# Computed tomography–assisted management of a mandibular dentigerous cyst in a dog with a nasal carcinoma

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**Case Description**—A 6-year-old neutered male Boston Terrier was examined to determine the cause of sneezing, bilateral nasal discharge, nasal congestion, lethargy, and coughing of 2 months' duration.

**Clinical Findings**—An undifferentiated nasal carcinoma was diagnosed. During computed tomography (CT) evaluation of response to tomotherapy radiation treatment, a mandibular dentigerous cyst, associated with an unerupted left mandibular first premolar, was monitored for expansion.

**Treatment and Outcome**—The dog had a profound response to radiation treatment, and the nasal carcinoma totally resolved. It was determined on the basis of CT that the rate of expansion of the dentigerous cyst was placing the dog at risk for mandibular fracture and loss of vitality to the surrounding teeth. The unerupted left mandibular first premolar and associated dentigerous cyst were surgically removed and submitted for histologic evaluation.

**Clinical Relevance**—Images obtained during sequential CT evaluations performed after radiation treatment of nasal carcinoma should be examined for evidence of the primary neoplasm as well as to detect unrelated lesions of the orofacial region that can compromise the quality of life. Findings of CT evaluations can be used to determine when and how to initiate treatment for dentigerous cysts in regard to the patient's response to radiation treatment. (*J Am Vet Med Assoc* 2009;235:710–714)

A 6-year-old 13.8-kg (30.4-lb) neutered male Boston Terrier was referred to the University of Wisconsin, Madison, Veterinary Medical Teaching Hospital with a 2-month history of sneezing, bilateral nasal discharge, nasal congestion, lethargy, and coughing. Examination revealed that the dog was bright and alert. Rectal temperature, heart rate, and respiratory rate were within reference ranges. Stertorous inspiratory sounds and bilateral serous nasal discharge were evident, but airflow was detected through both nares. Palpation revealed that the left mandibular lymph node was slightly larger than normal. Results of thoracic auscultation and radiography were unremarkable.

Nasal CT[a] revealed a large contrast-enhancing soft tissue mass in the caudal aspect of the left nasal cavity with invasion of the right cavity and hard palate and destruction of turbinates (**Figure 1**). In addition, the left frontal sinus was occluded and filled with nonenhancing secretions. Evaluation of the mandible revealed an unerupted left mandibular first premolar and an unerupted right mandibular first premolar (**Figure 2**). No pathologic changes were associated with either of the unerupted teeth. Multiple biopsy specimens of the nasal mass were obtained. Results of histologic examination were consistent with a poorly differentiated and invasive carcinoma. Results for cytologic evaluation of a fine-needle aspirate of the left mandibular lymph node were consistent with mild reactive lymphoid hyperplasia with mild eosinophilic inflammation.

The dog was enrolled in a clinical image-guided radiation treatment trial at our facility. The dog received coarse-fractioned radiation treatments delivered with a helical tomotherapy radiation unit[b]; prescribed dose to the tumor was 42 Gy in 10 fractions of 4.2 Gy delivered during a 2-week period. Serial CT evaluations were performed 1.5, 3, 6, 10, 15, 21, and 29 months after radiation treatment for evaluation of response. The initial CT evaluation 1.5 months after radiation treatment revealed a strong partial response; the size of the nasal mass was reduced by more than half. A CT evaluation performed 3 months after radiation treatment revealed similar findings, with no change in the partial response to treatment or the lymphadenopathy. No change was detected in the status of either of the unerupted mandibular teeth.

The CT evaluation 6 months after radiation treatment revealed a change in the status of the unerupted left mandibular first premolar. A 0.5-mm radiolucent halo surrounded the unerupted crown of the tooth (Figure 2). The unerupted right mandibular first

| **Abbreviation** | |
|---|---|
| CT | Computed tomography |

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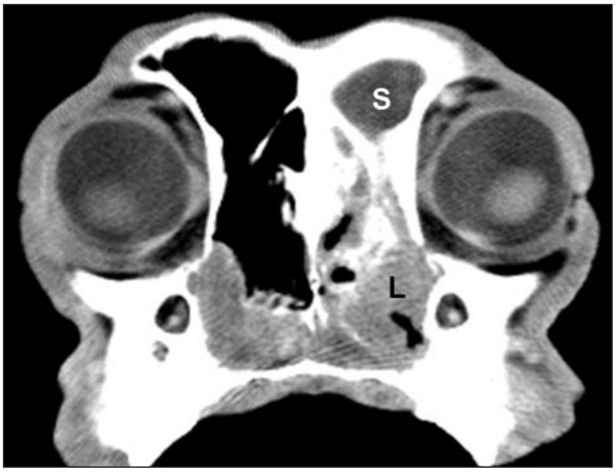


Figure 1—Contrast-enhanced bone-algorithm CT image of the caudal portion of the nasal cavity obtained from a 6-year-old Boston Terrier with an undifferentiated carcinoma prior to treatment of the neoplasia. The left nasal cavity (L) and parts of the right nasal cavity and nasopharynx are occupied by a contrast-enhanced, partially mineralized mass. The left frontal sinus (S) is occluded and filled with nonenhancing secretions.

premolar remained unchanged. Because serial CT evaluations would be performed on the dog to determine the response to radiation treatment, continued monitoring of the unerupted mandibular teeth was recommended. The CT evaluation also revealed static disease within the nasal cavity and no changes in the lymphadenopathy; however, results of cytologic assessment of the right mandibular lymph node were consistent with epithelial metastasis. The right mandibular lymph node was surgically removed, and results of histologic examination of the lymph node were consistent with a metastatic solid carcinoma.

Because of progressive disease, the owner's desire to pursue additional treatment for the dog, and strict criteria for the image-guided radiation treatment trial, the dog was removed from the tomotherapy clinical trial. Chemotherapy was instituted in accordance with a protocol consisting of alternating doses of carboplatin[c] (300 mg/m$^2$, IV) and doxorubicin[d] (25 mg/m$^2$, IV) administered every 3 weeks for a total of 4 doses of each drug. Piroxicam[e] (0.3 mg/kg [0.14 mg/lb], PO, q 24 h) was also instituted for the duration of the chemotherapy period. Complete blood counts were performed throughout the chemotherapy period, and toxic effects

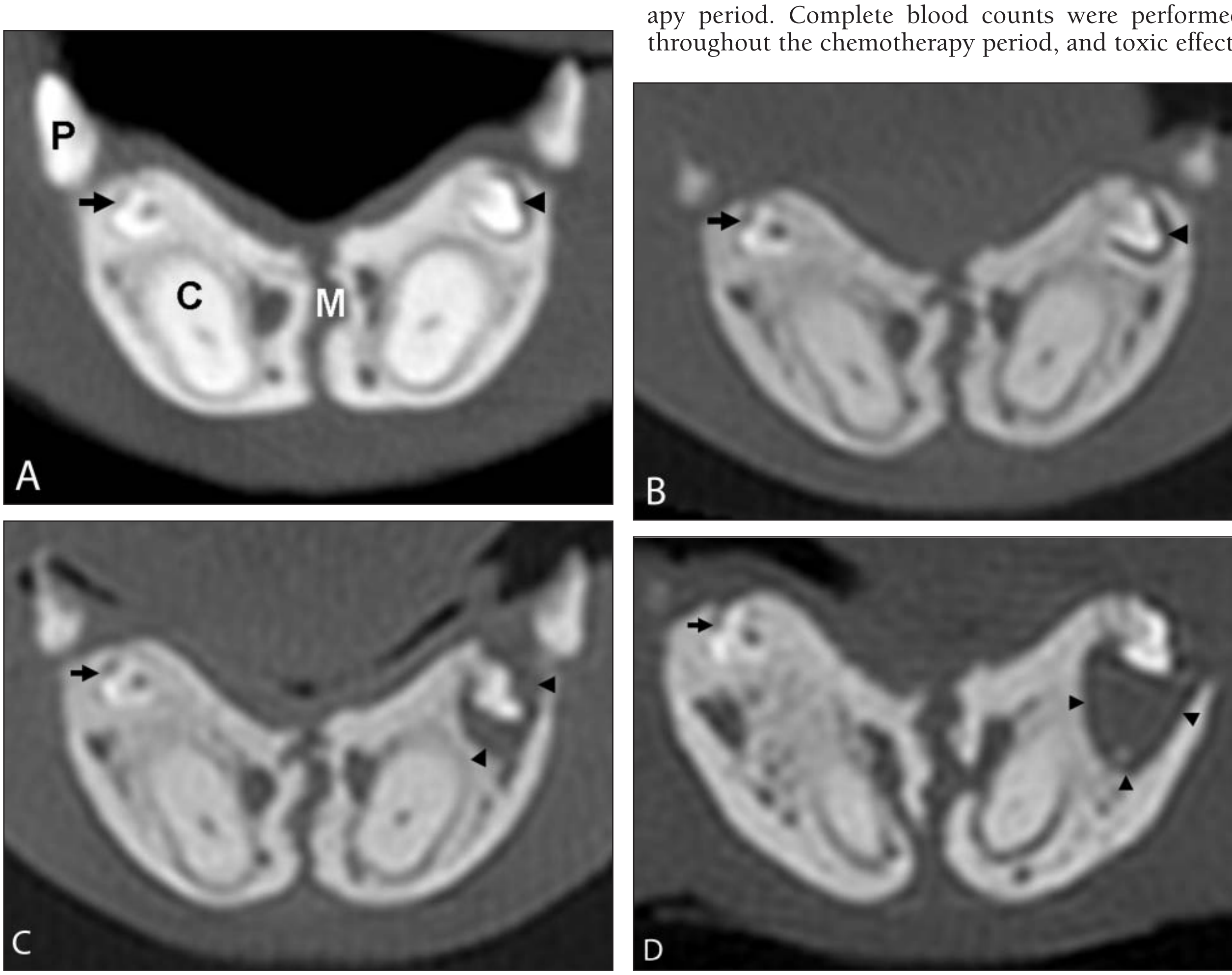


Figure 2—Close-up unenhanced bone-algorithm CT images of the rostral portion of the mandibles of the dog in Figure 1 before treatment for the neoplasia (A), 6 months after radiation treatment (B), 10 months after radiation treatment (C), and 15 months after radiation treatment (D). A—Notice the unerupted left mandibular first premolar (arrowhead) and unerupted right mandibular first premolar (arrow), root of the left mandibular canine (C), crown of the left mandibular second premolar (P), and the mandibular symphysis (M). All visible tooth roots are surrounded by a thin soft tissue halo, which represents normal periodontal ligament. B—The radiolucent halo surrounding the crown of the unerupted left mandibular first premolar is larger (arrowhead) than in panel A, but the unerupted right mandibular first premolar remains visually normal (arrow). C—The radiolucent halo around the crown of the unerupted left mandibular first premolar has expanded to a cyst with a diameter of 3 mm (arrowheads), but the unerupted right mandibular first premolar remains visually normal (arrow). D—The radiolucent cyst surrounding the unerupted left mandibular first premolar is now 6.0 mm in diameter (arrows), whereas the unerupted right mandibular first premolar remains visually normal (arrow).

were graded in accordance with standardized criteria established by a veterinary oncology group.

A CT evaluation performed 10 months after radiation treatment revealed no change in the nasal mass and continued detection of the radiolucent halo associated with the unerupted left mandibular first premolar; however, the halo had expanded to 3 mm in diameter (Figure 2). No change was evident for the unerupted right mandibular first premolar. The remaining lymph nodes were considered visually normal.

A CT evaluation performed 15 months after radiation treatment revealed results consistent with complete resolution of macroscopic neoplasia. Mild lymphadenopathy of the left mandibular lymph node was detected; results of cytologic evaluation were consistent with mild reactive lymphoid hyperplasia. A 6.0-mm radiolucent halo was visible around the crown of the unerupted left mandibular first premolar (Figure 2). On the basis of the CT measurements, the radiolucent structure was progressively increasing at the rate of approximately 0.75 mm/mo. A presumptive diagnosis of dentigerous cyst was made; differential diagnoses included odontogenic keratocyst and odontogenic neoplasia.

Clinically, the dog did not have any negative effects attributable to the dentigerous cystic condition. However, given the surprising response of the metastatic nasal carcinoma to treatment and the progressive nature of the oral pathologic condition, a full oral and maxillofacial examination, dental scaling and polishing, and cyst enucleation were performed by the Dentistry and Oral Surgery Service at our veterinary medical teaching hospital. The orofacial examination revealed that the left and right mandibular first premolars were missing, which was consistent with results obtained via CT. In addition, there was substantial crowding and rotation of all maxillary and mandibular premolars and molars as well as a class III malocclusion. Intraoral radiographs of the rostral portion of the left mandible were acquired to further assess vitality of the teeth surrounding the radiolucent structure. Radiographic assessment revealed substantial resorption of the mesial root of the left mandibular second premolar, which indicated that surgical extraction of that tooth was necessary.

Surgical enucleation of the cyst and the associated left mandibular first premolar was performed, and the left mandibular second premolar was also surgically extracted. The osseous defect was filled with a synthetic bone graft material[f] prior to closure. The enucleated cyst and left mandibular first premolar were placed in neutral-buffered 10% formalin and submitted for histologic examination.

The tooth and separate segments of the cyst wall were examined histologically (**Figure 3**). Segments of the cyst wall were composed of a band of dense collagenous fibrous connective tissue up to 1 mm thick; in a few areas, this tissue had abundant dense collagen with widely spaced stellate cells (which was suggestive of periodontal ligament) and rare small epithelial rests (rests of Malassez). Segmentally, this tissue was lined by a delicate nonkeratinizing stratified squamous epithelium with a thickness of up to 4 to 7 cell layers; in other areas, the epithelium was absent and the surface was lined by a thin layer of granulation tissue. The connective tissue contained a few small foci of cholesterol clefts along with a few hemosiderin-laden macrophages, plasma cells, lymphocytes, and neutrophils. The tooth was mildly misshapen, and dentin of the root variably abutted periodontal ligament, odontoblasts, or woven alveolar bone. The cervical region of the tooth contained stratified squamous epithelium, which partially stretched over the clear enamel zone in a thin peninsula; the remaining enamel was covered by a thin band of mineral. The histopathologic diagnosis was odontodystrophy of the left mandibular first premolar tooth with formation of a dentigerous cyst.

Serial follow-up examinations included CT evaluations at 21 and 29 months after radiation treatment. These examinations revealed no additional changes in the nasal disease, resolution of the dentigerous cyst, and no change in the status of the right mandibular first premolar.

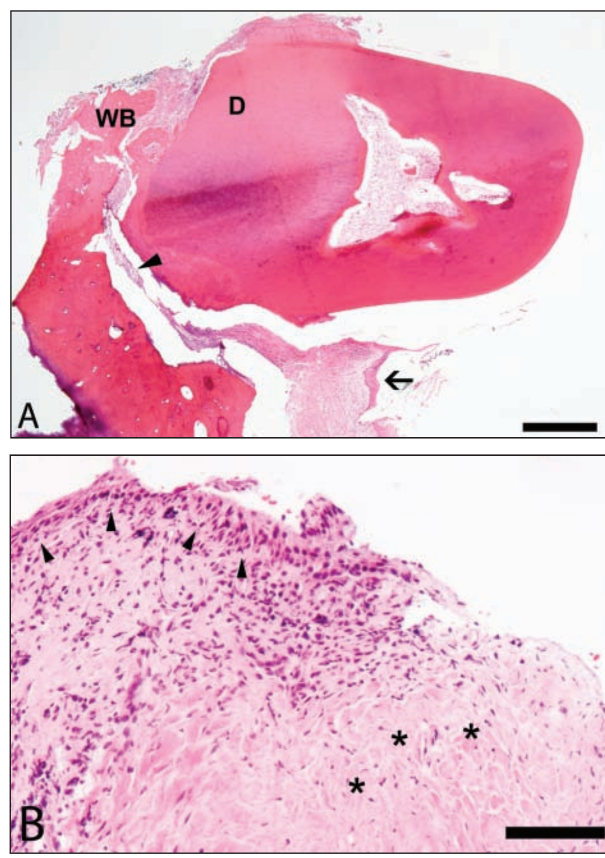


Figure 3—Photomicrographs of tissue sections of the unerupted left mandibular first premolar, cyst lining, and surrounding bone (A) and a portion of the dentigerous cyst wall (B). Notice in panel A that the unerupted left mandibular first premolar is mildly misshapen and the dentin (D) is bordered by periodontal ligament (arrowhead) or woven bone (WB). Also, the epithelium at the cervical area is identical to the cyst wall (arrow). In panel B, the dentigerous cyst wall has a thin epithelial lining (arrowheads) subtended by connective tissue (asterisks) that is similar to periodontal ligament. Notice that the thickness of the epithelial lining (< 6 cell layers) is consistent with the diagnosis of a dentigerous cyst. H&E stain; bar = 500 µm and 100 µm for panels A and B, respectively.

## Discussion

Odontogenic cysts are pathologic, epithelium-lined cavities with derivation from a tooth-related structure; in dogs, they include radicular cysts,[1,2] odontogenic keratocysts,[3,4] unclassified odontogenic cysts,[3,5] and dentigerous cysts.[3,6–9] Dentigerous (follicular) cysts are defined by their association with an unerupted tooth and arise from proliferation of the reduced enamel epithelium. Although dentigerous cysts are considered rare in animals,[10] they may not be as infrequent as believed.[3,6–9] The most commonly affected teeth in dogs are the mandibular first premolars, and dentigerous cysts most commonly affect brachycephalic breeds with dental crowding. Histologically, the cyst lining is attached to a tooth at the cementoenamel junction and encompasses the crown of the affected tooth. Radiographically, the cyst is a clearly defined unilocular lucency that surrounds the tooth crown and represents expansion from accumulation of a highly osmolar fluid and release of bone-resorbing factors (possibly prostaglandin $E_2$).[11,12] Computed tomography reveals dentigerous cysts as expansile lesions with smooth osseous margins, homogenous fluid of even density, and an embedded tooth.[13,14]

Dentigerous cysts are often diagnosed as incidental findings during intraoral radiography. However, when undiagnosed or left untreated, cysts can enlarge and obtain sufficient size to result in substantial bony expansion, which can potentially lead to the loss of teeth and even pathologic fracture of the jaw.[8] In a recent case report,[8] extensive bilateral odontogenic cysts were described that radiographically resembled dentigerous cysts and led to concern of bilateral mandibular fracture and euthanasia of the affected dog. One of the authors (JWS) for the report of the dog described here has treated bilateral mandibular fractures secondary to advanced bilateral dentigerous cysts. Given the rapid expansion of the cyst in the dog reported here, treatment was warranted to prevent subsequent mandibular or dental pathologic changes. In addition, neoplastic transformation of the cyst lining to ameloblastoma and squamous cell carcinoma have been reported.[15] For this reason, the cyst lining should always be submitted for histologic evaluation.

Although the exact mechanism that triggers cyst formation is currently unknown, it is clear that dentigerous cysts are associated with unerupted teeth. However, not all unerupted teeth form dentigerous cysts. In the dog described here, this was evident by the lack of cyst formation for the unerupted right mandibular first premolar. If a cyst does not form, treatment is not necessarily indicated; however, the tooth should be monitored regularly via radiography.

Surgical enucleation and removal of the associated tooth followed by curettage of the remaining alveolar bone is the treatment of choice for dentigerous cysts. It was performed in this dog because of the moderate size of the cyst and the desire to complete the treatment with only 1 surgery. In most instances, enucleation is a definitive treatment, with recurrence being exceedingly rare. In large cysts in which enucleation may lead to a pathologic fracture or damage to neurovascular structures, marsupialization may be chosen. This technique allows decompression and reduction in the size of the cyst and osseous defect. The cyst can then be enucleated during a subsequent surgery. Any teeth that are resorbing secondary to the cyst, such as the left mandibular second premolar in the dog described here, should be surgically extracted.

Differential diagnoses for dentigerous cysts include radicular cysts and odontogenic keratocysts. Radicular (periapical) cysts are inflammatory in nature and develop adjacent to the root of a diseased tooth (nonvital, necrotic pulp) from odontogenic epithelial residues (rests of Malassez) within the periodontal ligament. Odontogenic keratocysts derive from remnants of the dental lamina (rests of Serres) and may be aggressive with a high rate of recurrence.[11,15] Radiographically, an odontogenic keratocyst appears as a clearly circumscribed uniloculated or multiloculated lucency adjacent to the crown of an unerupted tooth.[12] Therefore, histologic examination is important to differentiate the exact nature of the cyst. Whereas the epithelial lining of a dentigerous cyst typically has a thickness of 4 to 6 cell layers, that of an odontogenic keratocyst has 8 to 10 cell layers.

Nasal tumors constitute approximately 1% to 2% of all neoplasms in dogs,[16,17] with carcinomas and sarcomas being most commonly diagnosed. Radiation treatment is the most effective means of achieving local tumor control, with median survival times of approximately 8 to 19.7 months.[18–22] The expectations for local and regional disease control in the dog described here have been exceeded, particularly in light of the fact that the original diagnosis was of a poorly differentiated carcinoma that spread to the regional lymph nodes within 6 months after radiation treatment.

It is highly unlikely that radiation treatment played a role in the development or progression of the dentigerous cyst in this dog. The biological effect of radiation on these tissues depends on a number of factors, including the magnitude of the delivered dose, the fractionation scheme, and sensitivity of the tissue.[23–25] Tomotherapy is an advanced form of conformal intensity-modulated radiation treatment that most precisely delivers radiation to the desired target. Therefore, the mandible received little radiation (approx 12 to 15 Gy during the course of 10 fractions, which represented approx 30% of the tumor dose).

Computed tomography–assisted monitoring played an important role in the management and decision-making process for this dog, and to our knowledge, such a use of CT has not been reported in dogs. In humans, the use of CT in the evaluation of complex diseases and conditions of the orofacial structures has been justified as being superior to plain-film radiography,[26–28] particularly when evaluating cystic and neoplastic diseases.[14,29] In evaluation of orofacial cysts in humans, CT is superior to plain-film radiography for the evaluation of cyst margins; the relationship to tooth roots, cortical bone, the mandibular canal, and the maxillary sinus; and the presence of embedded teeth.[14,29] Specifically, CT has been used in the evaluation of myxofibroma of the jaw,[27] postoperative maxillary cysts,[30] and lingual mandibular bone defects.[31] In the dog described here, intra-

SMALL ANIMALS

oral radiography was used to assess tooth vitality and the degree of tooth resorption of the surrounding teeth because no specific CT criteria have been established. The cyst was detected as an incidental finding during serial CT evaluation of the dog's head to determine the response to radiation treatment. Growth rate of the cyst in this dog was similar to reported growth rates of odontogenic keratocysts in humans (0.58 mm/mo)[32] and warranted surgical amelioration to avoid fracture of the jaw and pathologic changes of the surrounding strategic teeth in this long-term cancer survivor. Computed tomography proved beneficial in initial detection and monitoring and was useful in making the decision to pursue surgical intervention. It is likely that CT would be beneficial as a prospective monitoring tool in dogs with orofacial cysts.

a. HiSpeed Lxi, GE Medical Systems, Milwaukee, Wis.
b. TomoTherapy Inc, Madison, Wis.
c. Carboplatin, Hospira Inc, Lake Forest, Ill.
d. Doxorubicin, TEVA Parenteral Medicines, Irvine, Calif.
e. Piroxicam, TEVA Pharmaceuticals USA, Sellersville, Pa.
f. Consil Dental, Nutramax Laboratories Inc, Alachua, Fla.

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