Drinking Water Additive Decreases Plaque and Calculus Accumulation in Cats

David E. Clarke, BVSc, MACVSc

Summary:

This study was performed to determine the effect of a drinking water additive on reducing plaque and calculus accumulation in cats. A two-period, parallel crossover design was used with each period consisting of a 56-day test phase. Results demonstrated that the addition of xylitol to the drinking water was effective in reducing plaque and calculus accumulation in cats.

J Vet Dent 23 (2); 79 - 82, 2006

Introduction

Periodontal disease is diagnosed commonly in companion animal practice in adult cats.[1,2] There is a direct relationship between the development of periodontal disease, in particular gingivitis, and accumulation of dental plaque on the tooth surface.[3] Gingivitis is reversible and can be prevented with thorough plaque removal by the veterinarian and continued supragingival plaque control by the cat owner.[4] Plaque control by mechanical removal during toothbrushing with a toothpaste continues to be the most effective and widely employed oral hygiene method in humans.[5] However, toothbrushing may be technically difficult for many cat owners, resulting in low compliance and ineffective plaque removal. The use of a drinking water additive may improve oral health in cats. The purpose of the study reported here was to evaluate the reduction in plaque and calculus accumulation using a commercially available drinking water additive[a] containing xylitol.

Materials and Methods

Adult male and female domestic shorthair cats (n = 30), ranging in age from 2 to 14-years, were initially used in this study. The cats were considered in good health based on physical examination and the results of laboratory tests (full hematology examination, biochemistry analysis, urinalysis). The cats were privately owned by two clients and were housed at their individual homes throughout the study period. The study was performed in accordance with guidelines proposed by the Veterinary Oral Health Council (VOHC).[6]

The study was conducted as a two-period, parallel crossover trial. Each study period consisted of a 56-day test phase. The cats were grouped into two blocks based on their housing arrangements. The cats in the first group received Eukanuba adult chicken and rice dry biscuits[b] and fresh untreated water each day during the initial test phase. The cats in the second group received the same biscuits, but had access to fresh drinking water treated with xylitol at 0.005 % each day. Drinking water was supplied from the owner's household source located in Melbourne, Australia and supplied *ad libitum* throughout the study period. Biscuits were fed to each cat based on calculated body weight and basal requirements. No other food or dental hygiene products were provided during the study period.

Cats received professional teeth cleaning (including supra- and subgingival scaling) and tooth polishing at the start of each test phase to ensure the absence of plaque and calculus on tooth surfaces and to insure all cats started each test phase at the same oral health baseline. All cats were anesthetized for teeth cleaning, as well as for plaque and calculus evaluations, which were performed at the end of each test phase. At the initial evaluation, assessment of periodontal probing depth (PPD) and probing attachment level (PAL) demonstrated that periodontal disease was absent. All cats had full dentition and did not have grossly visible dental resorptive lesions. For all teeth scored, the PPD did not exceed 0.5-mm and there was no attachment loss using the cementoenamel junction as a reference point.

Oral examination and professional teeth cleaning were performed following the administration of a general anesthetic. Cats received intravenous Hartmanns solution[c] via a cephalic catheter[d]; premedication using a combination of buprenorphine[e] (0.008 mg/kg SQ), acepromazine[f] (0.05 mg/kg SQ), and glycopyrrolate[g] (0.01 mg/kg SQ); induction using a combination of ketamine[h] (5 mg/kg IV) and diazepam[i] (0.25 mg/kg IV); followed by maintenance with isoflurane[j] in oxygen via an endotracheal tube. Fourteen teeth were scored in each cat including the maxillary canine, and third and fourth premolar teeth; and, mandibular canine, third and fourth premolar, and first molar teeth bilaterally.

During the second test phase, cat #19 escaped out of the front door of the owner's house and was subsequently involved in a car accident, which resulted in the cat's death. The mean tooth scores (Table 1) and the total mouth mean scores (Table 2), which involve the statistical comparisons, do not include data from cat #19.

The final results were recorded using 29 cats. Each of the 29 cats were involved in both 56-day test phases, and therefore each cat had access to the untreated water during one test phase and water treated with the additive during the other test phase. This study design allowed each cat to act as its own control.

One-way analysis of variance (ANOVA) was used to compare the test regimes for differences in the plaque and calculus measurements. Comparisons between the individual group mean scores for plaque and calculus were performed

Table 1

Mean tooth plaque and calculus scores in cats receiving a drinking water additive (xylitol) [DNCS = did not complete study].

	Mean Tooth Plaque Scores		Mean Tooth Calculus Scores	
Cat #	Dry Diet Only	Dry Diet and Xylitol Treated Water	Dry Diet Only	Dry Diet and Xylitol Treated Water
1	18.28	6.42	3.28	1.35
2	15.85	5.35	3.42	1.14
3	8.07	3.21	5.50	3.42
4	18.85	5.28	2.57	1.00
5	12.85	5.35	4.00	1.07
6	8.50	2.92	2.92	0.85
7	15.57	4.78	5.71	0.78
8	13.21	6.78	4.00	1.71
9	13.14	4.57	4.35	1.78
10	15.42	5.85	4.21	1.28
11	11.85	5.71	3.00	1.00
12	13.14	3.71	5.35	1.35
13	7.00	5.57	4.92	2.00
14	9.35	4.07	3.07	1.35
15	7.92	2.00	5.21	0.92
16	15.36	3.85	11.57	2.71
17	6.50	2.92	3.78	2.28
18	6.42	4.00	2.50	2.21
19	DNCS	DNCS	DNCS	DNCS
20	8.71	4.57	3.64	2.42
21	9.28	5.28	4.71	2.21
22	10.21	6.85	4.28	3.00
23	8.35	6.64	8.07	4.07
24	9.00	4.85	2.57	1.78
25	7.85	5.28	3.21	2.42
26	9.21	5.28	3.21	2.50
27	8.85	5.71	2.85	2.28
28	8.78	7.85	3.14	2.35
29	7.00	5.78	4.00	3.21
30	9.71	6.92	3.07	2.28

Table 2

Total mean tooth scores in cats (n = 29) receiving a drinking water additive (xylitol).

Parameter	Treatment	Total Mean Tooth Score +/- SD	Percent Reduction	Significance When Compared to Treated Water
Plaque	Dry Diet Only	10.72 +/- 3.48	52.58 %	$P < 0.001$
	Dry Diet + Xylitol Treated Water	5.08 +/- 1.36		
Calculus	Dry Diet Only	4.21 +/- 1.86	53.49 %	$P < 0.01$
	Dry Diet + Xylitol Treated Water	1.96 +/- 0.84		

using Tukey's multiple comparisons test. A value of $P < 0.05$ was considered significant.

Plaque scores were determined based on visual assessment of plaque thickness and surface area coverage (%) on the buccal or labial crown surface aided by the application of a 2 % eosin disclosing solution[k].[7] The same examiner graded plaque accumulation throughout the test phases. Grading criteria for plaque coverage: 0 = no plaque detected; 1 = < 25 %; 2 = 25 - 50 %; 3 = 50 -75 %; 4 = 75 - 100 %. Grading criteria for plaque thickness: 1 = light; 2 = medium; 3 = heavy. The buccal tooth surface was divided into gingival and coronal halves. Each tooth half was scored for plaque coverage and thickness. The coverage score was multiplied by the thickness score to obtain a gingival and coronal plaque score for each half of the tooth. The gingival and coronal plaque scores for each tooth were added to obtain a total tooth score for each tooth. The total mouth score was obtained by adding all 14 individual total tooth scores. The total mean tooth score was obtained by dividing the total mouth score by 14.

Calculus scores were determined based on visual assessment of calculus thickness and surface area coverage (%) on the buccal or labial crown surface.[7] The disclosing solution was removed from the tooth surface with a toothbrush, followed by rinsing with water and air drying. The same examiner graded calculus accumulation throughout the test phases. Grading criteria for calculus coverage: 0 = no calculus detected; 1 = < 25%; 2 = 25 – 50 %; 3 = 50 -75 %; 4 = 75 - 100 %. Grading criteria for calculus thickness: 1 = (< 0.5-mm); 2 = (0.5 - 1.0 mm); 3 = (> 1mm). The buccal tooth surface was divided into mesial and distal halves. Each tooth half was scored for calculus coverage and thickness. The coverage score was multiplied by the thickness score to obtain a mesial and distal score for each half of the tooth. The mesial and distal calculus scores for each tooth were added to obtain a total tooth score for each tooth. The total mouth score was obtained by adding all 14 individual total tooth scores. The total mean tooth score was obtained by dividing the total mouth score by 14.

Results

All cats accepted and readily drank the treated water. When cats had access to the treated water, each individual cat as well as the whole group had significantly less plaque and calculus accumulations than when they had access to untreated water (Table 1). For cats drinking untreated water, the mean tooth plaque score was 10.7 +/- 3.5 compared with a mean tooth plaque score of 5.1 +/- 1.4 when drinking treated water. Plaque accumulation decreased by 52.3 % when drinking treated water. For cats drinking untreated water, the mean tooth calculus score was 4.2 +/- 1.9 compared with a mean tooth calculus score of 2.0 +/- 0.8 when drinking treated water. Calculus accumulation decreased by 53.5 % when drinking treated water (Table 2).

Discussion

Periodontal disease is a significant disease in client-owned domestic breed cats, as plaque rapidly forms on teeth when no oral hygiene is performed. Although there have been a number of studies demonstrating the plaque reducing abilities of tooth-brushing in the dog,[8,9] there are few studies that have been performed in the cat.[10] In companion animal practice, it is difficult to convince clients to brush their cats' teeth, and moreover, the majority of cats resist having their teeth cleaned with a toothbrush. For these reasons, the compliance of toothbrushing in client-owned cats is generally low. Therefore, the use of an effective method that also has positive owner compliance is especially warranted in the cat. The results reported here demonstrate that a drinking water additive improves oral health in the cat.

Xylitol is a five-carbon natural sugar alcohol or pentitol, which has been shown to have both an antibacterial effect on oral bacteria and dental plaque, as well as anti-calculus forming properties.[11-13] The non-fermentability or very low fermentability of xylitol by dental plaque leads to a number of consequential phenomena of possible significance that include: uptake by bacteria and inhibition of bacterial growth; formation of soluble extracellular polysaccarides that make plaque less adhesive to the tooth surface; and, inhibition of spontaneous precipitation of calcium phosphate, decreasing the formation and accumulation of dental calculus.[13]

The antibacterial properties and the xylitol metabolism of dental plaque may be interpreted by understanding that dental plaque contains bacteria. The bacteria, via the fructose phosphotransferase system, take up xylitol. Xylitol is metabolised into xylitol-5-phosphate within the bacterial cell. Xylitol-5-phosphate inhibits glycolysis and the uptake of glucose in the cell, which results in inhibition of bacterial growth.[12]

It is generally accepted that chewing xylitol sweetened gum after meals may reduce plaque formation and gingival inflammation in humans.[14,15] The results of two 12-month clinical studies showed that xylitol significantly reduced dental plaque when incorporated into chewing gum or a dental snack.[16,17] Subjects in these studies also had less inflammation of the periodontal tissues. In another study, the daily use of a xylitol-containing chewing gum in humans reduced the weight of plaque formed in comparison to when no chewing gum was used.[18] In these trials, the inability of chewing gum per se to remove plaque from the tooth surfaces indicated that the decrease in plaque formation when using a xylitol-containing product was due to the chemical activity of xylitol.

Microbiological studies add validity to these observations. A significant reduction in *Streptococcus mutans*, in both plaque and saliva compared with pre-treatment values, has been reported in humans chewing xylitol gums for 4-weeks.[19] Another study confirmed a significant decrease in salivary *Streptococcus mutans* after 2-months of chewing xylitol-containing gum.[20] In general, xylitol has been shown to reduce the bacterial growth rate.[21]

The xylitol molecule also has the ability to form complexes with certain cations, such as Ca^{2+}, Cu^{2+} and Fe^{2+}, based on its polyol properties.[22] The habitual consumption of xylitol has

shown that it not only concentrates calcium in plaque, but also keeps calcium ions in a soluble form, reducing calculus accumulation on the tooth surface.[23]

In the study presented here, the daily addition of xylitol to the drinking water of cats significantly reduced the accumulation of plaque and calculus following professional teeth cleaning (supra- and subgingival scaling and polishing). The results of this study showed that cats drinking water treated with xylitol had approximately half the plaque and calculus accumulation compared to when they were drinking untreated water. Xylitol is a useful adjunct in maintaining the oral health of cats during the period between professional teeth cleaning procedures.

---

[a] BreathaLyser, imRex Ltd, London, Canada

[b] Iams Company, Dayton, Ohio, USA

[c] Baxter Healthcare Pty Ltd, Old Toongabbie, NSW, Australia

[d] Optiva, Medex Medical Ltd, UK

[e] Temgesic, Reckitt Benckiser, West Ryde, NSW, Australia

[f] A.C.P.2, Delvet Pty Ltd, Seven Hills, NSW, Australia

[g] Glycosate Vet Injection, Naturevet, Glenorie, NSW, Australia

[h] Ketamine, Parnell Laboratories, Alexandria, NSW, Australia

[i] Pamlin, Parnell Laboratories, Alexandria, NSW, Australia

[j] Isorrane, Baxter Healthcare Pty Ltd, Old Toongabbie, NSW, Australia

[k] Plaque disclose gel, Professional Dental Supplies, Bayswater North, Victoria, Australia

Author Information

Dental Care for Pets, 55 Belgrave-Hallam Road, Hallam, Victoria, Australia, 3803.Email: david@dentalcareforpets.com.au.

References

1 Reichart PA, Durr U-M, Ttriadan H, et al. Periodontal disease in the domestic cat. A histopathologic study. *J Periodontal Res* 1984; 19: 67-75.

2 Lund EM, Armstrong PJ, Kirk CA et al. Health status and population characteristics of dogs and cats examined at private practices in the United States. *J Amer Vet Med Assoc* 1999; 214: 1336-1341.

3 Socransky SS. Relationship of bacteria to the etiology of periodontal disease. *J Dent Res* 1970;49: 203-222.

4 Kommen KS. The role of supragingival plaque in the prevention and treatment of periodontal disease: a review of current concepts. *J Periodont Res* 1986; 21 (Suppl): 5-22.

5 Addy M, Willis L, Moran J. Effect of toothpaste rinses compared with chlorhexidine on plaque formation during a 4-day period. *J Clin Periodontol* 1983; 10: 89-99.

6 The Veterinary Oral Health Center: A system for recognition of effectiveness of veterinary dental products. Summary of purpose and history. *J Vet Dent* 1997; 14: 70-72.

7 Logan EI. Oral cleansing by dietary means: results of six-month studies. In: *Proceedings of a Conference on Companion Animal Oral Health.* Sponsored by Hills Pet Nutrition, Inc, March 1-3, 1996, 11-15.

8 Tromp JA, van Rijn LJ, Jansen J. Experimental gingivitis and frequency of toothbrushing in the beagle dog model: clinical findings. *J Clin Periodontol* 1986: 13: 190-194.

9 Tromp JA, Jansen J, Pilot T. Gingival health and frequency of toothbrushing in the beagle dog model. Clinical findings. *J Clin Periodontol* 1986; 13: 164-168.

10 Richardson RL. Effect of administering antibiotics, removing the major salivary glands and toothbrushing on dental calculi formation in the cat. *Arch Oral Biol* 1965; 10: 245-253.

11 Trahan L. Xylitol: a review of its action on mutans streptococci and dental plaque – its clinical significance. *Int Dent J* 1995; 45: 77-92.

12 Waler SM, Rolla G, Assev S, Ciardi JE. The effect of xylitol on plaque metabolism. *Swed Dent J* 1984; 8: 155-161.

13 Makinen KK. New biochemical aspects of sweeteners. *Int Dent J.* 1985; 35: 23-35.

14 Steinberg LM, Odusola F, Mandel I. Remineralising potential antiplaque and antigingivitis effects of xylitol and sorbitol sweetened chewing gum. *Clin Prev Dent* 1992; 14: 31-34.

15 Cronin M, Gordon J, Rearden R, Balbo F. Three clinical trials comparing xylitol and sorbitol containing gums for their effect on supragingival plaque accumulation. *J Clin Dent* 1994; 5: 106-109.

16 Scheinin A, Makinen KK. The effect of various sugars on the formation and chemical composition of dental plaque. *Int Dent J* 1971; 21: 302-321.

17 Scheinin A, Makinen KK. Effect of sugars and sugar mixtures on dental plaque. *Acta Odontol Scand* 1972; 30: 235-257.

18 Mouton C, Scheinin A, Makinen KK. Effect on plaque of a xylitol-containing chewing gum. A clinical and biochemical study. *Acta Odontol Scand* 1975; 33: 33-40.

19 Loesche W, Grossman N, Earnest R et al. The effect of chewing xylitol gum on the plaque and saliva levels of Streptococcus mutans. *J Am Dent Assoc* 1984; 108: 587-592.

20 Wennerholm K, Emilson CG. Effect of sorbitol- and xylitol-containing chewing gum on salivary microflora, saliva, and oral sugar clearance. *Scand J Dent Res* 1989; 97: 257-262.

21 Gauthier L, Vadeboncoeur C, Mayrand D. Loss of sensitivity to xylitol by Streptococcus mutans LG-1. *Caries Res* 1984; 18: 289-295.

22 Angyal SJ, Greeves D, Mills JA. Complexes of carbohydrates with metal cations. 111. Conformations of alditols in aqueous solutions. *Aust J Chem* 1974; 27: 1447-1456.

23 Makinen KK, Soderling E. Solubility of calcium salts, enamel, and hydroxyapatite in aqueous solutions of simple carbohydrates. *Calcif Tissue Int* 1984; 36: 64.