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Feasibility of dental panoramic radiography for dental arch evaluation in small animals

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ABSTRACT: The purpose of this study was to evaluate the feasibility of dental panoramic radiography for dental arch evaluation in small animals. The dental arches of four Beagles, one Shih Tzu dog, and three Korean short-haired cats were radiographed using human panoramic X-rays. All animals were under general anaesthesia during the examination. The animals' heads were placed horizontal to the panoramic device, just as a human's head is placed in panoramic dental assessments. All animals were evaluated with an open and closed mouth view (human view). In the closed mouth view, the animal was provided a bite blocker for proper placement of the oral cavity. The open mouth view angle was approximately 30–45°. The maxilla and mandible were held in position with radiolucent 3M tape. The standard scoring measurement was performed based on visibility of the tooth root and the sharpness of the dento-alveolar margin. No significant differences in scoring were noticed between the two positions. The visibility of teeth roots in Beagles was far better than that in the Shih Tzu dogs and two Korean short-haired cats. In addition, the Beagle series showed sharp dento-alveolar margin scores. These results suggest that human panoramic dental X-rays represent a possible dental evaluation tool for animals with large skulls.

Keywords: dog; panoramic X-ray; dental radiograph; large skull

Evaluation of dental condition is of great importance because teeth are highly resistant to mechanical, chemical, environmental or physical trauma (Park et al. 2014). In veterinary dentistry, the diagnostic ability of animal dental abnormalities has been substantially improved. Although panoramic dental radiography can be utilised in the small animal dental field to improve imaging and diagnostic quality, it is, at present, only applied in human dental medicine. In addition, since there are few studies related to the whole dental arch, it is difficult to assess abnormalities associated with the whole dental structure in animals. Thorough and precise dental arch evaluation can be achieved using simple and non-invasive panoramic radiographic assessments (Rushton and Horner 1996). Many studies have been published regarding human dental panoramic radiography (Rushton et al. 1999; Masunaga et al. 2016). The purpose of this study was to determine the potential role of panoramic dental radiographic devices in veterinary medicine with the aim of improving imaging quality and of evaluating the dental arch using panoramic X-rays in small animals. Moreover, since there is variability in the size of canine heads, it is assumed that there could be difference in imaging quality based on breed. Hence, it is hypothesised that the image quality of larger skulled animals is better than that of smaller skulled animals. Since it is presumed that the closed mouth position could result in overlapping teeth on X-ray, each animal was evaluated with open and closed mouth views. Therefore, an additional hypothesis is that open mouth radiographs have better quality than those of the closed mouth position.

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MATERIAL AND METHODS

All dental radiographic images were generated with a panoramic dental X-ray unit (Vatec Pax-300). All dogs had X-ray settings of 60 kVp and 4 mA. For the first part of the experiment, a head of a skeletally mature Beagle dog was used. For the second part, the heads of a skeletally mature Shih Tzu dog and two Korean short-haired (KSH) cats were used. The cephalic index (the widest interzygomatic distance multiplied by 100 and then divided by the distance between inion and prosthion) and the rostrocaudal length of the dental arch (mesial margin of 401 to caudal margin of 411) were measured on the head radiographs to ensure similar skull and dental anatomy for all specimens (Fishberg 1902; Barrett et al. 1984). A full dental examination was performed for all animals and inspected for number of permanent teeth and macroscopic dental or oral abnormalities. In this study, dental panoramic radiographs from four Beagle dogs, one Shih Tzu dog, and three KSH cats were obtained. All animals were anaesthetised with tiletamine-zolazepam (5 mg/kg, *i.m.*, Zoletil; Virbac, France). Half of the induction dose of tiletamine-zolazepam was additionally administered when the animals appeared to be recovering from anaesthesia. The animals were positioned in a sternal recumbent position for panoramic dental radiography. The animals' heads were placed horizontal to the panoramic device, just as a human's head is placed in panoramic dental assessments. This study used both open and closed mouth views. The closed mouth view was performed first while the animal's head was positioned horizontal to the panoramic device, referred to as 'human position' in the present study. After the closed mouth assessment, the maxilla and mandible were securely separated with radiolucent 3M tape in order to maintain an approximately 30–45° angle (Figure 1). This position was necessary because the canine dental arch overlapped in the closed mouth view. The right mandibular first molar (409) has diagnostic value due to the fact that it is large enough to be seen, is larger than the maxillary first molar (Debowes and Dupont 2009) and fourth premolar, is mainly used for grinding (Perrone 2013), and is associated with many diseases. Hence, in this study we mainly evaluated the radiography of the right mandibular first molar (409). The tooth root and dento-alveolar margin were objectively evaluated using the following scoring method (Figure 2; Esmans et al. 2014): dental roots were scored as not visible (score 0), partially visible (score 1), or completely visible (score 2), and the sharpness of the dento-alveolar margin was scored as blurry (score 0), sharp (score 1), or very sharp (score 2; Figure 3). When analysing the scoring of the dental arch, the investigators were blinded to the breed of the animals.

RESULTS

Panoramic radiographs from four Beagles, one Shih Tzu dog, and three KSH cats were successfully obtained. The field of view of human panoramic dental radiography is wider than that of these animals (Figure 4). The area of human dental radiographs contains not only the whole dental arch, but also the temporomandibular joint with its surrounding soft tissue and the anterior cervical spine. However, animal panoramic dental radiographs are limited in evaluating these structures. The results from the brachycephalic breed, the Shih Tzu, revealed a wider field of view than that of the mesaticephalic breed, the Beagle. All animals except for the Beagles were considered to have a small skull size. Oral inspection revealed a complete set of 42 permanent teeth with 68 roots in every dog and 30 permanent teeth in the KSH cats, with no evidence of oral, periodontal, or dental diseases or anomalies (Evans and Miller 2013). There were no significant differences between the open and

Figure1. (**A**) Animals were placed in ventral recumbency and were positioned in (**B**) closed mouth view and (**C**) open mouth view

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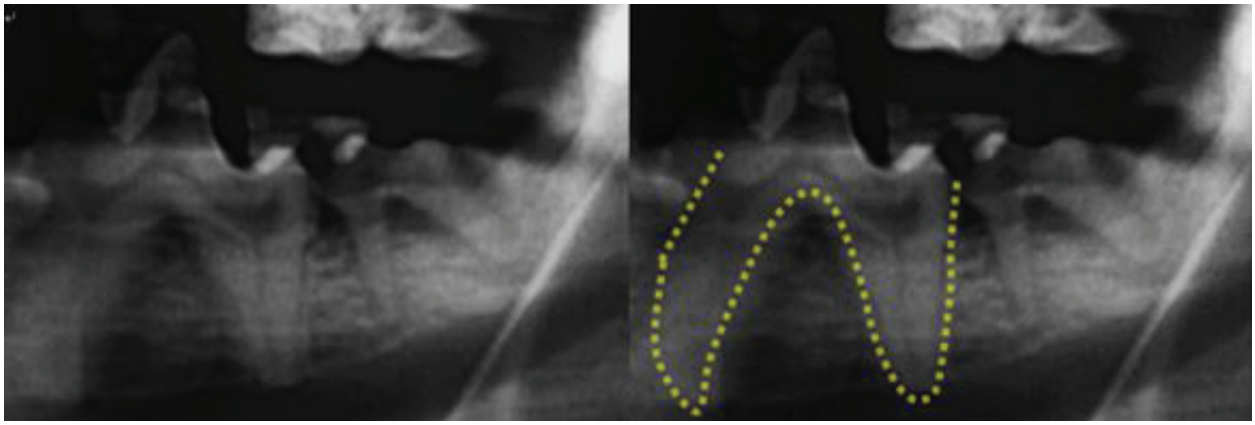

Figure 2. Radiographic images of the right mandibular first molar (409). Marked dento-alveolar margins and tooth roots were associated with animal breed (yellow line)

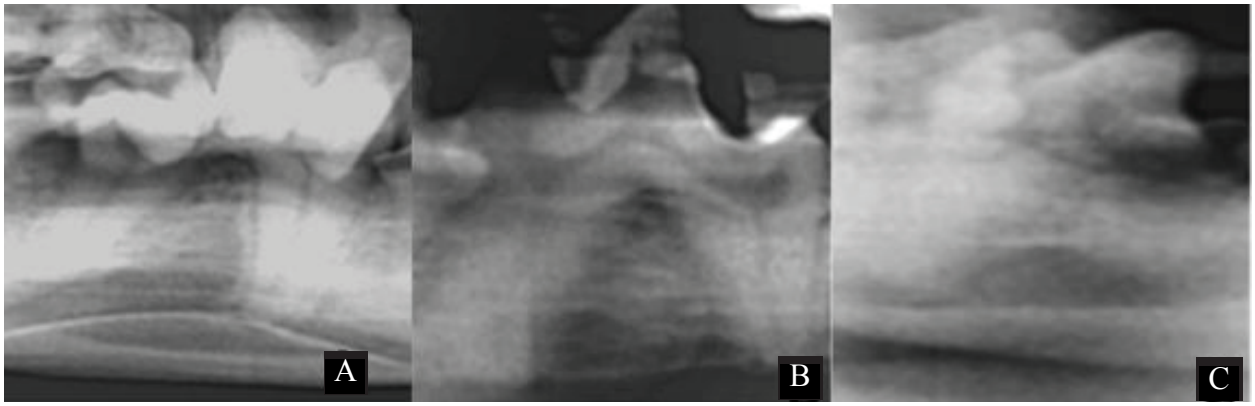

Figure 3. Panoramic dental radiographs of the right mandibular first molar (409) for objective scoring: (**A**) The dento-alveolar margin is very sharp (score 2), and the dental root is completely visible (score 2); (**B**) The dento-alveolar margin is partially visible (score 1), and the dental root is partially visible (score 1); (**C**) The dento-alveolar margin is not visible (score 0), and the dental root is not visible (score 0)

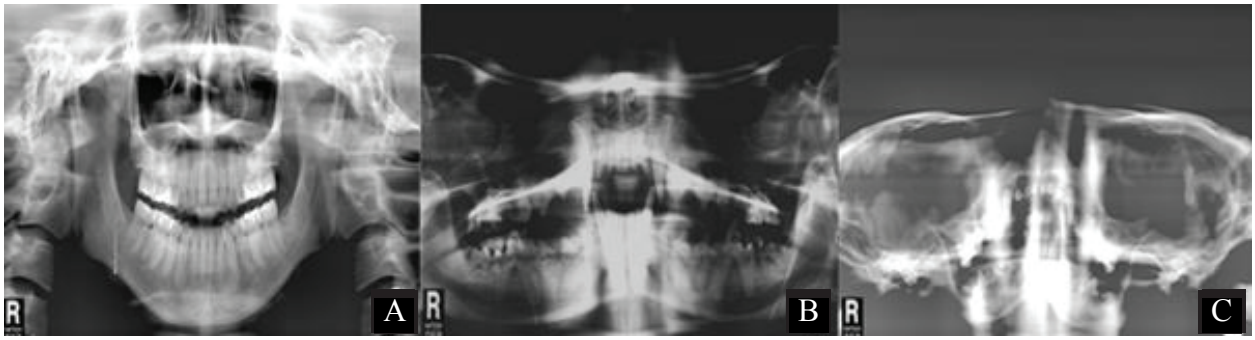

Figure 4. (**A**) The human panoramic dental radiograph had a wider field of view than (**B**) the Beagle dog's panoramic dental radiograph and (**C**) the Shih tzu dog's radiograph. The brachycephalic breed field of view is wider than that in (**B**)

closed mouth positions. The closed mouth dental radiographs were used for scoring. Scoring results of tooth root visibility and dento-alveolar margin sharpness are summarised in Tables 1–3. Table 1 shows the total scores of the Beagle group. Table 2 shows the total scores of the KSH cat group. The visibility of all teeth roots was far better in the Beagle dogs than in the Shih Tzu dog and the KSH cats. Also, the Beagle series showed sharp dento-alveolar margin scores. There were no significant differences between the Shih Tzu dog and the KSH cats (Table 3).

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Table 1. Dental root visibility and dento-alveolar margin sharpness scores for Beagles (n = 4)

	Dento-alveolar sharpness margin score	Tooth root visibility score	Total score
Beagle 1	2	2	4
Beagle 2	1	1	2
Beagle 3	1	1	2
Beagle 4	1	1	2
Mean value	1.25	1.25	2.5

Table 2. Dental root visibility and dento-alveolar margin sharpness scores for Korean short-haired (KSH) cats (n = 3)

	Dento-alveolar sharpness margin score	Tooth root visibility score	Total score
KSH 1	0	1	1
KSH 2	0	0	0
KSH 3	0	1	1
Mean value	0	0.7	0.7

Table 3. Tooth root visibility and dento-alveolar margin sharpness scores

	Dento-alveolar sharpness margin score	Tooth root visibility score	Total score
Beagle (n = 4)	1.25	1.25	2.5
Shih Tzu (n = 1)	0	1	1
KSH (n = 3)	0	0.7	0.7

DISCUSSION

The development of dental panoramic radiology represents major progress in small animal dental imaging. The principle of panoramic dental X-ray systems is very simple. A narrow X-ray beam passes through the animal's head, and the dental structure on a curved plane is projected onto a moving sensor through a slit (Farman 2007). The X-ray source and a digital film facing the source rotate 360° around the animal's head (Farman 2007). In the human panoramic X-ray system, structures outside the curved plane are blurred, and a relatively narrow structure in the dental arch is imaged with high contrast (Molander 1996). To obtain an image of teeth and jaws without overlapping structures, skull radiographs are often the modality of choice in animals. Dental radiographic examinations were commonly limited to intraoral and oblique lateral projections of the jaws using dental X-ray sets (Molander 1996). Skull radiographs are complicated by the presence of structures other than teeth. In other words, skull structures often overlap with teeth and interfere with accurate interpretation of dental disease. Hence, the panoramic imaging system is a reasonable modality in terms of image quality and cost in most dental practices. In panoramic dental radiographs, a radiographer can assess all of the teeth in detail. These panoramic X-ray systems provide useful information without any additional X-ray examinations (Rushton et al. 2002). Human panoramic radiography provides a wide view of the structure of the bilateral oral cavity (Nah 2008). The detector used in this study enabled 50 frames/degree of rotation. A panoramic image is reconstructed by overlapping series of images acquired during single rotation of the panoramic device (Molander 1996). Hence, the human panoramic dental X-ray system has a high frame rate, high sensitivity, and wide range (Angelopoulos et al. 2004). In this study, the brachycephalic breed had a broader field of view than the mesaticephalic breed. The reason for such a wider view is assumed to be that in brachycephalic breeds the oral cavity has a greater resemblance to the oral cavity of humans.

The lowest values of the kVp and mA exposure factors in the human panoramic dental X-ray unit (Vatec Pax-300) are 60 and four, respectively. This X-ray unit has exposure settings for humans rather than animals. The quality of the panoramic radiographs was generally poor, but adequate results were obtained in the large skull-sized Beagles. These observations imply that the kVp and mA were above the appropriate level for the small skull-sized animals. In this study, the Beagle series showed sharp dento-alveolar margin scores and high tooth root scores. Beagle 1 had a higher score than the others. Due to the small number of Beagle cases, it is difficult to formulate an average dental score. Hence, it is possible that some of the Beagle dental images could have a higher than observed score. Also, this study showed that the evaluation of the dental arch using human panoramic dental X-ray is more feasible in large skull-sized animals, with skulls that are similar in size to human ones. There were no significant differences between the two head positions. Hence, the human dental panoramic X-ray system has potential for routine

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application for general screening of the dental arch in large skull-sized animals. However, further study is required for application in veterinary medicine.

This study has some limitations. First, the number of breeds was very limited. A broader breed selection is needed since the results showed that the radiographic quality correlated with oral cavity size and skull size. Second, the exposure parameters (kVp, mA) of the panoramic X-ray machine were set for human skulls, resulting in overexposure in small animals. Further studies are required to optimise the protocol for each dolicho-, mesati-, and brachycephalic breed. Also, this study only investigated two skull types and head sizes. This protocol may be insufficient to completely evaluate a miniature dog or a small brachycephalic dog.

In human medicine, cone beam computed tomography is also used for dental imaging in addition to the panoramic X-ray system (Roza et al. 2011). Although, cone beam is considered a more accurate modality than panoramic dental radiography (Momin et al. 2009), it has higher effective doses (Ludlow et al. 2014), is more cost-inefficient and tends to create more artefacts than panoramic radiography (Scarfe and Farman 2008). However, reports regarding the usage of cone beam computed tomography in small animals are still scant, the question of whether cone beam computed tomography is a feasible modality for diagnosis in veterinary medicine awaits a definitive answer.

In summary, this study suggests that human dental panoramic dental X-ray represents a potential dental evaluation modality for large skull-sized dogs and our experiments reveal the method to be an effective, low-cost and rapid method for dental radiographic examination. More data and more specific manipulation of the panoramic device are needed to optimise kVp and mA for small breed dogs. With such optimised conditions, panoramic dental scanning may be of great utility in small animal practices.

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