Diagnostic value of the use of lateral and occlusal radiographic views in comparison with periodontal probing for the assessment of periodontal attachment of the canine teeth in dogs

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Objective—To determine the diagnostic value of 2 intraoral bisecting angle radiographic views in comparison with periodontal probing for the assessment of periodontal attachment of the canine teeth in dogs.

Study Population—466 canine teeth from 117 dogs.

Procedure—Periodontal probing measurements were recorded, and clinical attachment levels (CAL) were calculated at the mesial, buccal, distal, and lingual (or palatal) surfaces on each canine tooth. Occlusal and lateral radiographs of the canine teeth were obtained. Alveolar margin height (AMH) was measured at the same 4 surfaces. Values for AMH and CAL were compared on the basis of tooth surface, dental arch, and radiographic view.

Results—The AMH at the mesial and distal surfaces of the mandibular canine teeth was measurable on the lateral view and was significantly correlated with CAL. Similar results were found for the mesial and distal surfaces of the maxillary canine teeth. Buccal and lingual AMH were measured on the mandibular occlusal radiographic view, and values were significantly correlated with CAL, but only the buccal AMH could be assessed on the occlusal radiographic view of the maxilla with values that correlated significantly with CAL.

Conclusions and Clinical Relevance—The lateral radiographic view is suitable for evaluating periodontal attachment at the mesial and distal surfaces of the canine teeth in dogs. The occlusal radiographic view is suitable for assessing buccal surfaces as well as the lingual surface of mandibular canine teeth but not the palatal surface of maxillary canine teeth in dogs. (*Am J Vet Res* 2003;64:255–261)

Periodontitis results in the destruction of connective tissue and alveolar bone, and it is the most common cause of loss of periodontal attachment in dogs and humans. In dogs, severity of loss of periodontal attachment increases with age and decreases with increasing body weight.[1] Periodontal disease and attachment loss do not progress uniformly throughout the mouth, and maxillary premolars are usually the most severely affected teeth.[2-4] Canine teeth, however, are the most common site in which there is loss of attachment ≥ 3 mm, but because of the large root surface area of attachment for the canine teeth, mobility may not be clinically apparent until there has been substantial loss of attachment.[1,5] As a result, oronasal fistulae are common sequelae of undiagnosed deep palatal periodontal pockets in small-breed, narrow-muzzled dogs.[1,5] Extraction is the only option when there is direct communication with the nasal cavity.[6] It is functionally important to preserve canine teeth, and whenever possible, extraction should be avoided. Diagnostic tests that allow for the early detection of attachment loss are crucial for achieving this goal. Depth during periodontal probing, measurements of the amount of attachment, and dental radiography are the most common methods for diagnosis of periodontal disease in clinical practice.

During periodontal probing, measurements are obtained by use of a periodontal probe and reported as the number of millimeters.[7] Many styles of periodontal probe are available for clinical use. Diameter of the probe tip, probing force, and inflammation within the periodontal pocket can influence measurements obtained during periodontal probing.[8-10] The periodontal index described by Ramfjord[11] defines the measurement of **clinical attachment level (CAL)** as an assessment of 2 probing measurements: **cementoenamel junction (CEJ)** to the free **gingival margin (GM)** and free GM to the depth of the gingival sulcus. The measurement of the latter, also referred to as **probing depth (PD)**, is the more commonly used measurement of attachment. The CAL and PD of clinically normal dogs are 2 to 3 mm.[12]

The free border of the alveolar process is commonly but incorrectly referred to as the alveolar crest. The correct name of the free border of the alveolar process is the alveolar margin (margo alveolaris).[13]

When inflammation associated with periodontal disease extends beyond the soft tissues of the periodontium, destruction of the alveolar bone will result, and the alveolar margin will recede apically along the root surface. Dental radiography is the standard technique used in clinical practice for documenting bony changes associated with periodontitis. Radiologic signs of periodontitis in dogs are rounding of the alveolar

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margin with loss in continuity of the lamina dura, widening of the periodontal ligament space, and loss of **alveolar margin height (AMH)**.[14]

The amount of alveolar margin destruction in dogs with periodontitis can be quantified on radiographs by measuring the AMH, which is the distance between the alveolar margin and the CEJ.[15] In healthy dogs, the alveolar margin should be 2 to 3 mm apical to the level of the CEJ.[16] Crown-root ratio and percentage of root length are other methods of radiologically expressing attachment loss, but they are better used when studying the progression or advancement of disease over a prolonged period.[17-19] Because of variation in the length of the roots of teeth in dogs, absolute measurements expressed in millimeters are preferable to relative measurements expressed as percentages.[20]

Dental radiographs provide a 2-dimensional representation of a 3-dimensional object and allow assessment of AMH almost exclusively at the mesial and distal aspects of a tooth. Because of poor localization of the alveolar margin at the buccal and lingual (or palatal) sides of a tooth, there is often an underestimation of alveolar bone loss on radiographs.[21] In humans, it is accepted that conventional dental radiography will not register alveolar bone loss until 30 to 50% of the bone mineral has been destroyed.[22]

Dental radiographs are obtained by use of paralleling or bisecting angle techniques. In the paralleling technique, the radiographic film is positioned parallel to the long axis of the tooth, and the x-ray beam is directed perpendicular to the film. The paralleling technique allows for the most accurate radiographic representation of a tooth and its supporting structures, but it is feasible only for the mandibular premolars and molars. For all other radiographic views in dogs, the bisecting angle technique must be used. This technique is implemented by placing the radiographic film within the oral cavity as close to parallel to the long axis of the tooth as possible without bending or distorting the film. The x-ray beam is directed perpendicular to the line that bisects the angle formed by the film and the long axis of the tooth. In contrast to the paralleling technique, which is technically uncomplicated, the accuracy of the radiograph obtained with the bisecting angle method is dependent on use of the proper bisecting angle and, to some degree, the skull type of the dog. Inaccurate determination of the bisecting angle will result in foreshortening and elongation of the image. Dogs with brachycephalic skulls are generally more difficult to radiograph because of crowding and rotation of the teeth, whereas mesaticephalic and dolichocephalic dogs are easier to radiograph because the teeth are well separated.[23]

Obtaining 2 views that are at right angles to each other is a standard radiographic practice to achieve 3-dimensional reconstruction of an object, but it is often not feasible in intraoral radiography. The palate and tongue prevent proper placement of the radiographic film for an orthogonal view. By convention, a radiographic view is referred to by listing the aspect of the patient that first contacts the x-ray beam, followed by the surface where the beam exits to interact with the film; however, in oral radiography, the dorsoventral or ventrodorsal radiographic views are referred to as occlusal radiographic views in reference to the position of the radiographic film.[24]

In veterinary dentistry, radiographic views in the standard full-mouth radiographic series of a dog that are used to evaluate the canine teeth are occlusal views obtained by use of the bisecting angle technique.[25] In human dentistry, occlusal radiographic views are used to survey a large segment of the dental arch in a single radiograph and when patients are unable to open their mouths sufficiently wide to enable periapical radiographs, but they are not obtained for routine assessment of the alveolar margin.[26] Bitewing radiographs that include the crowns of the maxillary and mandibular teeth and the alveolar margin in the same radiograph are more appropriate for evaluation of the alveolar margin, but bitewing radiographs cannot be obtained in dogs because of certain anatomic distinctions (ie, nonvaulted hard palate).[26] Unique to the radiographic views in the standard full-mouth survey, the occlusal view allows for examination of the buccal and lingual (or palatal) alveolar margin.

Lateral radiographic views of the canine teeth are also obtained by use of the bisecting angle technique, but they are not standard views in the full-mouth radiographic survey of dogs and are usually obtained to evaluate the periapical region or during endodontic treatment to determine length of instruments. The lateral view also can be helpful when evaluating the alveolar margin at the mesial and distal aspects of the canine teeth.[27] The purpose of the study reported here was to determine the diagnostic value of 2 intraoral radiographic views obtained by use of the bisecting angle technique, compared with periodontal probing, for use in the assessment of periodontal attachment of the canine teeth in dogs.

Materials and Methods

Animals—One hundred seventeen dogs admitted to the Veterinary Medical Teaching Hospital at the University of California-Davis for dental treatment between August 1999 and December 2001 were included in the study. Distribution included 108 mesaticephalic, 7 dolichocephalic, and 2 brachycephalic dogs.

Procedure—Dental radiographs and measurements obtained during periodontal probing were recorded for the canine teeth of each dog. Dogs were anesthetized, and radiography and periodontal probing were then performed. Radiographs were obtained by use of a standard wall-mounted radiography unit[a] and group D radiographic film[b] (sizes 2 and 4). Radiographs were developed manually or by use of an automatic processor.[c] Periodontal probing was performed with a standard periodontal probe.[d]

Occlusal and lateral views of the maxillary and mandibular canine teeth were obtained by intraoral positioning of the radiographic film. The views were obtained by use of a bisecting angle technique. Radiographs were taken by a veterinarian, dental hygienist, veterinary technician, or supervised fourth-year veterinary student.

The PD measurements (ie, distance between the free GM and bottom of the sulcus) were obtained by lightly grasping the periodontal probe. Measurements were obtained at 4 sites (mesial, buccal, distal, and lingual [or palatal]) on each canine tooth. Location of the GM (ie, distance between the free GM and CEJ) was recorded at the same 4 sites on each canine tooth. All measurements were obtained by 1 of the authors (AJT). Values were recorded to the nearest millimeter.

Clinical analysis—Values for CAL (recorded to the nearest millimeter) were calculated for the mesial, buccal, distal, and lingual (or palatal) surfaces of each canine tooth. Values were calculated by use of the respective PD and GM measurements and the following equation:

$$CAL = PD \pm GM$$

All calculations were performed by 1 of the authors (AJT).

Radiographic analysis—The AMH was evaluated at the mesial, buccal, distal, and palatal-lingual tooth surfaces for each canine tooth by use of radiographs (233 [116 maxillary and 117 mandibular] occlusal and 466 [232 maxillary and 234 mandibular] lateral radiographic views). The mesial and distal alveolar margins were evaluated on the lateral radiographic views, and the buccal and lingual (or palatal) alveolar margins were evaluated on the occlusal radiographic views **(Fig 1)**. Margin of the alveolar bone was determined as the point at which the periodontal ligament space ends on the root surface. The CEJ was identified as the junction between the enamel and root surface or, in places where the enamel was indistinct, as the apical-most aspect of the tooth bulge. Radiographic films were viewed on a dental radiographic film viewer,[e] and the AMH was measured directly on the radiographic films by using a transparent plastic ruler.[f] Additional magnification was not used to obtain these measurements. All measurements were obtained by 1 of the authors (AJT), and values were recorded to the nearest millimeter. For tooth surfaces on the occlusal view radiographs where the alveolar margin was interpreted to be coronal to the CEJ, the AMH for that surface was reported as a negative value **(Fig 2)**. The AMH was not measured on tooth surfaces for which the alveolar margin or CEJ was not identifiable. Reasons for unreadable reference points included radiographic artifact (overlap, crowding of teeth, and misalignment of the x-ray tube with the film), indistinct enamel or tooth bulge, crown fracture, abrasion, or attrition. Each radiograph was also evaluated for foreshortening and elongation of images; radiographs with severely foreshortened or elongated images were excluded from the study.

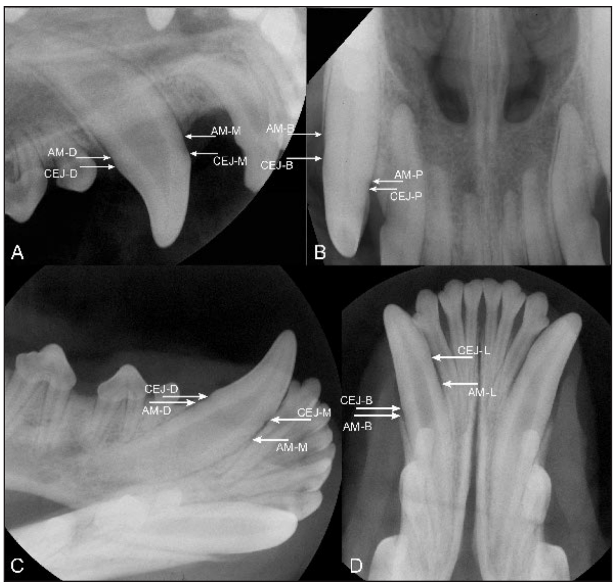

Figure 1—Right lateral maxillary (A), maxillary occlusal (B), mandibular (C), and mandibular occlusal (D) radiographic views of the canine teeth in a dog. Reference points for measurement of alveolar margin height are identified. AM–B = Alveolar margin–buccal surface. AM–D = Alveolar margin–distal surface. AM–L = Alveolar margin–lingual surface. AM–M = Alveolar margin–mesial surface. AM–P = Alveolar margin–palatal surface. CEJ–B = Cementoenamel junction–buccal surface. CEJ–D = Cementoenamel junction–distal surface. CEJ–L = Cementoenamel junction–lingual surface. CEJ–M = Cementoenamel junction–mesial surface. CEJ–P = Cementoenamel junction–palatal surface.

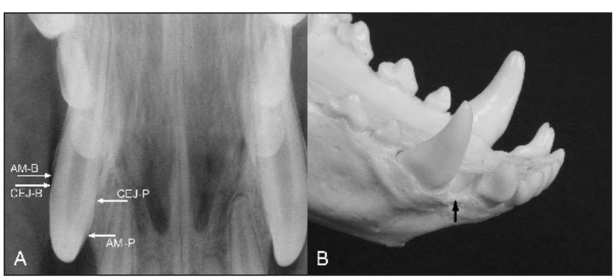

Figure 2—Panel A—Maxillary occlusal radiographic view of a dog in which the ridge in the interalveolar margin of the maxillary third incisor and canine tooth creates an artifact at the point where the AM–P of the right maxillary canine tooth is interpreted as coronal to the CEJ–P. Notice the normal relationship of the AM–B and CEJ–B on the same radiograph. Panel B—Photograph of the skull of a dog. Notice the ridge in the interalveolar margin (arrow) of the maxillary third incisor and canine tooth.

Statistical analysis—Linear regression and the Pearson product-moment **correlation coefficient (*r*)** were used to quantify the relationship between continuous dependent and independent variables. We used χ^2 tests of homogeneity to evaluate the joint distributions of categoric variables. Values of $P < 0.05$ were considered significant.

Results

Clinical measurements—The correlation between PD and CAL was examined on the basis of tooth surface and dental arch, and we determined that values for PD and CAL were correlated for all tooth surfaces. For the mandible, CAL and PD were significantly correlated for the mesial (r, 0.82; $P < 0.001$), buccal (r, 0.85; $P < 0.001$), distal (r, 0.91; $P < 0.001$), and lingual (r, 0.93; $P < 0.001$) surfaces. For the maxilla, CAL and PD were significantly correlated for the mesial (r, 0.83; $P < 0.001$), buccal (r, 0.62; $P < 0.001$), distal (r, 0.89; $P < 0.001$), and palatal (r, 0.94; $P < 0.001$) surfaces. The mean PD at each tooth surface consistently underestimated the respective mean CAL. For the mandible, mean values for CAL and PD were as follows: mesial, 3.21 and 3.11; buccal, 3.87 and 3.60; distal, 3.09 and 3.03; and lingual, 2.86 and 2.80, respectively. For the maxilla, mean values for CAL and PD were as follows: mesial, 3.18 and 3.02; buccal, 3.63 and 3.25; distal, 3.18 and 3.13; and palatal, 3.21 and 3.03, respectively. Values for PD were significantly less than values for CAL for clinically normal (PD $\leq$ 3) and pathologic (PD $\geq$ 4) conditions.

Radiographic measurements—The correlation between AMH and CAL was examined on the basis of tooth surface and dental arch, and values for AMH and CAL were correlated at all tooth surfaces except the palatal surface of the maxillary canine tooth on the maxillary occlusal view. For the mandible, values for

CAL and AHM were significantly correlated for the mesial (r, 0.27; $P < 0.001$), buccal (r, 0.35; $P < 0.001$), distal (r, 0.37; $P < 0.001$), and lingual (r, 0.26; $P = 0.013$) surfaces. For the maxilla, CAL and AMH were significantly correlated for the mesial (r, 0.39; $P < 0.001$), buccal (r, 0.33; $P < 0.001$), and distal (r, 0.42; $P < 0.001$) surfaces but not for the palatal surface (r, 0.056; $P = 0.42$).

The alveolar margin was measurable by use of the AMH measurement technique for 145 of 233 (62.2%) occlusal radiographic views and 450 of 466 (96.6%) lateral radiographic views.

Mean AMH for each tooth surface consistently underestimated the respective mean CAL. For the mandible, mean values for CAL and AMH were as follows: mesial, 3.17 and 2.62; buccal, 3.88 and 0.55; distal, 3.08 and 1.07; and lingual, 3.03 and –0.52, respectively. For the maxilla, mean values for CAL and AMH were as follows: mesial, 3.17 and 2.21; buccal, 3.62 and 0.89; distal, 3.18 and 1.09; and palatal, 3.25 and –1.27, respectively. Values for AMH were significantly less than values for CAL for clinically normal (AMH ≤ 3) and pathologic (AMH ≥ 4) conditions, except the palatal surface ($P = 0.33$) of the maxillary canine teeth on the maxillary occlusal radiographic view, mesial surface ($P = 0.13$) of the mandibular canine teeth on the lateral radiographic view, and buccal ($P = 0.20$) and lingual ($P = 0.08$) surfaces of the mandibular canine teeth on the mandibular occlusal radiographic view.

The AMH could not be measured for 158 of 466 (33.9%) canine teeth that were evaluated on the occlusal radiographic view and for 16 of 466 (3.4%) canine teeth on the lateral radiographic view. The teeth for which AMH could not be evaluated were separated on the basis of radiographic view, dental arch, and tooth surface. On the occlusal radiographic view, the teeth that could not be measured included 25 of 232 (10.8%) maxillary canine teeth and 133 of 234 (56.8%) mandibular canine teeth. On the basis of tooth surface, 11 of 232 (4.7%) maxillary canine teeth could not be measured at the buccal surface, and 18 of 232 (7.8%) could not be measured at the palatal surface. For the mandibular canine teeth on the occlusal radiographic view, 4 of 234 (1.7%) teeth could not be measured at the buccal surface, and 137 of 234 (58.6%) teeth could not be measured at the lingual surface. On the lateral radiographic view, teeth that could not be measured included 4 of 232 (1.7%) maxillary canine teeth and 12 of 234 (5.1%) mandibular canine teeth. Four of 232 (1.7%) maxillary canine teeth could not be measured at the mesial surface, and 1 (0.4%) maxillary canine tooth could not be measured at the distal surface. For the mandibular canine teeth on the lateral radiographic view, 11 of 234 (4.7%) teeth could not be measured at the mesial surface, and 2 of 234 (0.8%) teeth could not be measured at the distal surface.

On the occlusal radiographic view, AMH could not be measured because of crowding (26/170; 15.3%) or overlap (121/170; 71.2%) between the canine teeth and the third incisors, misalignment of the x-ray tube with the film (11/170; 6.5%), abrasion or attrition (3/170; 1.8%), crown fracture (2/170; 1.2%), and an unidentifiable alveolar margin (3/170; 1.8%) or CEJ (4/170; 2.4%). Overlap (118/147; 80.3%) and crowding (15/147; 10.2%) between the canine teeth and the third incisors were a feature of 133 of 147 (90.5%) surfaces that could not be measured on the mandibular occlusal radiographic view and prevented measurement of AMH at the lingual surface of the mandibular canine teeth in 69 of 117 (59.0%) mandibular occlusal radiographic views that were evaluated. In comparison, 14 of 170 (8.2%) of the surfaces that could not be measured on the maxillary occlusal radiographic view were the result of overlap (3/170; 1.8%) and crowding (11/170; 6.5%).

The AMH could be measured for 207 canine teeth on 103 of 116 (88.8%) maxillary occlusal radiographs, but it could not be measured for 25 canine teeth on 13 of 116 (11.2%) maxillary occlusal radiographs. For the mandibular occlusal radiographic view, AMH could be measured for 101 canine teeth on 48 of 117 (41.0%) occlusal radiographs, but it could not be measured for 133 canine teeth on 79 of 117 (67.5%) occlusal radiographs. The ability to measure AMH differed significantly between maxillary and mandibular occlusal radiographic views.

Negative values were obtained for AMH measurements on 124 of 233 (53.2%) of the occlusal radiographs in which the CEJ was identified as apical to the alveolar margin (90/116 [77.6%] of the maxillary occlusal radiographs and 34/117 [29.1%] of the mandibular occlusal radiographs). Values for maxillary and mandibular occlusal radiographic views differed significantly.

The association between negative values for AMH on the occlusal radiographs and radiographic artifacts (foreshortening or elongation) was examined. Foreshortening or elongation artifacts were evident in 17 of 116 (14.7%) maxillary occlusal radiographs and 6 of 116 (5.2%) mandibular occlusal radiographs. Eleven of 116 (9.5%) maxillary occlusal radiographs had foreshortened or elongated images and negative values for AMH, whereas 6 of 116 (5.2%) maxillary occlusal radiographs had foreshortened or elongated images and positive values for AMH. Seventy-nine of 116 (68.1%) maxillary occlusal radiographs did not have foreshortened or elongated images but had negative values for AMH, and 20 of 116 (17.2%) maxillary occlusal radiographs did not have foreshortened or elongated images and had positive values for AMH. The proportion of maxillary occlusal radiographic views with foreshortened or elongated images and negative or positive values for AMH did not differ significantly ($P = 0.21$). None of the 117 mandibular occlusal radiographic views had foreshortened or elongated images and negative values for AMH, and 6 of 117 (5.1%) mandibular occlusal radiographic views had foreshortened or elongated images and positive values for AMH. Thirty-four of 117 (29.1%) mandibular occlusal radiographic views did not have foreshortened or elongated images but had negative values for AMH, and 77 of 117 (65.8%) mandibular occlusal radiographic views did not have foreshortened or elongated images and had positive values for AMH. The proportion of mandibular occlusal radiographic views with foreshortened or elongated images and negative or positive values for AMH did not differ significantly ($P = 0.18$).

Artifacts attributable to overlap of teeth precluded the measurement of mesial AMH in 3 of 234 (1.3%) mandibular lateral radiographic views, whereas 3 of 18 (16.7%) of the tooth surfaces could not be measured on the lateral radiographic views. Crowding did not prevent AMH assessment on the lateral radiographic view. Of the 18 surfaces that could not be measured, 13 (72.2%) were attributable to dental pathologic changes, 6 (33.3%) were attributable to crown fracture, and 7 (38.9%) were attributable to abrasion or attrition. The inability to identify the CEJ as a measurement point accounted for 2 of 18 (11.1%) tooth surfaces that could not be measured on lateral radiographic views.

For the 232 maxillary lateral radiographs, AMH could be measured in 228 (98.3%) and could not be measured in 4 (1.7%). For the 234 mandibular lateral views, AMH could be measured in 222 (94.9%) and could not be measured in 12 (5.1%). The ability to measure AMH did not differ significantly ($P = 0.072$) between maxillary and mandibular lateral radiographic views.

Discussion

Surgical exposure of the alveolar margin with direct measurement of AMH is the most accurate method for assessing existing periodontal osseous destruction, but it is an invasive technique that is not practical for routine use.[28] Probing depth and CAL are examples of noninvasive measurement techniques that approximate the amount of periodontal attachment. Of the 2 measurement techniques, PD is the most commonly used by dentists and veterinary practitioners. In human patients, PD correlates well with CAL and is an acceptable technique for monitoring periodontal attachment.[29] When establishing the amount of destructive periodontitis that has occurred in a population of people in cross-sectional or longitudinal studies, PD measurements may result in a major underestimation (one sixth of actual values) of severe lesions.[30,31] Probing depth also uses the GM as a reference point and may not reflect an actual loss in attachment when there is hyperplasia or recession of the GM. Assessment of CAL is a more appropriate measurement technique for use in epidemiologic studies in humans, and it more closely corresponds to surgical measurements of AMH.[32,33]

Analysis of results of the study reported here suggests that a similar good correlation exists between PD and CAL in dogs; when loss of attachment is detected with PD, loss of attachment will also be detectable with CAL. Probing depth was also found to underestimate CAL at all tooth surfaces. This underestimation is likely to be clinically important when identifying pockets that require surgical periodontal treatment. For example, although closed root planing with a periodontal curette may be sufficient for the treatment of pockets up to 5 mm, a surgical flap would be necessary to gain access to pockets > 5 mm.[34]

In humans, measurement of AMH reportedly has a good radiologic correlation with clinical measurements obtained with a periodontal probe, and it has significantly better reproducibility and readability in comparison to other techniques.[35] The buccal and lingual (or palatal) AMH (62.2% of the occlusal radiographic views) and mesial and distal AMH (96.6% of the lateral radiographic views) could be measured by use of this radiographic technique in dogs; however, only AMH measurements at the mesial, buccal, distal, and lingual aspects of the canine teeth were found to correlate with their respective CAL measurements. Because of the poor correlation between AMH and CAL at the palatal aspect of the canine teeth on the maxillary occlusal radiographic view, periodontal probing measurement may be a more appropriate method for assessing palatal attachment. The poor correlation at this surface appears to be related to a radiographic artifact created by the ridge in the interalveolar margin between the maxillary canine teeth and the third incisors. The radiographic superimposition of the ridge over the palatal alveolar margin artifactually projects the alveolar margin in a more mesiopalatal location on the tooth surface.

Dental radiographs are useful for documenting alveolar bone destruction and monitoring the progression of bone loss associated with periodontitis, but it is not useful in the assessment of active disease. Multiple longitudinal studies[36-38] in humans have provided information on the clinical loss of attachment preceding radiographic detection of bone loss, especially in the early stages of periodontitis. In the study reported here, similar results were elucidated, and mean AMH measurements were found to consistently underestimate attachment, compared with mean CAL values. Because the radiographic measurement of AMH consistently underestimates the amount of attachment, compared with CAL values, the clinical value of interpreting AMH measurements in combination with periodontal probing measurements for assessing the periodontal attachment of the canine teeth is high. Underestimation of attachment by the measurement of palatal AMH on the maxillary occlusal radiographic view did not differ significantly and can be explained by the poor correlation between palatal AMH and palatal CAL.

The AMH could not be measured for 33.9% of the canine teeth evaluated on the occlusal radiographic view. Misalignment of the x-ray tube with the film that excluded the CEJ or the alveolar margin from the radiographic view accounted for a small percentage (6.5%) of the tooth surfaces that could not be measured, and the tooth surfaces that could not be measured were the result of artifacts inherent to the occlusal radiographic view (86.5%), overlap (71.2%), and crowding (15.3%). Overlap and crowding between the canine teeth and the third incisors were more common on the mandibular occlusal radiographic view and prevented measurement of AMH for the lingual surface of the mandibular canine teeth in 59.0% of the mandibular occlusal radiographic views that were evaluated, which resulted in a significant difference in the ability to measure AMH between maxillary and mandibular occlusal radiographic views. In comparison, the AMH for the palatal aspect of the maxillary canine teeth could not be measured in only 11.2% of the maxillary occlusal radiographs. Despite the relative ability to measure palatal AMH on the maxillary occlusal radiographic view, compared with the lingual AMH on the mandibular occlusal radiographic view, the clinical value of palatal AMH measurement is low because of its poor correlation with CAL. Therefore, although the maxillary occlusal radiographic view is more adaptable than the mandibular occlusal radiographic view for measurement of AMH, only the measurement of buccal AMH is potentially of clinical value on the maxillary occlusal radiographic view.

The CEJ of the canine teeth was identified apical to the alveolar margin in slightly more than half (53.2%) of the occlusal radiographs that were evaluated; this represented a radiographic appearance consistent with erupting or incompletely erupted teeth, but only fully erupted teeth were detected in the dogs of our study. This inverse relationship yielded negative values for AMH that were of questionable clinical value for fully erupted teeth. Foreshortening and elongation artifacts are commonly found on bisecting angle technique radiographs and can adversely influence the measurement of AMH. However, in the study reported here, a significant association between negative values for AMH and foreshortening and elongation of images on radiographs was not identified.

It is commonly accepted that it is more difficult to obtain intraoral radiographs in dogs with brachycephalic skulls.[23] Brachycephalic dogs comprised only 2 of 117 dogs in the study reported here and were not considered to comprise a substantial proportion of the study population. The difficulty in obtaining intraoral radiographs in brachycephalic dogs is perhaps most applicable to the maxillary premolars and molars and less of a concern when obtaining radiographs of the canine teeth because of their rostral location in the mouth and lack of the zygomatic arch.

Compared with assessment of AMH on the occlusal radiographic view, the assessment of AMH on the lateral radiographic view was possible in most lateral radiographs that were evaluated, and overlap artifacts that were prominent on the occlusal radiographic view precluded the measurement of mesial AMH on only 1.3% of the mandibular lateral radiographic views. Crowding did not prevent AMH assessment on the lateral radiographic view, and most (72.2%) of the tooth surfaces that could not be measured on the lateral radiographic view were related to dental pathologic conditions, complicated crown fracture, abrasion, or attrition, which prevented identification of 1 or both of the landmarks used to assess AMH. In comparison to the occlusal view in which there was a significant difference between the maxilla and mandible in terms of the ability to measure AMH, a significant difference did not exist in the ability to measure AMH on the maxillary and mandibular lateral radiographic views. Therefore, lateral radiographic views of the maxillary and mandibular canine teeth are equally suitable for the measurement of mesial and distal AMH.

[a]Heliodent MD, Siemens, München, Germany.
[b]Kodak Ultra-speed, Kodak, Rochester, NY.
[c]PeriPro II, Air Techniques Inc, Hicksville, NY.
[d]CP12, Hu-Friedy Manufacturing Inc, Chicago, Ill.
[e]67-0400, Rinn Corp, Elgin, Ill.
[f]L16, Helix USA, Medford, NY.

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