the upper lip or penetrate the nostrils.

In a herbivorous rodent that is fed a high-energy or processed (eg, pelleted) diet, the duration of chewing is reduced and the pattern of chewing is altered as the food is processed faster within the oral cavity with more crushing, than grinding, movements. The cheek teeth lack sufficient attrition and are exposed to greater than normal intrusive forces. Because the teeth are not worn down at the same rate that they grow and erupt, they elongate. At a variable degree of elongation, the resting pressure on the teeth slows and sometimes prevents further eruption; however, apical growth continues. The tissues around the apices remodel; in the mandible, the results can often be palpated as firm swellings on the ventrolateral surface. Elongation of the crowns reduces feeding efficiency, although signs are often minimal; this is usually accompanied by changes in tooth curvature which create spurs that damage the soft tissues and gaps between the teeth where food material becomes impacted, which results in periodontal abscessation. The latter is likely to result in obvious clinical signs of significant loss of condition and debility.

Three less common causes are also associated with malocclusion. Root abscesses that are secondary to periodontal disease, loosen teeth and result in malocclusion. In guinea pigs, hypovitaminosis C induces weakening of collagen and loosening of the teeth [6,12]. Trauma or caries that eliminates an
occlusal surface, allows the tooth or teeth opposite to elongate and results in malocclusion [12].

After the teeth elongate, reduced jaw motion and altered structural alignment further contribute to the formation of sharp edges on the occlusal surface of the cheek teeth. These are usually referred to as spurs or spikes. In guinea pigs, they are typically found on the buccal surface of the maxillary cheek teeth (Fig. 13) and on the lingual surface of the mandibular cheek teeth because of the strong curvature of the teeth [22,25]. In chinchillas, the pattern of spur formation is less predictable. Spurs can form opposite to the ones seen in guinea pigs. Spurs can even form on the mesial or distal surfaces of the occlusal table [8]. Because lingual and buccal mucosae are very sensitive, even small spurs which cut into them are painful [20]. In guinea pigs, the curvature of the cheek teeth, the steep angle of the occlusal table, and the convergence of the dental arcades rostrally that results in mesial drift of the mandible help in the formation of long spikes that can literally bridge over the tongue and prevent normal prehension and swallowing (Fig. 14) [22]. In chinchillas more than in guinea pigs, crown elongation is accompanied by apical elongation. Apical elongation seems to cause more problems to the patient than crown elongation. In the mandible, the roots impinge on the ventral cortex which induces bone remodeling. In advanced cases, the roots will perforate the cortex. The swellings may be painful. In the skull, the apices can extend into the orbit and the nasal cavity (Figs. 15, 16). They compress the infraorbital nerves, cause lacrimal duct obstruction and nasal and ocular discharge, and epiphora [7]. By the time that root

Fig. 13. Buccal spur on the first maxillary left molar of a guinea pig. The spurs lacerate the buccal mucosa and are painful. Their presence alone is cause for anorexia. (From Legendre LFJ. Malocclusion in guinea pigs, chinchillas and rabbits. Can Vet J 2002;43:385–90; with permission.)
elongations can be readily detected, they are irreversible; therefore, timely treatment of crown elongation is highly recommended [8].

Regardless of the cause, cheek teeth elongation requires occlusal leveling as the first part of treatment. Radiographs, anesthesia, and analgesia are prerequisites. It is essential to obtain radiographs before leveling because abscessed or periodontally-diseased teeth will require extraction. A radiograph will also show that the mesial cheek teeth are longer than the distal ones (Fig. 17). Thus, more must be taken off the rostral cheek teeth than the caudal ones. An adequate depth of anesthesia can be reached with injectable drugs alone if the treatment involves no more than occlusal leveling. For more invasive or prolonged treatment, the patient should be masked following an induction dose. Unfortunately, the mask interferes with the oral examination and surgery. The mask is temporarily removed and the work proceeds until the patient awakens, at which time the mask is replaced. This up-and-down anesthesia technique is time consuming and unhealthy for the operator, who probably breathes as much anesthetic gas as the patient. One way to bypass this problem is to introduce a short, small-bore catheter into one nostril and to connect it to a nonrebreathing circuit. The author maintains rabbits and guinea pigs on 2% to 3% isoflurane. An assistant needs to hold the catheter in place and occlude the other nostril, but the dental work can proceed uninterrupted (Fig. 18). The resulting shorter procedure is much safer for the patient.

Specialized equipment is necessary to safely and efficiently reduce elongated crowns. A dental speculum (Jorgensen Laboratories), a set of cheek dilators (Jorgensen Laboratories), special long HL flat fissure burs that fit within a soft tissue protector (see the article on rabbits elsewhere in
this issue) or at least #558 burs (SS White Burs, Lakewood, New Jersey), surgical loops, and a good light source are mandatory. Tongue depressors that are split lengthwise also help to protect the soft tissues. The bur mounted on a straight nosecone, low-speed hand-piece is gently introduced in the oral cavity and moved in a sweeping motion to table the occlusal surface of the cheek teeth, taking care not to injure the surrounding soft

Fig. 15. Chinchilla who has severe dental disease. (A) Lateral view. The roots of the maxillary cheek teeth have elongated into the orbit. The maxilla is pointing upward because of the crown elongation of the cheek teeth. The apices of the mandibular cheek tooth roots have perforated and deformed the ventral cortex of the mandible. The mandibular incisors are elongated. (B) Oblique view. Buccal spurs on the maxillary cheek teeth are pronounced. Jugae that cover the apices of the maxillary cheek teeth roots are visible in the orbit. Jugae and perforations are visible at the ventral edge of the mandible.
tissues [26]. Cotton swabs are helpful to clean the debris and saliva that accumulate in the back of the mouth. Remember that the occlusal angle of chinchillas is horizontal whereas it is 30° in guinea pigs. The simplest way to remember which way the angulation goes is to remember that when viewing a rostro-caudal radiograph the occlusal tables form an open “V.” A large portion of the crowns usually needs to be removed but it is rare to expose the pulp. Nevertheless, fresh dentin is exposed and one can expect postoperative pain; therefore, analgesics are recommended.

Fig. 16. Guinea pig with severe dental disease. (A) Lateral view. Jugae are visible inside the orbit and on the ventral side of the mandible. The maxilla is pointed upward and the change in angulation resulted in an anterior cross bite. (B) Oblique view. Buccal and lingual spurs are visible on the cheek teeth. The extreme elongation of the incisors and the deformation of the ventral cortex of the mandible are apparent.
Following treatment, there is less pressure on the teeth and on the surrounding periodontal tissues, which allows them to heal. If the patient is debilitated at the time of treatment, it must stay on a recuperative diet for a few days longer. Guinea pigs may present with anorexia, because they were unable to swallow because of tongue trapping and the mouth being

![Fig. 17. Lateral radiograph of a guinea pig skull. The mesial cheek teeth are longer than the distal ones. The mouth is permanently held open; this situation alters the relationship of the incisors.](image)

![Fig. 18. The nasal tube is inserted 2 cm to 2.5 cm into one of the nostrils and is held in place manually while the other nostril is included. Because these patients do not mouth breathe, most of the anesthetic is inhaled. Dental work is performed while the patient is controlled in this manner.](image)
held open. Treatment frees the tongue and usually allows them to eat again (Fig. 19). As soon as possible, the diet is switched to a more voluminous, energy-poor, abrasive form. Such a diet (hay and fresh grass) ensures more tooth wear and decreases the chance of recurrence. Tooth elongation is not recognized in wild chinchillas, whereas it is common in captive-bred individuals [27]. Therefore, owners should be encouraged to keep their pets on a diet that is similar to what it would eat in the wild. By extrapolation, one can assume that the same holds true for guinea pigs, which do eat grasses in the wild [28].

Fig. 19. (A) This guinea pig is unable to eat. The elongation of the mandibular cheek teeth has trapped its tongue. (B) Reduction of the length of the crowns of the mandibular cheek teeth frees the tongue and allows the patient to go back to eating immediately.
Dietary change is only curative for early cases where an inadequately abrasive, low-volume diet was the cause and if there have not been any serious apical changes. In many cases the teeth will elongate again because of an inability or unwillingness to chew normally; occlusal leveling will need to be repeated every 4 to 8 weeks [24]. Persistent and recurrent incisor malocclusions are best treated by extracting all four incisor teeth. The spurs that form on the mesial surface of the mandibular fourth premolar and the distal surface of the third molar will need to be dealt with regularly, but not as often.

Lately, it was noted that patients who were on a pelleted diet, and who should have improved on a rougher diet, kept returning for further trimmings. It was discovered that the masticatory muscles adapted to being stretched during tooth elongation and were slow to return to normal after treatment; patients were unable to properly close their mouth and chew their food. Their mouth literally “hangs” open after occlusal leveling and the cheek teeth elongate anew. Using a headgear that lifts the mandible helps them chew efficiently and controls tooth elongation (Fig. 20) [22]. Ongoing research shows that wearing the neoprene headgear 12 hours a day seems sufficient to keep the crowns short. In cases that are diagnosed early, the headgear also shows promise for cure, which eliminates the need to perform crown reduction. Except for some hair being rubbed away, there have not been any deleterious side effects of the headgear.

Cheek tooth extraction

Tooth elongation results in increased curvature of the tooth and can cause displacement. Misaligned teeth lose their interproximal contacts which allows food to get trapped. Fermentation and increased pressure on the tissues contribute to the formation of caries lesions, periodontal pockets, and periodontal abscesses. Periodontal abscesses often extend to the periapical region, which kills the pulp, and ultimately, the tooth. The tooth can also become loose because of lack of periodontal support. Cheek teeth also become loose when in the line of a fracture, after excessive selenium intake, with hypovitaminosis C in guinea pigs, and with deep caries. A tooth that is loose, diseased, or displaced and causes ongoing pathology, needs to be extracted. Poor access and minute patient size make cheek tooth extraction a difficult task. Periodontal disease loosens teeth, which eases the work [12,23], but leaves inflamed tissue to heal. The extent of disease is rarely detected on clinical examination so radiography is advisable. In the case of elongated elodont teeth, there is often apical deformity in addition to periodontal bone loss; this complicates extraction and radiography is essential in its planning. The process is started in the same way as for any other tooth; luxators are used to sever the periodontal ligament. Few instruments are designed for that purpose; when needed, one can adapt other dental instruments that have bent, thin, sharp blades [23]. Bent hypodermic needles (18–23 gauge), make good luxators when working on the small
brachyodont teeth that are found in rats, mice, gerbils, and hamsters [12]. Care is of the utmost importance when extracting these teeth; broken root fragments are impossible to retrieve atraumatically. Missing teeth may cause shifting of the adjacent teeth or overeruption of the opposite ones. This is rarely a serious problem for brachyodont teeth, but tends to create a “step mouth,” which seriously affects chewing in the true herbivores.

Once loosened, healthy aradicular hypsodont cheek teeth have straight walls and are relatively easily to remove with the help of small bent forceps. Conversely, if the teeth suffer from root elongation or ankylosis, an intraoral approach becomes involved and time consuming. For the mandible, an extraoral approach is available [12,23]. An incision is made over the
ventro-lateral aspect of the mandible. Bone that overlies the apical area of the affected tooth is cut away, using a bur or fine bone chisel, taking care not to damage the local blood vessels and nerves. The exposed root is loosened with luxators; some of the periodontal ligament can be cut with a fine scalpel blade. The tooth is extracted either through the aperture that is created or repelled into the oral cavity [12,23]. The infected area is curetted clean of debris and granulation tissue, bony prominences are smoothed over, the soft tissues are closed, and the bony defect is packed with osteoconductive material, if this is available. Alternatively, if the area is grossly infected it is left open to drain, unless there is profuse bleeding. In this case, local application of antibiotic is helpful; antibiotic powder (tetracycline, doxycycline) can be mixed with the osteoconductive material that is used to fill the defect, the alveolus can be filled with tetracycline ophthalmic ointment [12] or preferably, a periocutetic product (eg, Doxyrobe gel, Pharmacia Animal Health, Pharmacia Upjohn, Kalamazoo, MI). Whenever possible, the gingiva is elevated around the oral defect and sutured closed to reduce contamination from the oral cavity.

Extraction of a continuously growing cheek tooth has long-term repercussions. The opposite tooth will overgrow and regular trimming will be necessary for the rest of the animal’s life. Adjacent teeth may shift which gives rise to further periodontal disease and malocclusion; the shifted teeth will not occlude properly which results in the formation of a step mouth. If the space left after extraction does not heal completely, food will be impacted in the open alveolus and cause ongoing infection with a likelihood of fistulation to the skin surface. Because upper and lower cheek teeth do not match one-on-one, extracting the tooth that is opposite from the diseased one does not resolve the problem, and often exacerbates the malocclusion.

Summary

Our dental knowledge of rodents is still patchy but their increasing popularity and advances in technology allow us to make good strides toward better understanding. Cutting incisors with nail clippers and treating incisor problems without examining cheek teeth is no longer acceptable. Good practice dictates that a thorough examination is performed, a diagnosis is made, and treatment is planned and executed appropriately. Dentistry is expanding at a tremendous rate; the next few years should provide plenty of opportunities to solve most of the remaining problems with dental disease in rodents.

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