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A Full-Mouth Radiographic Survey of Periodontal Bone Loss in Dogs

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Abstract

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Periodontitis is considered to be a chronic inflammatory disease with progressive destruction of the supporting connective tissues and alveolar bone resorption. This may result in loss of teeth, especially in small breed dogs. More than 90% of the small dog population older than 3 years has some measurable periodontal disease. The objective of this study was to evaluate the relationship between clinically observed periodontal disease indicators and radiographic findings using full-mouth radiographs in poodles. The dogs were divided by age into three groups: Group 1 aged 3-5 years, Group 2 aged 6-9 years, and Group 3 aged10-13 years. For clinical and radiographic analyses the upper and lower teeth were assessed as follows: incisors, canines, and premolars/molars. Our results indicated that the prevalence and severity of periodontal disease increased with age. In addition, the deepest pockets and most severe bone loss were found around the canine teeth. The values obtained from radiographic analysis correlated well with clinical measurements. Full-mouth radiographic surveys show clearly the alveolar bone level around the whole dentition of dogs. It should be performed prior to institution of any treatment. Follow-up radiographs should be taken at regular intervals to determine the long-term success of the treatment.

Periodontal disease, alveolar bone loss, full-mouth radiography, incisors, canines, premolars, molars

Periodontal disease is one of the most prevalent inflammatory diseases in dogs. Factors contributing to prevalence and severity of periodontal disease include breed, genetics, age, diet, chewing behaviour and systemic health (Rugg Gunn 1993; Hoffmann and Gaengler 1996). More than 90% of the small dog population older than 3 years has some measurable degree of periodontal disease (DeBowes et al. 1996). The primary cause of such disease is plaque accumulation on tooth surfaces composed of bacteria aggregates in the matrix of salivary components (Harvey and Emily 1993). Gingivitis is considered the first stage of disease that clinically appears with gingival erythema. Gingivitis is reversible and may persist for a long time without progressing to periodontitis. However, the equilibrium disruption between subgingival plaque bacteria and host immune response leads to periodontal tissues destruction and pocket formation. A number of risk factors can influence this balance (Kinane and Lindhe 1997). Once the pocket has formed in this way, plaque removal becomes more difficult, and the process continues to bone resorption. Proteolytic enzymes, local inflammatory mediators such as prostaglandins, and bacterial endotoxins may induce bone resorption (Kinane and Lindhe 1997). Periodontal disease is accompanied by a combination of soft and hard tissue changes. It must be understood that various stages of periodontal disease can exist in the same oral cavity at the same time (Wiggs and Lobprise 1997). To adequately assess and monitor periodontal disease, using the periodontal probe and radiographic survey are extremely important. Detection of periodontitis is primarily a clinical diagnosis, radiology can be used to document and assess

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the extent of the bone loss. Periodontitis is characterized by radiographic detectable bone loss that is progressive in nature (Morgan et al. 1990). Dental radiographs form an essential part of a comprehensive oral examination, and radiological findings are a key element in dental decision-making (Verstraete et al. 1998). Ideally, whole-mouth radiographs should be taken when the patient is first presented for dental treatment (Thunthy 1993).

A full-mouth survey is defined as a series of radiographs depicting not only the teeth present, but also edentulous parts of the jaw. Pathological radiographic changes are usually discrete and therefore clarity and detail are essential (Goaz and White 1994) so, the images should be without superimposition of the adjacent structures. In veterinary dentistry intraoral radiographic techniques are therefore required (Verstraete 1999).

The objective of the study reported here was to evaluate the relationship between clinically observed periodontal disease indicators and radiographic findings on full-mouth radiographs. The study was undertaken in a series of different age poodles referred for dental treatment where full-mouth radiography had not been previously done.

Materials and Methods

Animals

A total of 42 male and female dogs (poodles), aged 3 to 13 years, of average body weight 6.7 ± 2.8 kg were examined in the study. The animals were presented for routine treatment of periodontal disease at the Clinic for Small Animal Medicine and Surgery, Veterinary Faculty, University of Ljubljana. All procedures were performed with permission of the owners. A questionnaire was given to the owners in order to obtain the information on the diet, oral hygiene and living conditions of their dogs. Dogs were divided into three age groups as follows:

Dogs aged 3 to 5 years (n = 10).
Dogs aged 6 to 9 years (n = 18).
Dogs aged 10 to 13 years (n = 14).

The examination and periodontal charting were performed under general anesthesia using dental explorer and Williams periodontal probe.

Clinical parameters

The amount of dental plaque accumulation, calculus deposits, and degree of gingival inflammation on buccal and lingual sides of the entire dentition were measured using the Plaque index (Pl I) and Calculus index (CI) modified by Logan and Boyce (1994) and Gingival index (GI) modified by Rateitschak et al. (1989). Additional assessment of tooth mobility - Mobility index (MI) and furcation involvement - Furcation index (FI) modified by Rateitschak et al. (1989) were estimated.

Pocket depth (PD) was measured mesiobuccally, buccally, distobuccally and lingually around all teeth. The averages of clinical parameters were calculated.

Groups of teeth

According to tooth size and position, three groups of teeth were formed. The first group included upper and lower incisors (103, 102, 101, 201, 202, 203, 303, 302, 301, 401, 402, 403), the second group consisted of upper and lower canines (104, 204, 304 and 404), and the third group comprised upper and lower premolars and molars (105, 106, 107,108, 109, 110, 205, 206, 207, 208, 209, 210, 305, 306, 307, 308, 309, 310, 311, 405, 406, 407, 408, 409, 410, 411). Modified Triadan system notation for tooth labelling was used.

Radiographic analysis

A full-mouth radiographic survey was made prior to comprehensive oral examination and periodontal charting. A standard wall-mounted dental radiograph unit (Toshiba, Tokio, Japan), along with standard intraoral dental films (Agfa Dentus, M2, Mortsel, Belgium) size 0 (22 × 35 mm), 2 (31 × 41 mm) and 4 (57 × 76 mm), speed D was used. Intraoral radiographs of the mandibular premolars and molars were obtained by using standard radiographic tehniques. Because of the morphology of the dog´s oral cavity the bisecting angle technique was used to evaluate maxillary teeth and mandibular incisors and canine teeth. In some cases an additional slightly oblique view was used to separate the two mesial roots of the maxillary fourth premolars.

The determination of periodontal bone loss was based on radiographically determined regression of the alveolar crest. A distance from the cemento-enamel junction to the depth of the radiographically determined defect was evaluated on each region of interest: mesial and distal side of all the teeth and intraradicular side of the multirooted teeth. A standard radiographic analysis using a magnifying glass and millimeters net for close examination of small details were made (see Plate VI).

Statistical analysis

Clinical observations and radiographic findings were compared according to the age of dogs and the group of teeth. Univariate statistical analysis was performed on all numeric study variables to determine normality of distribution. Non-parametric data analysis was performed using Spearman's correlation coefficient. Analysis of variance for multiple comparisons was used to depict the differences in various groups of teeth and ages of dogs. SAS 8.02 programme (ANOVA - GLM procedure for non-balanced data) was used for the analysis of data. If analysis of variance test was significant, post test analysis with the help of Duncan test was used to find the specific difference. *P* values of less than 0.05 were accepted as statistically significant.

Results

Clinical observations

Clinical examination of periodontal tissue state revealed that all parameter values increase linear with the age of the animal (Table 1). The deepest pocket measurements were obtained from the distobuccal aspect (PDd) in all teeth that were assessed.

The highest values of periodontal parameters were found in the group of dogs aged 10-13 years. Severe periodontal disease with the highest parameters were found around upper and lower canines.

The analysis of each periodontal index was made using the analysis of variance (ANOVA/GLM), and values between different age groups within particular group of teeth were compared.

Plaque index (Pl I)

There was a significant difference in average values between the youngest and the oldest dogs in the group of lower and upper canines ($F = 5.17$, $df = 2$, $p = 0.007$) and among all age groups in the lower and upper premolars and molars ($F = 16.98$, $df = 2$, $p < 0.0001$).

Calculus index (CI)

There was a significant difference in the average values between the oldest versus both younger groups of dogs in the lower and upper canines ($F = 7.59$, $df = 2$, $p = 0.007$) and lower and upper premolars and molars ($F = 14.82$, $df = 2$, $p < 0.0001$).

Gingival index (GI)

There was a significant difference in the average values between the oldest versus both younger groups of dogs in the lower and upper premolars and molars ($F = 12.89$, $df = 2$, $p < 0.0001$).

Mobility index (MI)

There was a significant difference in the average values between the youngest and the oldest group of dogs in the lower and upper canines ($F = 3.32$, $df = 2$, $p = 0.04$).

Furcation index (FI)

There was a significant difference in the average values between the oldest versus both younger age groups of dogs in the lower and upper premolars and molars ($F = 16.13$, $df = 2$, $p < 0.0001$).

Pocket depth buccally (PD b)

There was a significant difference in the average values between the youngest and the oldest group of dogs in the lower and upper canines ($F = 3.59$, $df = 2$, $p = 0.03$) and between the oldest versus both younger groups in the lower and upper premolars and molars ($F = 12.58$, $df = 2$, $p < 0.0001$).

Pocket depth mesiobuccally (PD m) and distobuccally (PD d)

There was a significant difference in the average values of PD m between the oldest versus both younger groups of dogs in the lower and upper canines ($F = 7.87$, $df = 2$, $p = 0.0007$). The same difference was present also for PD d ($F = 7.84$, $df = 2$, $p = 0.001$).

Pocket depth lingually (PD l)

There was a significant difference in the average values between all age groups in the lower and upper premolars and molars ($F = 13.96$, $df = 2$, $p < 0.0001$).

Table 1
Mean values and SD of periodontal indexes in different group of teeth and different age group of the animals

	Lower and upper incisors			Lower and upper canines			Lower and upper premolars and molars		
Peri-odontal index	3–5 years	6–9 years	10–13 years	3–5 years	6–9 years	10–13 years	3–5 years	6–9 years	10– 13 years
Pl I	1.02 ± 0.88	1.14 ± 1.18	1.23 ± 1.13	1.59 ±* 0.59	1.86 ± 0.90	2.19 ±* 0.89	1.25 ±* 0.75	1.53 ±* 0.98	1.77 ±* 0.96
CI	1.58 ± 1.12	1.46 ± 1.18	1.50 ± 1.17	2.11 ± 0.96	2.48 ± 0.97	2.95 ±* 1.05	1.67 ± 1.38	1.62 ± 1.30	2.14 ±* 1.41
GI	1.10 ± 0.92	1.08 ± 1.15	1.06 ± 1.12	1.68 ± 0.48	1.66 ± 0.83	1.95 ± 0.87	1.07 ± 0.81	1.02 ± 0.87	1.34 ±* 1.00
MI	0.87 ± 1.28	0.70 ± 1.19	0.76 ± 1.12	0.00 ± 0.00	0.16 ± 0.48	0.33 ±* 0.80	0.26 ± 0.68	0.30 ± 0.90	0.35 ± 0.93
FI	-	-	-	-	-	-	0.39 ± 0.84	0.50 ± 1.03	0.94 ±* 1.27
PD b	2.58 ± 1.63	2.78 ± 2.55	3.11 ± 2.51	3.46 ±* 1.45	4.10 ± 2.58	5.24 ±* 4.41	2.16 ± 1.10	2.26 ± 1.55	2.77 ±* 1.81
PD m	2.60 ± 1.40	3.20 ± 2.58	3.63 ± 2.59	3.00 ± 2.04	3.61 ± 2.47	6.45 ±* 4.72	2.11 ± 1.34	2.32 ± 2.08	2.67 ± 1.68
PD d	3.60 ± 1.40	4.20 ± 2.58	4.63 ± 2.59	4.00 ± 2.04	4.64 ± 2.45	7.41 ±* 4.80	3.08 ± 1.32	3.32 ± 2.08	3.67 ± 1.68
PD l	2.78 ± 1.81	2.78 ± 2.44	2.73 ± 2.15	2.79 ± 1.19	3.70 ± 2.69	4.10 ± 3.06	1.52 ±* 0.73	1.81 ±* 1.15	2.30 ±* 1.54

* Statistically significant difference in periodontal indexes between age groups of dogs within particular group of teeth (Duncan test on the level of $p = 0.05$).

Radiographic analysis

Alveolar bone loss was measured on mesial and distal sides of the tooth and intraradicularly (Table 2). Extreme bone loss was observed around canine teeth.

The analysis of each value of the alveolar bone level was done with analysis of variance (ANOVA/GLM) comparing values between different age groups within particular group of teeth.

Mesial alveolar bone level (M)

There was a significant increasing in the average values between the oldest versus both younger groups in the lower and upper canines ($F = 8.08$, $df = 2$, $p = 0.0004$), and lower and upper premolars and molars ($F = 12.62$, $df = 2$, $p < 0.0001$).

Intra-radicular alveolar bone level (F)

There was a significant difference in the average values between the oldest versus both younger groups of dogs in the lower and upper premolars and molars ($F = 14.55$, $df = 2$, $p < 0.0001$).

Distal alveolar bone level (D)

In the group of lower and upper incisors a significant difference was observed between both younger groups of dogs ($F = 3.76$, $df = 2$, $p = 0.02$). In the group of lower and upper canines the value differed in all age groups ($F = 7.22$, $df = 2$, $p = 0.001$). In the group of lower and upper premolars and molars there was a significant difference between the oldest versus both younger groups of dogs ($F = 12.5$, $df = 2$, $p < 0.0001$).

Using the Spearman correlation coefficient, a statistical significant correlation was confirmed between advanced periodontal disease as assessed by clinical examination and alveolar bone loss assessed from intraoral radiographs (Table 3).

Discussion

In the present study radiographic analysis of periodontitis have correlated well with the clinical measurements of plaque, calculus, gingival inflammation, assessment of the tooth mobility, pocket depth and furcation involvements in poodles. Our findings are in

Table 2
Alveolar bone loss (mean ± SD) in different groups of teeth in by age of the animals

	Lower and upper incisors			Lower and upper canines			Lower and upper premolars and molars		
Age Years	3–5 years	6–9 years	10–13 years	3–5 years	6–9 years	10–13 years	3–5 years	6–9 years	10– 13 years
M	3.06 ± 2.59	2.41 ± 2.59	2.91 ± 2.62	4.54 ± 7.45	2.32 ±* 5.42	6.98 ±* 8.41	0.57 ± 1.43	0.73 ± 1.66	1.30 ±* 2.13
F	-	-	-	-	-	-	0.41 ± 1.09	0.65 ± 1.59	1.23 ±* 1.86
D	3.27 ±* 2.69	2.48 ±* 2.82	3.15 ± 2.95	4.29 ±* 7.61	2.23 ±* 5.05	6.45 ±* 7.99	0.67 ± 1.58	0.73 ± 1.65	1.32 ±* 2.02

* Statistically significant difference of alveolar bone loss between age groups of dogs within particular group of teeth (Duncan test on the level of $p = 0.05$).

accordance with previous study of Harvey et al. (1994). However, we performed full-mouth radiographic surveys which clearly show the alveolar bone level around the whole dentition. Although routine use of full-mouth radiography is well established in human dentistry investigations regarding its efficacy. The advent of panoramic oral radiography has not replaced the intraoral full-mouth series in humans (Kantor and Slome 1989). The main reason for this is that the panoramic radiographic view has been found to be inferior to the full-mouth intra-oral series in its ability to correctly detect the evidence of periodontal disease (Valachovic et al. 1986). A full-mouth radiography of small animal patients referred for dental treatment is not routinely done in practice (Verstraete et al. 1998). An alternative approach generally used is to radiograph areas where one expects to find lesions on the basis of results of oral examination and periodontal probing. With the increase of sophistication of veterinary dentistry and increased availability of suitable dental radiographic equipment, the question arises whether the current standard of care should be upgraded to include a full-mouth radiography when an animal is first referred for dental treatment (Verstraete 1999).

This is done for two main reasons: to determine the condition of the teeth and bone, and to establish a baseline for future changes.

The present results support earlier reports suggesting that periodontal disease does not occur with equal severity in all areas of the oral cavity (Morgan et al. 1990; Harvey and Emily 1993; Hennet and Belows 2000). Incisors, having relatively small single roots, tend to be lost earlier than other teeth, particularly in small breed dogs that have relatively less bone supporting each tooth. The jiggling effect on a single root tooth magnifies the mobility resulting from bone loss and further weakens the supporting apparatus. In our

Table 3
Spearman correlation coefficients between periodontal indexes and alveolar bone loss in total

Alveolar Bone loss/mm	Pl I	CI	GI	MI	FI	PD b	PD m	PD d	PD l
M	r= 0.22 <0.0001	r=0.22 <0.0001	r= 0.32 <0.0001	r = 0.42 <0.0001	r = 0.52 <0.0001	r = 0.32 <0.001	r = 0.47 <0.001	r = 0.47 <0.0001	r = 0.36 <0.0001
F	r = 0.37 <0.0001	r = 0.35 <0.0001	r = 0.47 <0.001	r = 0.29 <0.0001	r = 0.54 <0.0001	r = 0.47 <0.0001	r = 0.43 <0.0001	r = 0.43 <0.0001	r = 0.45 <0.0001
D	r = 0.20 <0.0001	r = 0.24 <0.0001	r = 0.33 <0.001	r = 0.39 <0.0001	r = 0.49 <0.0001	r = 0.33 <0.0001	r = 0.47 <0.0001	r = 0.46 <0.0001	r = 0.38 <0.0001

study, clinical examinations of the periodontal tissue conditions revealed that values of all parameters increase linearly with advancing age of the animal. Index of gingival inflammation is slightly lower in the group of dogs aged 6 to 9 years in spite of higher plaque index comparing with younger group of dogs. It could be explained that the periodontal disease is a process with active and inactive phases. On the other hand, canine teeth have massive roots, and thus even though the root is single, the area of periodontal attachment is so large that mobility does not become clinically apparent until massive tissue destruction has occurred. In the present study the assessment of tooth mobility was slightly lower compared with the other two groups of teeth. The periodontal pockets may be filled with pus and may contribute to formation of periodontal abscesses or gingival clefts, and in small-breed dogs often cause oronasal fistulae.

Periodontal disease progresses from marginal gingiva apically, with subsequent reduction and apical migration of the epithelial attachment and alveolar bone resorption. Because of the bone loss, periodontitis can cause a significant increase in depth of the pocket where plaque can accumulate, and continue its destructive process (Wiggs and Lobprise 1997). Typically, the untreated periodontitis leads to tooth loss in small-breed dogs.

In animals older than 3 years, more than 90% of the small dog population has some measurable periodontal disease (DeBowes et al 1996).

The differences in severity of periodontal disease among age and breeds of dogs may be due to differences in specific anatomic factors such as tooth size relative to jaw bone height or thickness (Harvey and Emily 1993). In the group of premolars and molars the upper fourth premolar is the most severely affected with plaque and calculus accumulation, most of which attaches to the buccal aspect of the crown. This area is not subjected to routine dietary abrasion because the lower carnassial teeth occlude lingual to the upper carnassial teeth.

Sensitivity of radiography in detecting alveolar bone loss in human beings has been found to be in the order of 85% (Douglass et al. 1986). As periodontitis occurs, the crestal portion of the alveolar process begins to resorb. In radiographic images this destruction is evident as either a cup-shaped notch or scalloping of the crest.

Early periodontitis was marked by interproximal crestal bone resorption and triangulation of the crestal periodontal ligament. The interproximal crestal bone normally showed a straight radiopaque line running from 1-2 mm below to cement enamel junction of one tooth to that of the proximal cement enamel junction of the adjacent tooth (Fig. 1-F). In moderate periodontitis, bone loss up to approximately 50% occurred. Both horizontal and vertical bone loss can be seen, as well as loss of bone in the furcation areas (Fig. 1-A and B). With vertical bone loss, infrabony pockets may develop. Radiographically these are usually evidenced by a vertical or V-shaped flaw, with the root of the tooth forming one side of the defect (Wiggs and Lobprise 1997; Mulligan et al. 1998). It is important to differentiate between horizontal and vertical bone loss from a treatment point of view (Herr et al. 1995). In advanced periodontitis, a bone loss greater than 50% of alveolar bone occures and resorption may proceed apically. Additionally, furcation involvement was common, and the periodontal ligament space may widen, indicating tooth mobility (Fig. 1-C and J).

Our results indicate that routine use of a full- mouth radiography may be justifiable when the patient is first presented for dental treatment.

Consequently, full-mouth radiographs of periodontitis patients should be performed prior to the institution of any treatment and also should be taken at regular time to monitor outcome of the treatment.

Rentgenografický průzkum dutiny ústní psů s periodontální ztrátou kosti

Periodontitida je považována za chronické zánětlivé onemocnění vedoucí k postupnému poškození pojivových tkání v okolí zubu a resorbci alveolární kosti. Zejména u psů malých plemen může vést až ke ztrátě zubů. Více než 90 % populace malých psů má zjevné periodontální onemocnění po dosažení věku 3 let. Cílem zde publikované studie bylo zhodnotit souvislost mezi klinicky pozorovanými indikátory periodontálního onemocnění a rentgenografickými nálezy na rentgenových snímcích celé dutiny ústní u pudlů. Podle stáří byli psi rozděleni do tří skupin a to 3-5 let, 6-9 let, a 10-13 let. Pro klinickou a rentgenologickou analýzu byly horní a dolní zuby uspořádány do tří skupin: řezáky, špičáky a premoláry/moláry. Naše výsledky ukazují, že prevalence a vážnost periodontálního onemocnění vzrůstá s věkem psů. Mimo to nejhlubší kapsy a vážná ztráta kosti byly nalezeny u horních a dolních špičáků. Hodnoty rentgenografické analýzy pozitivně korelovaly se všemi klinickými měřeními. Rentgenové snímky celé dutiny ústní velmi jasně ukazují úroveň celé alveolární kosti okolo chrupu a měly by předcházet zahájení jakékoliv terapie. Pro kontrolu léčby by měly být dodatečně zhotovovány v pravidelných časových intervalech.

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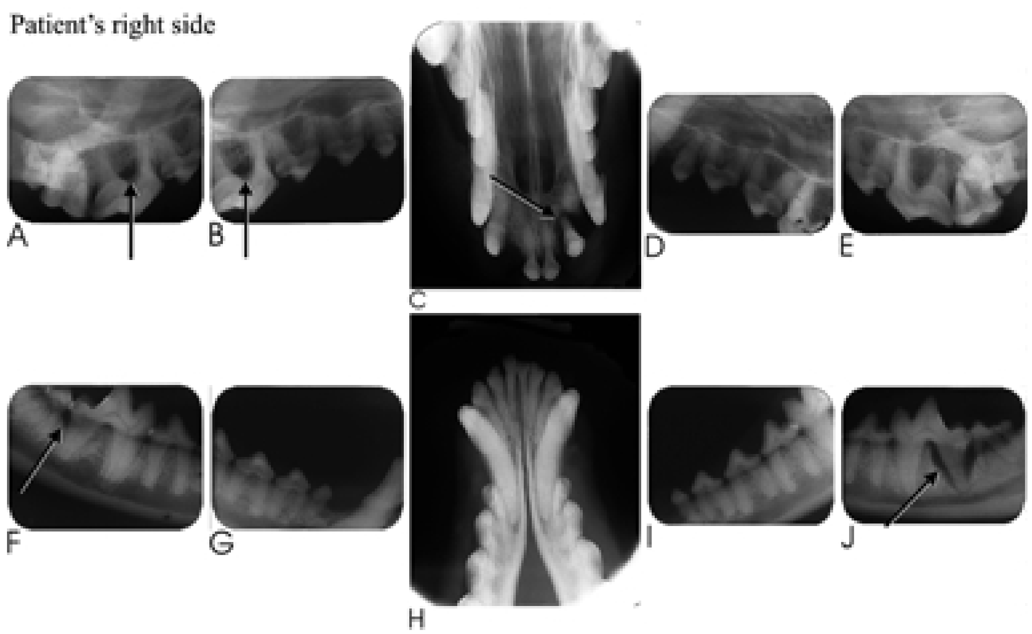
Figure 1: A full mouth radiographic survey in a twelve year old poodle



Legend: A, B, C, D, E - maxillary teeth, F, G, H, I, J - mandibular teeth
A and B - arrows indicate moderate periodontitis
C and J - arrows indicate advanced periodontitis
F arrow indicates early periodontitis