Radiographic evaluation of the classification of the extent of tooth resorption in dogs

Santiago Peralta, DVM; Frank J. M. Verstraete, DrMedVet; Philip H. Kass, DVM, PhD

Objective—To determine applicability of the 2007 American Veterinary Dental College (AVDC) classification method for determining extent of tooth resorption in dogs.

Animals—224 dogs > 1 year old admitted for periodontal treatment or other dental procedures in 2007.

Procedures—Full-mouth radiographs of all dogs were reviewed for evidence of tooth resorption. Tooth resorption in dogs was classified in accordance with the radiographic criteria described for use in human teeth and, when applicable, the guidelines described in the 2007 AVDC classification method.

Results—851 of 943 (90.2%) affected teeth met the radiographic characteristics of 1 of the 5 stages of tooth resorption described by the AVDC classification method. Among tooth resorption types described for human teeth, the AVDC classification method was totally applicable (100%) in 17 teeth with external surface resorption, 21 teeth with external replacement resorption, and 736 teeth with external cervical root surface resorption, but it was applicable in only 56 of 121 (46.3%) teeth with external inflammatory resorption and none of the teeth with internal resorption.

Conclusions and Clinical Relevance—The AVDC classification method was useful to describe the extent of tooth resorption in dogs, but it did not reflect the radiographic patterns and location of lesions. The AVDC classification method was applicable in some, but not all, of the teeth with various resorption types in dogs. The AVDC classification method could be adapted best to lesions that have radiographic patterns of external replacement resorption and external cervical root surface resorption. (*Am J Vet Res* 2010;71:794–798)

The prevalence of tooth resorption has been reported[1] for a group of 224 adult dogs for which full-mouth diagnostic-quality radiographs were obtained. In that study,[1] tooth resorption was diagnosed and classified in accordance with radiographic guidelines described for use in humans.[2] Use of the classification method for humans was applicable in 908 of 943 (96.3%) teeth in dogs. To complement these findings, another study was conducted that focused on the veterinary classification of the extent of tooth resorption in dogs.

The classification of any disease process is crucial from a medical standpoint because it enables clinicians to establish optimal diagnoses and treatments, provides a reliable source of information useful for research purposes, and allows comprehensive description in the medical records. The method for classification of tooth resorption in veterinary medicine has evolved as a tool originally intended for staging of resorption lesions in cats and traditionally has been based on the presumption that tooth resorption is an external and progressive process.

Abbreviation

AVDC	American Veterinary Dental College

Historically, the most widely accepted methods for classification of tooth resorption in animals have been those proposed by investigators for use in cats[3,4] and that of the AVDC,[5] which is presumed to be applicable to cats as well as other animal species. Some variations of these classifications have been proposed.[6] The classification method described in 1 report[3] includes 4 stages that are based on clinical and radiographic findings (stage 1, shallow enamel or cementum lesions that do not involve the dentin; stage 2, lesions that have progressed to affect the dentin but that do not involve the tooth pulp; stage 3, lesions that have progressed to involve the pulp; and stage 4, lesions that involve massive loss of tooth substance with or without resultant root ankylosis).

In another study,[4] investigators detected different radiographic patterns of tooth resorption in cats and suggested that there may be 2 types of tooth resorption. The 2 types described are similar to external replacement and external inflammatory resorption in humans,

Received May 5, 2009.
Accepted June 8, 2009.
From the Dentistry and Oral Surgery Service, William B. Pritchard Veterinary Medical Teaching Hospital (Peralta), and the Departments of Surgical and Radiological Sciences (Verstraete) and Population Health and Reproduction (Kass), School of Veterinary Medicine, University of California-Davis, Davis, CA 95616. Dr. Peralta's present address is Servicio de Odontología y Cirugía Oral Veterinaria, Carrera 15 No. 36-16, Bogotá, Colombia.
Address correspondence to Dr. Verstraete (fjverstraete@ucdavis.edu).

as described elsewhere.[2] In that study,[4] the authors also suggested that tooth resorption in cats can be classified on the basis of the extent of the lesions by use of a classification method similar to that for the 4-stage method.[3]

The AVDC adopted a 5-stage classification system that was based on the extent of tooth resorption lesions as follows[5]: stage 1, loss of tissue is limited to enamel or cementum; stage 2, loss of cementum or enamel (or both) and dentin, and the lesion does not involve the pulp cavity; stage 3, resorption has reached the pulp cavity, but the tooth retains its integrity; stage 4, extensive loss of hard tissue (which is further subdivided into 3 subcategories as follows: 4a = the crown and root are equally affected, 4b = the crown is more severely affected than is the root, and 4c = the root is more severely affected than is the crown); and stage 5, complete loss of the crown with the root remnant covered by gingiva. The AVDC classification method does not specify the type or types of tooth resorption for which it is intended. This classification method was developed on the basis of existing classification methods for use in cats, but the current version of the classification method does not make reference to any particular species. Therefore, it is not known whether these criteria should be adjusted for the various types of tooth resorption and the radiographic patterns seen in dogs. The purpose of the

Figure 1—Lateral radiographic view of the mandibular teeth of a dog with stage 2 tooth resorption. Notice the external resorption lacuna (black arrows) at both roots of the left mandibular first molar tooth. The lesions involve the dentin without penetrating into the pulp cavity.

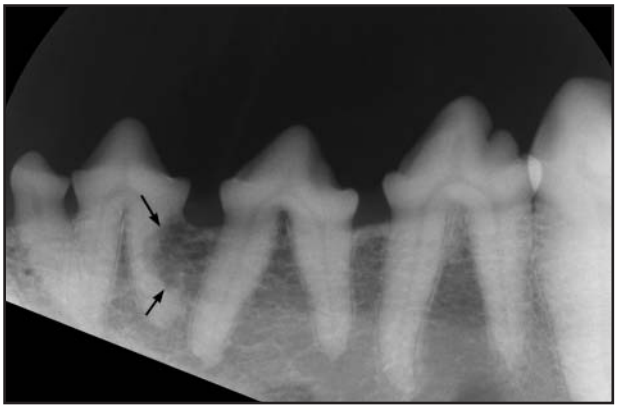

Figure 2—Lateral radiographic view of the mandibular teeth of a dog with stage 3 tooth resorption. There is a large external resorption lacuna (black arrows) penetrating into the pulp cavity at the distal aspect of the distal root of the left mandibular second premolar tooth.

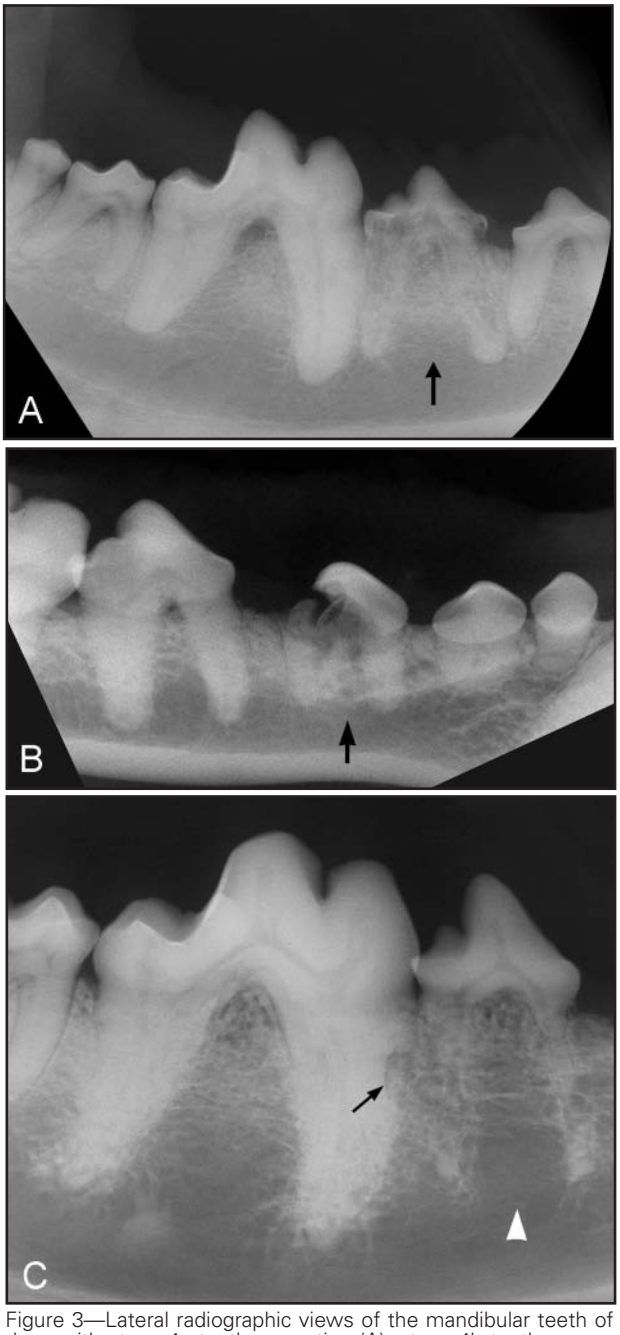

Figure 3—Lateral radiographic views of the mandibular teeth of dogs with stage 4a tooth resorption (A), stage 4b tooth resorption (B), and stage 4c tooth resorption (C). In panel A, the integrity of the crown and roots of the right mandibular fourth premolar tooth (black arrow) is equally compromised. In panel B, extensive loss of dental hard tissues, especially affecting the crown, is visible at the mandibular third premolar tooth (black arrow). In panel C, there is extensive loss of dental hard tissue of the roots of the right mandibular fourth premolar tooth (white arrowhead). Notice also the stage 2 lesion (black arrow) at the mesial root of the right mandibular first molar tooth.

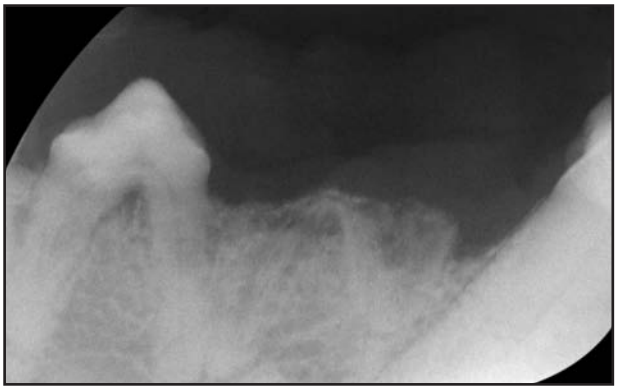

Figure 4—Lateral radiographic view of the mandibular teeth of a dog with stage 5 tooth resorption. The roots of the right mandibular second premolar tooth are in an advanced state of tooth resorption. The crown of the tooth is missing, and soft tissues cover the root remnant.

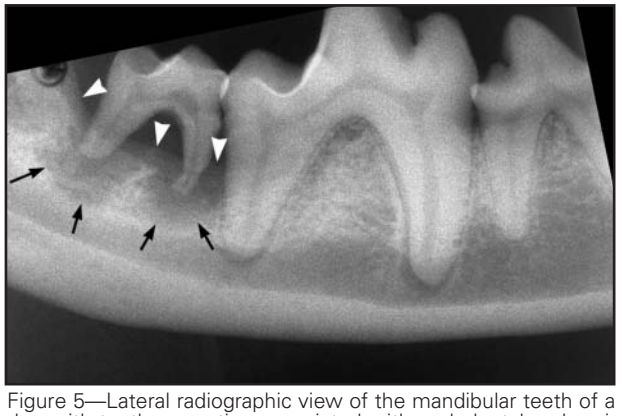

Figure 5—Lateral radiographic view of the mandibular teeth of a dog with tooth resorption associated with endodontal and periodontal disease that affects the right mandibular second molar tooth (as indicated by periapical lucent areas [black arrows] at both roots and horizontal alveolar bone loss [white arrowheads]). Tooth resorption evident at apices of both roots involves the pulp, regardless of the extent or stage of progression of the lesions.

study reported here was to determine the applicability of the current AVDC classification guidelines[5] for use in tooth resorption in dogs.

Materials and Methods

Full-mouth radiographs of 224 dogs admitted to the University of California-Davis William B. Pritchard Veterinary Medical Teaching Hospital during 2007 for periodontal treatment or other dental procedures were prospectively reviewed for evidence of tooth resorption. Inclusion criteria were dogs > 1 year old for which diagnostic-quality full-mouth radiographs (including lateral views of the canine teeth) were obtained. Types of tooth resorption for these dogs have been reported in another study[1] conducted by the authors.

Diagnosis and classification of tooth resorption were performed on a tooth-by-tooth basis. Type of tooth resorption was classified by use of radiographic criteria described for tooth resorption in humans.[2] Tooth resorption also was classified on the basis of radiographic evaluation into the 5 stages **(Figures 1–5)** in accordance with the guidelines described by the AVDC **(Appendix)**.[5]

Table 1—Applicability of the AVDC classification method for extent of tooth resorption[5] in dogs with various types of tooth resorption.

Type of tooth resorption	Applicability
External surface resorption	17/17 (100.0)
External replacement resorption	736/736 (100.0)
External Inflammatory resorption	56/121 (46.3)
External cervical root surface resorption	21/21 (100.0)
Internal resorption	0 (0)

Results represent number of teeth in which the AVDC classification system could be used/number of teeth with that type of tooth resorption (percentage).

Results

Overall, 851 of 943 (90.2%) affected teeth fulfilled the radiographic characteristics of 1 of the 5 stages of tooth resorption described in the AVDC guidelines. Among types of tooth resorption described for use in humans, the AVDC classification method was applicable in 17 of 17 (100%) teeth with external surface resorption, 736 of 736 (100%) teeth with external replacement resorption, 56 of 121 (46.3%) teeth with external inflammatory resorption, 21 of 21 (100%) teeth with external cervical root surface resorption, and 21 of 35 (60.0%) teeth with resorption lesions considered unclassifiable. The 5-stage classification method described by the AVDC was not considered applicable in any of the 13 teeth with internal tooth resorption detected in the study **(Table 1)**.

Of the 851 affected teeth in which the AVDC classification method was applicable, none were classified as stage 1. However, 715 (84.0%) were classified as stage 2, 38 (4.5%) were classified as stage 3, 6 (0.7%) were classified as stage 4a, 4 (0.5%) were classified as stage 4b, 66 (7.8%) were classified as stage 4c, and 22 (2.6%) were classified as stage 5 **(Table 2)**.

Of the 17 external surface resorption lesions in which the AVDC classification method was applicable, all 17 (100%) were classified as stage 2. Of the 736 external replacement resorption lesions in which the AVDC classification was applicable, 664 (90.2%) were classified as stage 2, 10 (1.4%) were classified as stage 3, 47 (6.4%) were classified as stage 4c, and 15 (2.0%) were classified as stage 5. Of the 56 external inflammatory resorption lesions in which the AVDC classification was applicable, 22 (39.3%) were classified as stage 2, 20 (35.7%) were classified as stage 3, 5 (8.9%) were classified as stage 4a, and 9 (16.1%) were classified as stage 4c. Of the 21 external cervical root surface resorption lesions in which the AVDC classification was applicable, 7 (33.3%) were classified as stage 2, 6 (28.6%) were classified as stage 3, 1 (4.8%) was classified as stage 4a, 2 (9.5%) were classified as stage 4b, 1 (4.8%) was classified as stage 4c, and 4 (19.0%) were classified as stage 5. Distributions in classification for the stage of resorption among the 4 lesion groups (external surface resorption, external replacement resorption, external inflammatory resorption, and external cervical root surface resorption) differed significantly ($P < 0.001$); external cervical root surface resorption lesions had the highest scores for stage of resorption, followed by external inflammatory resorption lesions,

Table 2—Tooth resorption in dogs cross-classified for the extent of resorption as determined by use of the AVDC classification method[5] and type of tooth resorption.

Stage	Affected teeth (n = 851)	External surface resorption (n = 17)	External replacement resorption (n = 736)	External inflammatory resorption (n = 56)	External cervical root surface resorption (n = 21)	Internal resorption (n = 0)
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	715 (84.0)	17 (100)	664 (90.2)	22 (39.3)	7 (33.3)	0 (0)
3	38 (4.5)	0 (0)	10 (1.4)	20 (35.7)	6 (28.6)	0 (0)
4a	6 (0.7)	0 (0)	0 (0)	5 (8.9)	1 (4.8)	0 (0)
4b	4 (0.5)	0 (0)	0 (0)	0 (0)	2 (9.5)	0 (0)
4c	66 (7.8)	0 (0)	47 (6.4)	9 (16.1)	1 (4.8)	0 (0)
5	22 (2.6)	0 (0)	15 (2.0)	0 (0)	4 (19.0)	0 (0)

Results represent number of teeth (percentage).
n = Number of teeth.

external replacement resorption lesions, and external surface resorption lesions.

Discussion

The radiographic applicability of the AVDC classification method for the extent of tooth resorption was only slightly less than that of the human classification method for type of tooth resorption when used in dogs. The AVDC classification[5] was applicable in 851 of 943 (90.2%) affected teeth, whereas the human classification method described elsewhere[2] was applicable in 908 of 943 (96.3%) affected teeth.[1] However, there were a number of shortcomings associated with the use of a classification designation based on extent of tooth resorption.

One of the limitations was the fact that the AVDC classification method does not consider the location and radiographic patterns of the lesions. The same limitation has been described[4] for tooth resorption lesions in cats. The authors described 2 types of tooth resorption in cats that were based on radiographic patterns and suggested that tooth resorption should be first classified by the type of resorption and then by the extent of resorption.[4,7]

Also, although the AVDC classification method was applicable in all teeth with external surface resorption, external replacement resorption, and external cervical root surface resorption, it was applicable in only 56 of 121 (46.3%) teeth with external inflammatory resorption and in none of the teeth with internal resorption. From an epidemiological perspective, this difference is important because as was reported in our other study[1] on tooth resorption, external inflammatory resorption is the second most frequent type of tooth resorption in dogs. In practical terms, this means that approximately half of the teeth with one of the most common types of tooth resorption (external inflammatory resorption) are not included in the classification method. Similarly, although internal resorption was detected infrequently in dogs,[1] the fact that the AVDC classification method does not accommodate these teeth is of clinical relevance because the diagnosis and classification may impact clinical decisions.

The inapplicability of the AVDC classification method in approximately half of the teeth with external inflammatory resorption and in all of the teeth with internal resorption can be explained by the fact that the criteria are based on the presumption that the lesions are external and the condition is progressive. Approximately half of the teeth with external inflammatory resorption were associated with endodontal disease; in such cases, resorption was detected at the periapical area of the root and it invariably involved the pulp cavity, even during the earliest stages of resorption. Because the AVDC classification method only considers pulp involvement at more advanced stages of resorption (ie, stages 3 and 4), by definition, some of the teeth with external inflammatory resorption did not fulfill the criteria.

The distribution for the various stages of tooth resorption was interesting. For example, no stage 1 lesions were detected, which is consistent with its definition. Stage 1 lesions are those that affect only the cementum or enamel.[5] Because the cementum is not visible on radiographs, it is impossible to detect lesions that are limited to this tissue. Although enamel is visible on radiographs, it is unlikely that any of the types of tooth resorption will be limited to this tissue, which makes it unlikely that this type of resorption would be detected and diagnosed in the enamel.

Also, all of the external surface resorption lesions were classified as stage 2. This is consistent with this type of tooth resorption, which is characterized by shallow lacunae involving only the cementum and dentin.[2] Additionally, analysis of our results revealed that regardless of the type of tooth resorption, stage 2 was the most common stage for tooth resorption in the dogs. This finding must be interpreted with caution because of the inherent limitations of radiography in regard to tooth resorption. When there is tooth resorption on the mesial or distal aspects of a tooth, it is relatively simple to identify the depth of the lesion. In contrast, when the lesion is located on the buccal or lingual aspects of a tooth, it is virtually impossible to determine the extent of the lesion. In the study reported here, the criteria used were more likely to cause us to err on the conservative side; thus, we may have underestimated the number of teeth with pulp involvement.

Stage 3 lesions were infrequently found in teeth with external replacement resorption. This can be explained by the fact that the progression pattern for this type of tooth resorption appears to be around the pulp cavity without direct involvement of the pulp cavity

until late in the course of the condition. In some cases in the present study, even after substantial loss of root structure indicative of a stage 4c lesion, the pulp cavity remained intact.

We found that some types of tooth resorption did not have any of the 3 subcategories of stage 4 lesions. For example, no stage 4a or stage 4b lesions were found among teeth with external replacement resorption. This is not surprising because this type of tooth resorption is characterized by a progressive replacement of root tissues by bone, which leaves the crown tissues intact.[2,8–10] Thus, by definition, stages 4a and 4b are not applicable to this type of tooth resorption. In the case of teeth with external inflammatory resorption, no stage 4b lesions were detected. This can be explained by the fact that this type of tooth resorption is associated with periodontal or endodontal disease, both of which are processes that involve tissues at or below the cementoenamel junction. Therefore, the stage 4b subcategory is not applicable to this type of tooth resorption.

In stage 5 lesions, only root remnants remain; therefore, the identification of the underlying type of tooth resorption is challenging and subject to error. In the study reported here, some of the stage 5 lesions were classified on the basis of the radiographic characteristics of tooth resorption detected simultaneously in other teeth of the same dog. Thus, although the total number of stage 5 lesions detected was low (22/851 [2.6%] teeth), the margin of error when classifying the type of tooth resorption was likely to be high.

Classification methods for type of tooth resorption in humans are not free of controversy. Some investigators claim[10] that since the classification method described by Andreasen and Andreasen[2] was published, research has identified other types of tooth resorption. Other investigators claim[11] that these new classification methods, which are based on radiographic and histologic criteria, can lead to overlap and repetition of some of the categories and therefore propose that a classification method based on cause of the tooth resorption be implemented. Nevertheless, most human classification methods categorize tooth resorption into types that can be recognized on the basis of radiographic patterns.[2,8–11] In contrast, for the classification method for use in dogs and cats, only 1 author[12] has proposed the use of criteria based on extent of the lesions. However, the classification method based on extent of lesions is applied only after the lesion has been classified in accordance with type of tooth resorption. Moreover, a classification category based on extent of tooth resorption is only described for use in lesions that correspond to external cervical root surface resorption. Interestingly, this subclassification resembles that proposed by other investigators[3] for use in resorption lesions of cats.[10,12]

The classification method for human tooth resorption described by Andreasen and Andreasen[2] is applicable for use in tooth resorption of dogs. There are limitations for the sole use of the AVDC classification method[5] that is based on extent of tooth resorption. Therefore, we suggest that the latter be used only as a secondary tool to determine the extent of some types of tooth resorption in dogs. In particular, teeth with external replacement resorption and external cervical root surface resorption are best characterized by the secondary use of the AVDC classification method[5]; however, this is not the case for teeth with internal tooth resorption or external inflammatory resorption.

References

1. Peralta S, Verstraete FJ, Kass PH. Radiographic evaluation of the types of tooth resorption in dogs. *Am J Vet Res* 2010;71:784–793.
2. Andreasen FM, Andreasen JO. Luxation injuries of permanent teeth: general findings. In: Andreasen JO, Andreasen FM, Andersson L, eds. *Textbook and color atlas of traumatic injuries to the teeth*. 4th ed. Copenhagen: Blackwell Munksgaard, 2007;372–403.
3. Lyon KF. Subgingival odontoclastic resorptive lesions. Classification, treatment, and results in 58 cats. *Vet Clin North Am Small Anim Pract* 1992;22:1417–1432.
4. DuPont GA, DeBowes LJ. Comparison of periodontitis and root replacement in cat teeth with resorptive lesions. *J Vet Dent* 2002;19:71–75.
5. Nomenclature Committee of the American Veterinary Dental College. Veterinary dental nomenclature—classification of tooth resorption. Available at: www.avdc.org/Nomenclature.html#resorption. Accessed Mar 31, 2009.
6. Reiter AM, Mendoza KA. Feline odontoclastic resorptive lesions: an unsolved enigma in veterinary dentistry. *Vet Clin North Am Small Anim Pract* 2002;32:791–837.
7. DuPont GA, DeBowes LJ. By any other name (lett). *J Vet Dent* 2002;19:60.
8. Tronstad L. Root resorption—etiology, terminology and clinical manifestations. *Endod Dent Traumatol* 1988;4:241–252.
9. Gunraj MN. Dental root resorption. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999;88:647–653.
10. Heithersay GS. Management of tooth resorption. *Aust Dent J Endod Suppl* 2007;52:S105–S121.
11. Fuss Z, Tsesis I, Lin S. Root resorption—diagnosis, classification and treatment choices based on stimulation factors. *Dent Traumatol* 2003;19:175–182.
12. Heithersay GS. Invasive cervical resorption. *Endod Topics* 2004;7:73–92.

Appendix

Descriptions of the extent of tooth resorption in dogs based on a classification method described by the AVDC.[5]

Stage	Radiographic characteristics
1	Mild loss of dental hard tissue (cementum or cementum and enamel)
2	Moderate loss of dental hard tissue (cementum or cementum and enamel, with loss of dentin that does not extend to the pulp cavity)
3	Deep loss of dental hard tissue (cementum or cementum and enamel, with loss of dentin that extends to the pulp cavity); most of the tooth retains its integrity
4	Extensive loss of dental hard tissue (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
5	Remnants of dental hard tissue are visible only as irregular opacities on radiographs, and gingiva completely covers the remnant of the resorbing root