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Comparison of Dentoalveolar Bony Defects Measurements by Dental Radiography and Computed Tomography in Companion Animals

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ABSTRACT

Background: Dental disorders are commonly encountered in companion animals and diagnosed with dental radiography (DTR) and computed tomography (CT). No study has been reported previously that compares dental measurements from DTR and CT in companion animals with periodontitis-related bone loss. The purpose was to compare the DTR and CT of bony defects in cats and dogs with dental disease.

Methods: This is a retrospective study and the records of Jeonbuk Animal Medical Center were reviewed between June 2019 and October 2020. All patients underwent both modalities. In DTR, *bisecting* angle *technique* was used. In CT, slice thickness was applied at either 0.5 mm or 1.0 mm depending on the size of the patients. Bony defects of dentoalveolar structures were measured.

Result: Eight dogs and eight cats with dental disease were included. All measurements in both cats and dogs were smaller in DTR than in CT. Additionally, CT with thin slice thickness provided more sufficient and accurate information for dental diagnosis. Conclusively, CT examination for dental disease showed to be superior in the assessment of periodontitis-related bone lesions by obtaining precise images without distortion and overlap and can possibly substitute DTR in cats and small dogs.

Key words: Bony defects, Computed tomography, Dental radiography, Endodontic disease, Periodontitis.

INTRODUCTION

Dental disease such as periodontitis, endodontic disease and tooth resorption is common in cats and dogs. Dental disease can be associated with discomfort, pain to the patient and lead to structural changes such as widening of the periodontal ligament space, vertical and horizontal alveolar bone loss and tooth loss. If not treated properly, dental disease may even lead to systemic diseases such as renal, hepatic and cardiac disorders (Logan *et al*. 2002; Pavlica *et al*. 2008; Glickman, 2009).

Dental radiography (DTR) has traditionally been the imaging modality of choice used to diagnose dental disease (Tsugawa and Verstraete, 2000). However, DTR has several limits such as distortion and overlay of teeth and periodontal structures that result in insufficient diagnostic information which could prove difficult in prognostic assessment based on bony defects. One common limiting complication is the superimposition of the roots in three-rooted teeth and small sized dogs with crowded teeth (Hirschmann, 1987; Misch *et al*. 2006; Korostoff *et al*. 2016). Furthermore, one study concluded that measurements of bone loss in DTR can be underestimated up to 1.5 mm compared with surgical measurements for humans (Eickholz and Hausmann, 2000).

Some of these limitations can be overcome with clinical computed tomography (CT). CT provides cross-sectional images without distortion and overlay and even multiplanar reconstructions and three-dimensional images with across angles. In CT images, lesions at all locations including the buccal and lingual sides can be easily detected, whereas there are limitations to these in DTR (Fuhrmann *et al*. 1995; Misch *et al*. 2006). Also, skull structures such as the nasal cavity and the temporomandibular joint, which are often affected in severe dental disorders, can be easily visualized on CT. There have been several studies subjectively comparing DTR with CT for image quality and CT was found to provide superior quality diagnostic images (Iikubo *et al*. 2009; Campbell *et al*. 2016; Lee *et al*. 2020).

Since DTR and CT has been previously compared in normal dentition of dogs and cats (Lee, 2020), it would provide value if a similar comparison of DTR and CT measurements would be conducted in diseased dentition (dental lesions with bony defects). The aim of this study is to measure the bony defects associated with dental disease and compare these measurements bony defects associated with dental diseases by using DTR and CT for cats and small

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sized dogs. The authors hypothesized that measurements in DTR would be significantly different from those in CT due to distortion and overlap.

MATERIALS AND METHODS

This is a retrospective study with ethics approval from the Animal Care and Use Committee at Jeonbuk National University (JBNU 2019-053). The records from Jeonbuk Animal Medical Center in Republic of Korea were reviewed between June 2018 and October 2019. All animals were client-owned and was presented with oral discomfort such as dysmasesis, salivation and redness of gingiva.

Animals included were those with confirmed diagnosis of dental disease such as periodontitis, endodontic disease, tooth resorption and skull fracture. These were based on clinical signs, oral examination, DTR and CT. Animals were excluded if they had undergone only DTR or CT.

Eight dogs and eight cats met the inclusion criteria for the study. Dog breeds included Poodle (n=3), Maltese (n=2), Beagle (n=2) and Miniature pinscher (n=1). Cat breeds included domestic short hair (n=4), Persian (n=2), Siamese (n=1) and American short hair (n=1). The mean age of the dogs was 7.43 years (range of 1 to 13 years) and the mean for cats was 4.75 years (range of 1 to 9 years). The mean body weight of dogs was 5.3 kg (range of 2.7 kg to 11.6 kg) and the mean weight of the cats was 3.82 kg (range of 2.65 kg to 5.58 kg).

In dogs, a total of 50 teeth were reviewed and included diagnoses of periodontitis (n =45), endodontic disease (n=3), tooth resorption (n=1) and mandibular fracture (n=2). In cats, a total of 25 teeth were reviewed including those diagnosed with periodontitis (n=20), endodontic disease (n=2), tooth resorption (n=3) and maxillary fracture (n=1).

All animals were sedated with medetomidine hydrochloride (40 µg/kg, IV, Domitor; Orion Pharma, Finland) and tiletamine-zolazepam (5 mg/kg, IV, Zoletile; Virbac, France) for DTR and CT.

To avoid alteration and variation of the images, bisecting technique for DTR and consistent scan technique for CT were used.

DTR images were obtained using a dental x-ray (AnyRaya□, Vatech Korea, Hwaseong-si, Korea). The exposure setting was 2 mA at 60 kVp for 0.03 sec to 0.08 sec, slightly adjusted according to the image quality. The standard bisecting angle technique was used in order to obtain an image with minimal distorstion and the most precise measurements of the tooth as much as possible. CT images were obtained using a 16-row multidetector CT scanner (Alexion, TSX-034A, Toshiba Medical System, Tochigi, Japan). The exposure setting was 120 kVp, 150 mAs, 0.688 pitch, 0.75 rotation time, 1 recon overlap and bone high resolution Kernel frequency (FC 81). Slice thickness was adjusted 0.5 mm (CT 0.5) or 1.0 mm (CT 1.0) depending on the size of the patients. The images were multiplanar reconstructed using a bone algorithm.

All images were transferred to the picture-archiving and communication system (PACS) and measurements were conducted using a PACS viewer (INFINIT; Infinitt Healthcare, Seoul, Korea). Measurements were performed blindly by one observer. The measurements of the CT images were performed at the bone window (WL: 500, WW: 4000) and the bone density of the images was adjusted to optimize assessment.

The measurements obtained for each defect were (Fig 1): 1) the length from cemento-enamel junction (CEJ) to the apex of the alveolar bone defect in teeth with periodontitis (A); 2) pulp-cavity tooth width ratio (P/T ratio) in teeth with endodontic disease (B/C); 3) the length from cemento-enamel junction to apex of lysis lesion of teeth (D); 4) width of fracture gap in patient with mandibular fracture (Misch *et al*. 2006; Park *et al*. 2014).

For statistical analysis, SPSS software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, USA) was used. For analysis of bony defects, a paired t-test was used for the difference between the two methods, DTR and CT 0.5 and DTR and CT 1.0 Additionally, repeated measured ANOVA was used for measurements of bony defects according to three measurement methods: DTR, CT 0.5 and CT 1.0.

RESULTS AND DISCUSSION

Twenty-nine teeth of one dog were imaged with DTR and CT 0.5; 43 teeth of 4 dogs were imaged with DTR and CT 1.0. Nineteen teeth of 2 dogs and one mandibular fracture of 1 dog were imaged with DTR and both slice thicknesses in CT. Of the 8 cats, all lesions including 24 teeth and one maxillary fracture were imaged with DTR and CT 1.0. All the lesions were measured using DTR and CT (Fig 2).

The mean measurements of bony defects for the 29 teeth of one dog, obtained with DTR and CT 0.5, were 5.50±2.80 for DTR and 6.11±2.83 for CT 0.5. For the 43 teeth

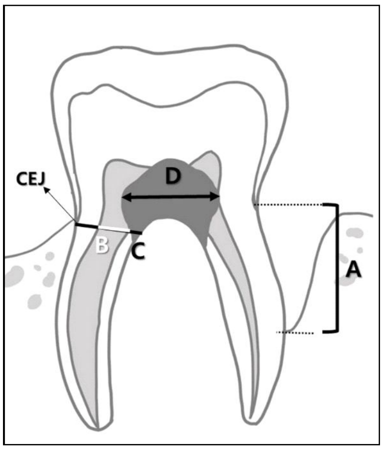

Fig 1: The standard measurements in patients with dental disease. Height of surrounding alveolar bone defects (A) measured from CEJ to apex of defect. Measurements of P/T ratio (B/C) were performed at the level of CEJ of the tooth and the length from cemento-enamel junction to apex of lysis lesion of teeth (D) was measured.

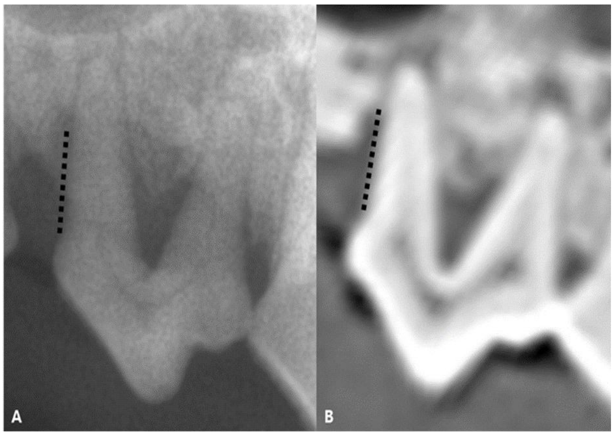

Fig 2: Image of the third premolar in a 4-year-old Beagle. Alveolar bone loss associated with periodontitis can be seen in both DTR (A) and CT 0.5 (B). The height of the bony defect (dotted line) was measured from CEJ to apex of the defect (unit of measure; mm).

between the 4 dogs, the mean measurements were 3.78±2.32 in DTR and 4.63±2.75 for CT 1.0. For the 25 teeth images obtained from 8 cats, the mean measurements were 2.43±1.32 for DTR and 3.04±1.51 for CT 1.0 (Table 1).

In both dogs and cats, bony defects in DTR measured smaller than CT 0.5 and CT 1.0 with differences up to 4 mm (Fig 3). All analysis exhibited statistically significant differences at a level of 5% (P<0.01).

The 20 teeth that had undergone all three modalities measured the smallest, which was 4.78±2.72 for DTR, followed by 5.40±2.88 for CT 0.5 and 5.43±2.94 for CT 1.0. As a result of the post test, a subgroup could not be divided, but there was a statistically significant difference (P<0.05).

Since the number of teeth with lesions in each item is small, it is not enough to produce statistically significant results, so the detailed results of statistical processing are presented by grouping the cases of all items into one.

Additionally, there were lesions not visible on the DTR but only detected by the CT study. Examples include right temporomandibular subluxation in one dog with a fracture in the ipsilateral mandibular bone. Also, in one cat, a nasopharyngeal polyp and a lymphadenomegaly were detected.

In this study, the bony defects of the tooth structure in DTR and CT were measured and the feasibility of CT for dental diagnosis was evaluated. The author hypothesized that the measurement values in DTR would be different to those of CT. Periodontitis was the most commonly affected dental disease present in this study. With periodontitis, teeth and periodontal structures progressively get destroyed, leading to a widening of the peri-ligament space due to alveolar bone loss, osteomyelitis and can ultimately result in tooth loss (Campbell *et al*. 2016). In this study, the bony defect created by the periodontitis has been well demonstrated by both imaging modalities. However, as previously mentioned, these measurements differed significantly between CT and DTR which is a consistent finding with the hypothesis (Fig 3).

Endodontic disease was the second most prevalent disease in this study. Radiographically, the roots showed a widening of the pulp cavity compared with adjacent teeth. Measurements of bony defects in DTR were smaller than CT 0.5 and CT 1.0 in all animals. These results are consistent

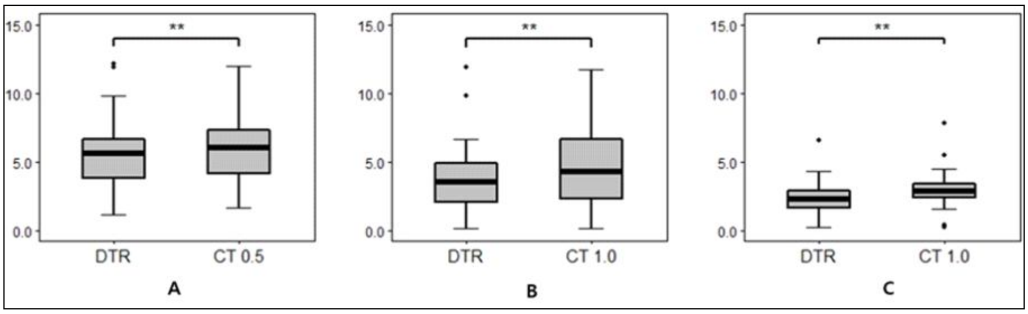

Fig 3: Difference of bony defects according to measurement method of dogs (A and B) and cats (C). In dogs, bony defects measured smaller in DTR than both CT 0.5 (A) and CT 1.0 (B). Also, measurements in DTR were smaller in DTR than CT 1.0 in cats.

Table 1: Difference of bony defects according to tooth measurement methods in dogs and cats.

Species	N	M±SD			p
		DTR	CT 0.5	CT 1.0	
Dog	29	5.50±2.80	6.11±2.83	-	0.004
	43	3.78±2.32	-	4.63±2.75	< 0.001
	20	4.78±2.72	5.40±2.88	5.43±2.94	0.029
Cat	25	2.43±1.32	-	3.04±1.51	< 0.001

All measurments are statistically significant with p<0.001. DTR; Dental Radiography, CT 0.5; CT with 0.5 mm slice thickness, CT 1.0; CT with 1.0 mm slice thickness.

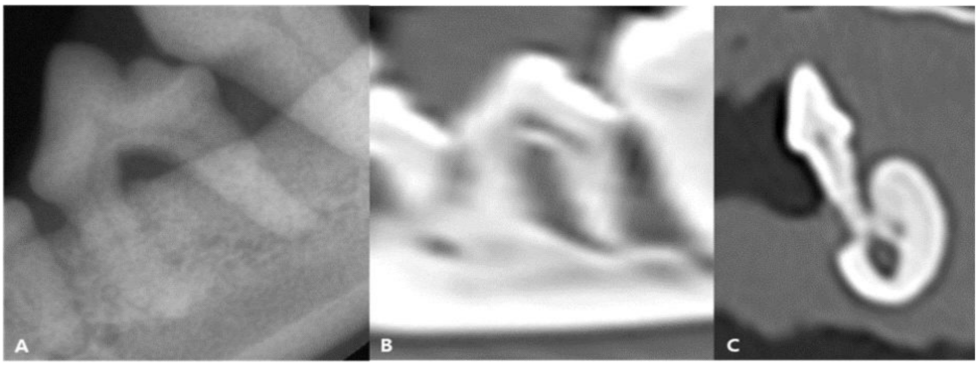

Fig 4: Image of third premolar in a 13-year-old Maltese. Horizontal alveolar bone loss was detected in DTR but vertical bone loss could be underestimated in this image (A). However, severe alveolar bone loss is remarkable in buccal aspect in sagittal (B) and transverse (C) CT MPR (multiplanar reconstruction) images.

with our hypothesis and lesions could be underestimated as seen in a previous study (Eickholz and Hausmann, 2000; Lee *et al*. 2020). CT provides cross sectional images and multiplanar reconstructed images, allowing the selection of images that best represents the defect. These allow for the assessment of oral disease not only in interproximal lesions, but also in evaluating all aspects of oral disease, including lingual and buccal aspects.

Although DTR does provide high resolution two-dimensional images that are useful for viewing entire structures, they can often be difficult to evaluate due to the overlapping adjacent skull and dental structures. Particularly in the case of maxillary teeth, it is difficult to approach the sensor at a constant angle due to the hard palate and more likely to be misread than mandibular teeth because of superimposition with skull structures such as the zygomatic arch (Roy, 2018).

In most cases, the difference between the modalities was about 1 mm, but in one lesion the difference was measured up to 4 mm. In this case, alveolar bone loss of the surrounding teeth with periodontitis was biased toward the buccal side (Fig 4). Only horizontal bone loss was observed in DTR due to the overlapping of the lingual side with relatively less bone loss. Yet, defects on the buccal side were observed in transverse and sagittal CT multiplanar reconstructed images, enabling accurate measurement of the lesion. This problem was thought to occur in early stages of dental diseases. Bone loss in these early stages is minimal and there is overlap with surrounding intact dental structures. In turn, the lesion can be misdiagnosed as normal in DTR. However, in the case described above, lesions can be detected in CT images, which are difficult to detect in DTR, due to the multiplanar reconstructed image with various directions. Additionally, the inherent feature of CT study, the CT images of jaws enable us to detect easily bone lesions including maxillary and mandibular fracture as in this study. Difference between the DTR and CT measurements in a cat group is less than a dog group. The different measurement result between cats and dogs may originate from the inherent body conformation. This means that a group of cats with a constant weight has a relatively small difference in measurement compared to a group of dogs with a large difference in weight (2.7 kg to 11.6 kg in this study).

The radiation exposure and cost of CT study is higher than DTR generally. However, depiction of whole arcade of jaws and teeth with the skull lesions by a single CT scanning can lead clinician to a more precise diagnosis and effective treatment for patients and owners consequently.

The limitation of this study is that there was no gold-standard reference that corresponded to the actual value of lesions. All animals included in this study were client owned patients and performing surgical measurements or autopsies were realistically difficult. However, CT images obtained with thin slice thickness have excellent spatial resolution for examining small structures and provide images without overlap. Therefore, it was considered that CT images may provide measurements quite close to a gold-standard reference. Further studies comparing actual measurements through autopsy and clinical measurements can be pursued in cats and dogs.

CONCLUSION

CT is superior in the evaluation of periodontitis-related bone loss by obtaining precise images without distortion and overlap and can possibly replace DTR clinically. In applying CT to patients with oral disorders, setting the slice thickness to 0.5 mm is recommended because dental structures are small and crowded especially in cats and small-sized dogs. In DTR, measurements of bony defects were smaller than those of CT and this suggest that lesions tend to be underestimated in DTR especially in terms of the buccal and lingual elements.

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