Title
Diagnostic Imaging in Veterinary Dental Practice.

Journal
Journal of the American Veterinary Medical Association, 255(2)

ISSN
0003-1488

Authors
Lee, Da Bin
Watson, Katherine D
Wanamaker, Mason W
et al.

Publication Date
2019-07-15

DOI
10.2460/javma.255.2.167

Peer reviewed

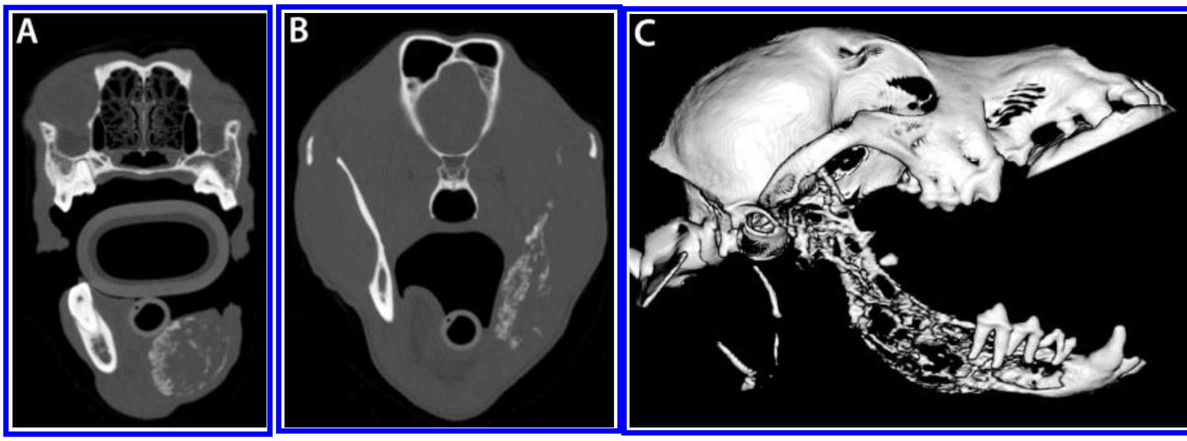

Figure 1—Representative CT images of the head of a 9-year-old Jack Russell Terrier cross with a right mandibular mass. Transverse CT images obtained at the level of the left mandibular second molar tooth (A) and mandibular rami (B) and viewed with bone settings (window width, 2,500 HU; window level, 480 HU) and a 3-D reconstructed image of the right side of the skull (C) are shown.

History and Physical Examination Findings

A 9-year-old 8.7-kg (19.1-lb) spayed female Jack Russell Terrier cross was referred to the dentistry and oral surgery service of a veterinary medical teaching hospital (VMTH) for evaluation of a mass that grossly spanned most of the right mandible. The client had noticed thickening of the area 4 months prior to the examination. At that time, the dog was treated by the primary care veterinarian with extraction of the right mandibular first and second molar teeth and was administered clindamycin hydrochloride (4.3 mg/kg [2 mg/lb], PO, q 12 h) for 7 days. Approximately 2 weeks before examination at the VMTH, the dog was returned to the primary care veterinarian because of pronounced right mandibular swelling, decreased appetite, and signs of oral pain; radiography of the skull revealed an extensive lytic and proliferative process involving most of the right mandible and possibly the caudal aspect of the right zygomatic arch. Tramadol (2.9 mg/kg [1.3 mg/lb], PO, q 8 to 12 h) was prescribed. A CBC, serum biochemical analysis, urinalysis, thoracic radiography, and abdominal ultrasonography were performed at another referral clinic on the day prior to the visit to the VMTH. Hematologic results revealed lymphopenia (0.98×10^3 lymphocytes/µL; reference range, 1.05×10^3 lymphocytes/µL to 5.10×10^3 lymphocytes/µL) and hyperglobulinemia (6.5 g/dL; reference range, 2.5 to 4.5 g/dL); urinalysis results were unremarkable. Abdominal ultrasonographic examination findings were unremarkable aside from chronic degenerative renal changes. Mild generalized cardiomegaly and a moderate diffuse bronchial pattern were detected on thoracic radiographs. Gabapentin (11.8 mg/kg [5.4 mg/lb], PO, q 8 to 12 h) and tramadol (at the previous dosage) were prescribed.

On examination at the VMTH, the dog was bright, alert, and responsive with unremarkable general physical examination findings. Extraoral examination revealed facial asymmetry with moderate right temporal muscle atrophy and diffuse thickening of the ventral aspect of the right mandible with signs of discomfort on palpation. Intraoral examination revealed missing right mandibular first and second molar, right and left maxillary second premolar, and left mandibular second premolar teeth. Mobility of the right mandibular first to fourth premolar teeth and third molar tooth was detected. There was moderate generalized gingivitis and plaque and calculus accumulation (more pronounced on the right mandibular teeth than on the left mandibular teeth).

The dog was anesthetized, and contiguous transverse 0.6-mm collimated CT images of the head and thorax with 3-D volume rendering were obtained before and after administration of contrast medium (iopamidol solution;[a] 850 mg of I/kg [386 mg of I/lb], IV). Unenhanced images were acquired with a bone reconstruction filter, and contrast-enhanced images were acquired with a soft tissue reconstruction filter. Images were viewed with bone (window width, 2,500 HU; window level, 480 HU) and soft tissue (window width, 350 HU; window level, 40 HU) settings. All digital images were evaluated on a medical-grade flat-screen monitor by use of commercially available software.[b–d] Representative CT images are shown **(Figure 1)**.

Determine whether additional studies are required, or make your diagnosis, then turn the page→

This report was submitted by Da Bin Lee, DVM; Katherine D. Watson, DVM, PhD; Mason W. Wanamaker, DVM; and Boaz Arzi, DVM; from the Dentistry and Oral Surgery Service (Lee), Anatomic Pathology Service (Watson), and Diagnostic Imaging Service (Wanamaker), William R. Pritchard Veterinary Medical Teaching Hospital, and the Department of Surgical and Radiological Sciences, School of Veterinary Medicine (Arzi), University of California-Davis, Davis, CA 95616.

Address correspondence to Dr. Arzi (barzi@ucdavis.edu).

Diagnostic Imaging Findings and Interpretation

Extensive, moderately contrast-enhancing, expansile, and osteolytic changes were observed to be associated with the entirety of the right mandible from the apical margin of the right mandibular canine tooth to the dorsal aspect of the coronoid process, including involvement of the condylar process **(Figure 2)**. Despite the severe osseous change and cortical lysis of the right mandible, there was no gross CT evidence of invasion of the temporal bone, zygomatic bone, or left mandible. The right mandibular and medial retropharyngeal lymph nodes were mildly enlarged but assessed as having a normal shape and hilus. No abnormalities were detected in the thorax. Three-dimensional reconstructed images revealed rostral displacement of all right mandibular premolar teeth and allowed for a better spatial understanding of the entire osseous lesion.

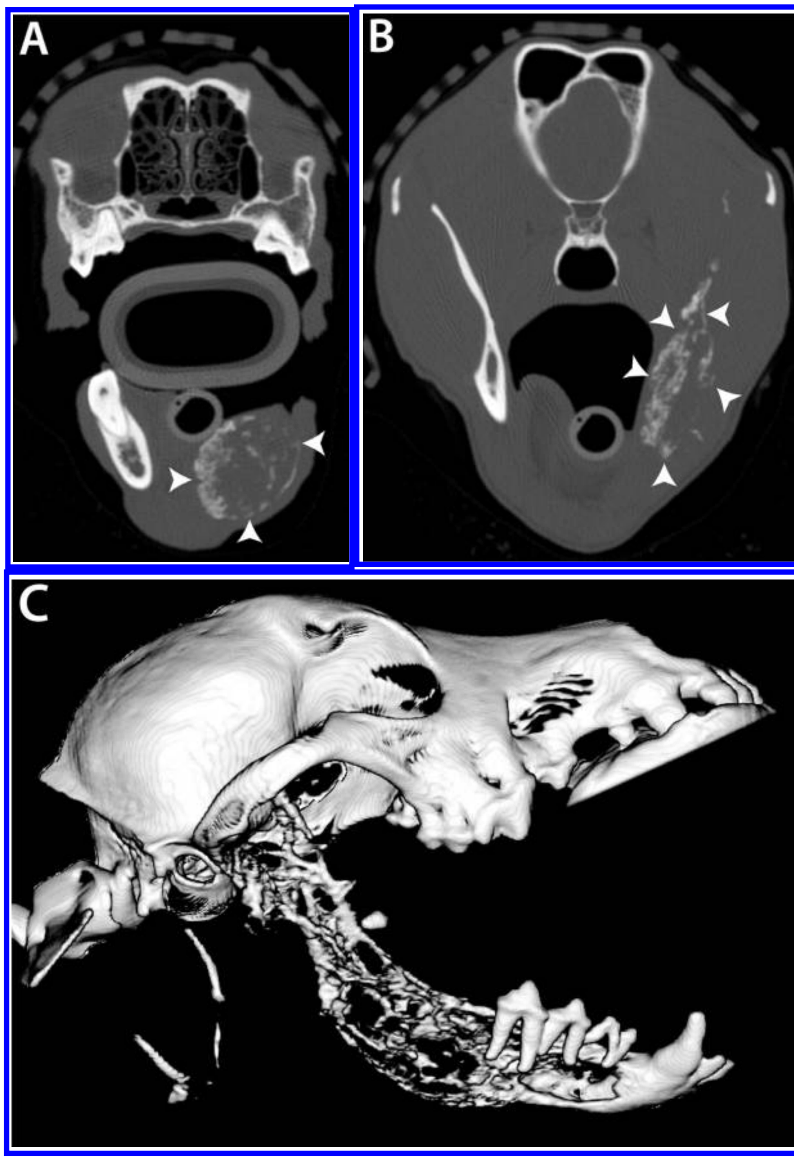

Figure 2—Same CT images as in Figure 1. A and B—Notice the markedly expansile and osteolytic changes spanning the entire right mandible (arrowheads). C—The lesion extends from the level of the apical margin of the right mandibular canine tooth caudally to include the body, ramus, and condylar process of the mandible. The right mandibular second premolar tooth was identified as a persistent deciduous tooth with no permanent successor.

Treatment and Outcome

Radiation therapy planning was performed at the time of the CT scans owing to clinical suspicion of extensive malignancy. During the same anesthetic episode as for CT, supragingival sonic scaling was performed on the right mandibular premolar teeth and third molar tooth. Incisional biopsies of the edentulous region of the right mandible was performed with a 4-mm disposable biopsy punch. Ampicillin sodium (20 mg/kg [9.1 mg/lb], IV) was administered once during surgery, and carprofen (2.2 mg/kg [1 mg/lb], IV) was administered once after surgery. The dog was discharged from the hospital, and the owner was instructed to administer carprofen (1.4 mg/kg [0.6 mg/lb], PO, q 12 h) for 5 days and to continue gabapentin and tramadol administration at the previously described dosages as needed for additional analgesia. The owner was instructed to feed a soft diet for 2 to 3 weeks after the procedure. The histopathologic diagnosis was severe, regionally extensive, chronic, neutrophilic, and lymphoplasmacytic osteomyelitis and stomatitis with bony remodeling **(Figure 3)**. The dog was subsequently administered clindamycin (17.2 mg/kg [7.8 mg/lb], PO, q 12 h) for 14 days.

Three weeks after dental scaling and biopsies, the dog was returned for another biopsy and collection of samples for aerobic and anaerobic bacterial and fungal cultures with antimicrobial susceptibility testing. Biopsy was repeated to confirm the diagnosis because of the uncommon imaging and clinical findings. The client reported that the dog's appetite and energy level had improved since the previous visit. Thickening of the mandible was subjectively mildly increased. General anesthesia was induced, and incisional biopsies of the right mandible were performed with a 4-mm disposable biopsy punch in the following 3 areas: the alveolar mucosa and bone at the level of the right mandibular first premolar tooth, right mandibular third molar tooth, and edentulous region (which comprised sites for the missing right mandibular first and second molar teeth). The samples were

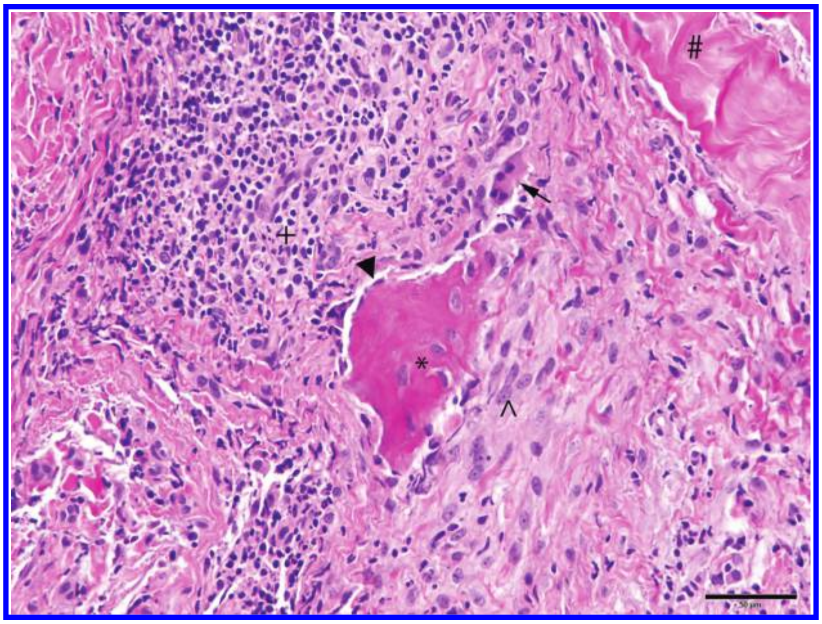

Figure 3—Photomicrograph of a biopsy sample from the right mandible of the dog in Figure 1. Isolating islands of woven bone and inflammation with large numbers of neutrophils, lymphocytes, and plasma cells (plus sign) are present. Bony trabeculae had densely packed osteocytes within lacunae (asterisk), which had scalloped margins lined by variable numbers of plump osteoblasts (arrowhead) or osteoclasts (arrow). Scattered throughout the inflammatory cells are plump cuboidal to spindloid cells including fibroblasts (caret) and collagen deposits (pound sign). H&E stain; bar = 50 µm.

submitted for histologic examination and culture and susceptibility testing. Ampicillin sodium (20 mg/kg, IV) was administered during surgery, and carprofen (2.2 mg/kg, IV) was administered once after surgery. The dog was discharged from the hospital, and the owner was instructed to administer carprofen (4.3 mg/kg, PO, q 24 h) for 5 days and amoxicillin trihydrate–clavulanate potassium (14.4 mg/kg [6.5 mg/lb], PO, q 12 h) until culture and susceptibility tests results were available (10 days) and to continue gabapentin at the previously described dosage as needed for additional analgesia. The histopathologic examination findings confirmed the previous diagnosis. Aerobic culture yielded small numbers of a non–Enterobacteriaceae organism, gram-positive non–spore-forming (catalase-positive) rods, and small numbers of *Pasteurella canis*. Results of anaerobic and fungal cultures were negative. On the basis of susceptibility testing results, amoxicillin trihydrate–clavulanate potassium treatment was continued at the previously described dosage for 3 months.

The dog was reevaluated by means of cone-beam CT 3 months after the second biopsy procedure. The owner reported that the dog was doing well clinically, eating well, and playing. The mandibular swelling was subjectively mildly increased on palpation. A cone-beam CT unit[e] was used to obtain images. The field of view was 18 X 16 cm, and serial slices of the skull were obtained with a scan time of 24 seconds, which resulted in a voxel size (slice thickness) of 250 µm. Compared with the previous conventional CT scan results, osteolysis extended slightly further in the rostral region around the root of the right mandibular canine tooth, and there was a subjective increase in the amount of mineralized bone along the medial margin of the right mandible. The owner was instructed to continue administration of amoxicillin trihydrate–clavulanate potassium at the same dosage for a finite time period subject to continued clinical progress and follow-up.

Comments

For the dog of this report, a comprehensive approach that included diagnostic imaging, histologic examination, and microbiologic testing led to the diagnosis of a nontypical and rare case of extensive mandibular osteomyelitis. Osteomyelitis is an inflammation of cortical bone and the medullary cavity.[1] The etiopathogenesis of osteomyelitis in dogs most commonly begins with bacterial infection, with the most frequently isolated bacteria being *Staphylococcus* spp, followed by *Escherichia coli* and *Streptococcus* spp.[2–6] Other aerobic organisms that have been identified include *Pasteurella* spp, *Pseudomonas* spp, *Proteus* spp, *Serratia* spp, *Klebsiella* spp, *Corynebacterium* spp, and enterococci.[7] Anaerobic organisms such as *Bacteroides* spp, *Nocardia* spp, *Clostridium* spp, *Actinomyces* spp, *Fusobacterium* spp, and *Peptostreptococcus anaerobius* have also been reported.[1,6,8,9] Investigators of 1 study[8] isolated anaerobic bacteria from 18 of 28 (64%) dogs and cats with osteomyelitis, and within that sample, the most commonly infected bones were the radius and ulna, mandible, and tympanic bulla. Less commonly, fungal infections have been reported as a cause for osteomyelitis[1]; cryptococcal osteomyelitis of the maxilla in a dog was recently reported.[10] Infectious agents may be introduced into the mandible as a result of trauma, surgical intervention, periodontal lesions, nonvital teeth, extension of soft tissue infection, or hematogenous spread.[11]

Clinical signs of osteomyelitis vary and depend on the stage of the disease process.[1] Acute osteomyelitis is characterized by local erythema, soft tissue swelling, and signs of pain that often accompany clinical signs of systemic illness (fever, leukocytosis, anorexia, and lethargy).[1,7,12] Signs usually develop within a few days after bone contamination.[7] In chronic osteomyelitis, acute and systemic clinical signs can subside, and infection can manifest as draining tracts, recurrent cellulitis, and abscess formation.[12] Osteomyelitis in veterinary patients is usually chronic at the time of diagnosis.[9]

The use of conventional radiography for the diagnosis of osteomyelitis is hindered by poor sensitivity. A 30% reduction of bone matrix is needed to detect bone loss that is often apparent radiographically only after 1 to 2 weeks of infection.[1] The reported sensitivity and specificity of radiography in the detection of osteomyelitis secondary to injury are 62.5% and 57.1%, respectively.[13] Radiographic changes can include cortical resorption, periosteal proliferation, loss of trabecular patterns, lucency around surgical implants, and sequestra with or without involucra.[7,12] Computed tomography has been regarded as a more accurate and useful modality for imaging of the maxillofacial region owing to the complexity of skull anatomy and the superimposition of structures when radiography is used.[14] Osteomyelitis can be detected earlier with CT than with conventional radiography, and CT can provide high-resolution images for assessment of soft tissue involvement, articular damage, periosteal reactions, and cortical destruction as well as identification of sequestra and foreign material.[1,7] Other diagnostic imaging modalities that are used to evaluate osteomyelitis include MRI, ultrasonography, and nuclear scintigraphy.[1,7]

Diagnosis of bacterial osteomyelitis should be made on the basis of positive microbial culture results[7,12] as well as diagnostic imaging findings. Fungal cultures, cytology, serology, and examination of biopsy samples may aid in the diagnosis of fungal osteomyelitis.[12]

Treatment of osteomyelitis depends on chronicity of the disease, severity of signs, and underlying cause. Systemic antimicrobial treatment on the basis of culture and antimicrobial susceptibility test results is the mainstay of treatment and should be continued for at least 4 to 6 weeks in patients with chronic osteomyelitis. Surgical debridement may be indicated to remove necrotic tissue.[12,15]

For the dog of the present report, contrast-enhanced CT was performed because neoplasia was considered as the top differential diagnosis, and this diagnostic imaging modality proved to be essential in assessing the extent of osteolysis and involvement of structures of the maxillofacial region. In addition, because of the uncommon imaging and clinical findings, biopsies were performed on 2 occasions to confirm the histopathologic diagnosis of osteomyelitis. Microbial culture yielded small numbers of aerobic bacteria, and these results were interpreted with caution given that antimicrobial treatment was initiated prior to the collection of samples for culture. Antimicrobial susceptibility test results were used to guide drug selection for the long-term treatment.

In the dog of this report, many of the clinical signs commonly associated with extensive and chronic osteomyelitis, such as draining tracts, abscess formation, and cellulitis, were absent. Our results supported that, in addition to CT and clinical findings, culture and antimicrobial susceptibility testing should not be neglected even in patients for which neoplasia is considered to be the most likely differential diagnosis. The value of CT as a diagnostic imaging modality for maxillofacial swelling of unknown origin was exemplified in this case.

Footnotes

a. Isovue-370, Bracco Diagnostics Inc, Singen, Germany.
b. eFilm, Merge Healthcare, Chicago, Ill.
c. eFilm Workstation 2.1.0, Merge Healthcare, Chicago, Ill.
d. InVivo5, Anatomage, San Jose, Calif.
e. NewTom, QR s.r.l., Verona, Italy.

References

1. Cockshutt JR, Sumner-Smith G. Bone infection. In: Sumner-Smith G, ed. *Bone in clinical orthopedics.* Stuttgart, Germany: Thieme, 2002;204–217.
2. Johnson KA. Osteomyelitis in dogs and cats. *J Am Vet Med Assoc* 1994;204:1882–1887.
3. Siqueira EG, Rahal SC, Ribeiro MG, et al. Exogenous bacterial osteomyelitis in 52 dogs: a retrospective study of etiology and in vitro antimicrobial susceptibility profile (2000–2013). *Vet Q* 2014;34:201–204.
4. Caywood DD, Wallace LJ, Braden TD. Osteomyelitis in the dog: a review of 67 cases. *J Am Vet Med Assoc* 1978;172:943–946.
5. Smith CW, Schiller AG, Smith AR. Osteomyelitis in the dog: a retrospective study. *J Am Anim Hosp Assoc* 1978;14:589–592.
6. Walker RD, Richardson DC, Bryant MJ, et al. Anaerobic bacteria associated with osteomyelitis in domestic animals. *J Am Vet Med Assoc* 1983;182:814–816.
7. Robinson D. Osteomyelitis and implant-associated infections. In: Tobias KM, Johnston SA, eds. *Veterinary surgery: small animal expert consult* [e-book]. 2nd ed. St Louis: Elsevier Inc, 2017;775–783.
8. Muir P, Johnson KA. Anaerobic bacteria isolated from osteomyelitis in dogs and cats. *Vet Surg* 1992;21:463–466.
9. Johnson KA, Lomas GR, Wood AK. Osteomyelitis in dogs and cats caused by anaerobic bacteria. *Aust Vet J* 1984;61:57–61.
10. Block K, Battig J. Cryptococcal maxillary osteomyelitis and osteonecrosis in a 18-month-old dog. *J Vet Dent* 2017;34:76–85.
11. Arzi B, Fiani N. Diagnostic imaging in veterinary dental practice. Permeative bone loss in a Himalayan cat. *J Am Vet Med Assoc* 2009;235:1149–1151.
12. Schulz KS, Hayashi K, Fossum TW, et al. Other diseases of bones and joints. In: Fossum TW, ed. *Small animal surgery* [e-book]. 5th ed. Philadelphia: Elsevier Inc, 2018;1309–1312.
13. Braden TD, Tvedten HW, Mostosky UV, et al. The sensitivity and specificity of radiology and histopathology in the diagnosis of posttraumatic osteomyelitis. *Vet Comp Orthop Traumatol* 1989;3:98–103.
14. Bar-Am Y, Pollard RE, Kass PH, et al. The diagnostic yield of conventional radiographs and computed tomography in dogs and cats with maxillofacial trauma. *Vet Surg* 2008;37:294–299.
15. Griffon D. Osteomyelitis. In: Griffon D, Hamaide A, eds. *Complications in small animal surgery.* Ames, Iowa: Wiley-Blackwell, 2016;28–33.