Effectiveness of a Vegetable Dental Chew on Periodontal Disease Parameters in Toy Breed Dogs

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Summary:
Sixteen toy breed dogs completed a parallel, 70-day two-period, cross-over design clinical study to determine the effect of a vegetable dental chew on gingivitis, halitosis, plaque, and calculus accumulations. The dogs were randomly assigned into two groups. During one study period the dogs were fed a non-dental dry diet only and during the second study period were fed the same dry diet supplemented by the daily addition of a vegetable dental chew. Daily administration of the dental chew was shown to reduce halitosis, as well as, significantly reduce gingivitis, plaque and calculus accumulation and therefore may play a significant role in the improvement of canine oral health over the long-term. J Vet Dent 28 (4); 230 - 235, 2011

Introduction
Periodontal disease is a significant problem in client-owned dogs with toy breeds being over-represented. While there are many factors that contribute to its prevalence, accumulation of a bacterial plaque biofilm is the initiating cause and thus plays a key role in its pathophysiology. During the initial stages of plaque formation, the bacteria are usually the resident flora of the oral cavity and include predominantly aerobic, gram positive colony forming non-motile cocci.

When plaque is not removed from the tooth surface, it is constantly bathed in saliva and will mineralize to form dental calculus. Calculus, per se, is not the primary cause of periodontal disease, but once formed, it immediately becomes covered with dental plaque, thus advancing the disease process. Plaque, on contact with the gingival margin, initiates an inflammatory response, termed gingivitis, which results in gingival edema and a potential increase in the periodontal sulcus depth. Left untreated, there is a shift in the subgingival bacterial population towards a larger proportion of anaerobic bacteria, resulting in an increase in volatile sulfur compounds and halitosis.

Regardless of the disease stage, plaque control is critical to therapeutic success. Numerous mechanical and chemical methods have been proposed for plaque control and its effect on periodontal health in the dog, including toothbrushing10-12, dental chews with and without enzymes13-18, gels19, barrier sealants20, clindamycin21, and chlorhexidine22-27. While it is generally accepted that toothbrushing in humans is the most effective method of plaque removal, it is not the most common method in the dog, as few owners are diligent in brushing their dogs’ teeth over the long-term and many dogs will not tolerate daily brushing.28-30 Since a major limiting factor in providing adequate canine dental home care is owner compliance, an easy option, such as feeding a daily dental chew, may contribute to an improvement in canine oral health.

The purpose of the study reported here was to evaluate the effectiveness of a vegetable dental chew on reducing halitosis, gingivitis, and dental substrate accumulation in toy breed dogs.

Material and Methods
Sixteen toy-breed dogs, six males, ten females, age 3 to 14-years (mean = 7.7, median = 6.3), and weighing 4.1 to 8.4-kg (mean = 5.7, median = 5.6) were selected. Dogs needed to satisfy the following criteria to be selected for enrollment in the study: consenting owners, toy breed, full dentition, normal occlusion, clinically healthy with respect to a complete physical examination, full blood, and urine evaluations. Eighteen teeth were used for evaluations: maxillary third incisor teeth (103/203), maxillary canine teeth (104/204), maxillary third premolar teeth (107/207), maxillary fourth premolar teeth (108/208), maxillary first molar teeth (109/209), mandibular canine teeth (304/404), mandibular third premolar teeth (307/407), mandibular fourth premolar teeth (308/408) and mandibular first molar teeth (309/409).

Dogs were housed individually and provided their respective diet once daily and water ad libitum. Two different feeding regimes were used: a negative control group fed a dry diet and a test group receiving the same diet with the addition of a daily vegetable chew. All dogs were given their daily food at 4 pm and the vegetable chew between 8 pm - 12 pm. No plaque or calculus control treats, chews, chew toys, or dental hygiene products were provided to the dogs for the duration of the study, other than the vegetable chew.

The chew has a unique Z-shaped design, intended to enhance prehension and prolong chewing time (Fig. 1). The ingredients of the chew included corn starch, glycerin, soya protein, rice flour, sorbitol, corn derivatives, water, and potassium sorbate with no meat products. There were no active anti-plaque or anti-calculus or agents, meat products in the vegetable chews.

Figure 1
Vegetable chew.
At the beginning of the study (Days -14 to -7), all dogs underwent clinical and oral examination and had blood and urine analyzed. All dogs were fed the dry diet for 14-days in a pre-study, acclimation phase (Fig. 2). At Day -7, all dogs were given a vegetable chew to ensure acceptance for a minimum of 2-minutes. In a previous study, it was shown that dogs need to be acclimated to a chew prior to commencement of the study in order to achieve ideal compliance from the outset. At Day 0, each dog was anesthetized using buprenorphine (0.0075 mg/kg), acepromazine (0.04 mg/kg), and atropine (0.06 mg/kg) premedication SQ. A cephalic intravenous cathether was placed, fluids commenced at 10 ml/kg/hr, anesthesia induced with alfaxalone (2.0 mg/kg) IV and maintained via endotracheal tube with isoflurane in oxygen (1L/min). Following anesthesia, all dogs had gingivitis evaluated. A Williams periodontal probe was placed subgingivally on the buccal side of each evaluated tooth and based on visual assessment a numerical gingivitis score was given using a modification of a previously designed method: 0 = no inflammation and no bleeding on probing; 1 = inflammation and no bleeding on probing; 2 = inflammation and delayed bleeding on probing; 3 = inflammation and immediate bleeding on probing. The sum of the gingival scores was divided by the number of evaluated teeth (n = 18) to obtain a mean gingival score for each dog.

The teeth were thoroughly and completely scaled followed by polishing with a fine grade paste supra- and subgingivally. After polishing, halitosis was evaluated using a digital halimeter. Three separate measurements were obtained by placing the collection tube into the dog’s mouth over the tongue to the level of the maxillary fourth premolar teeth and manually holding the mouth closed. The halimeter collected oral breath for 180-seconds and gave a quantitative measurement. This was repeated twice with 30-second intervals between collections. The individual readings were summed and averaged in order to obtain a mean mouth halitosis score.

Following this anesthetic episode, each dog was allowed to recover from anesthesia in individual cages and eventually returned to their owner. Each dog began the study according to the “clean tooth model” since the absence of plaque was confirmed with 2% erythrosine. On Day 0, each dog was randomly allocated into two groups of eight. One group was then randomly allocated to be the negative control, while the other group received the vegetable chew. On Day 28, the groups were interchanged, so each dog effectively acted as its own control. At Days 28 and 56, gingivitis, halitosis, plaque, and calculus were evaluated and scored under general anesthesia using the same regime as described above. The same scorer (DEC) was used at all evaluation times and was blinded to the feeding regimen and the scoring order. Dogs presented to the scorer were randomly selected from each group at each evaluation time.

Plaque evaluation scores were determined using a method that was modified to visually assess plaque coverage and thickness on the buccal surface of the evaluated teeth aided by applying 2% erythrosine, immediately rinsing with water, and gently drying the tooth with air. The tooth crown was divided horizontally into gingival and coronal halves and each half assigned a numerical score for both plaque surface area coverage (0 = no observable plaque; 1 = < 25 %; 2 = between 25 and 50 %; 3 = between 50 and 75 %; 4 = > 75 %) and plaque thickness (0 = no observable plaque; 1 = pink to light red; 2 = red; 3 = dark red). The individual coverage and thickness scores from the gingival half of the tooth were multiplied to obtain the “gingival half score”. The coverage and thickness scores from the coronal half of the tooth were multiplied to obtain the “coronal half score”. The gingival and coronal half scores were added to obtain the total tooth score. The sum of the 18 gingival half scores was divided by the number of evaluated teeth (n = 18) to obtain a “mean gingival score” for each dog. The sum of the 18 coronal half scores was divided by the number of evaluated teeth (n = 18) to obtain a “mean coronal score” for each dog. The sum of the 18 tooth scores was divided by the number of evaluated teeth (n = 18) to obtain a “mean mouth score” for each dog.

Calcium evaluation scores were based on visual assessment of calculus coverage and thickness on the buccal surface of
the evaluated teeth following removal of the plaque and 2% erythrosine by gentle toothbrushing, rinsing with water, and gently drying with air. The tooth crown was divided vertically into mesial, central, and distal thirds and each section assigned a numerical score for both calculus surface area coverage (0 = no observable plaque; 1 = < 25%; 2 = between 25 and 50%; 3 = between 50 and 75%; 4 = > 75%) and calculus thickness (0 = no calculus present; 1 = < 0.5-mm; 2 = > 0.5-mm). The individual coverage and thickness scores from the mesial section of the tooth were multiplied to obtain the “total mesial score”, which was repeated for the central and distal sections. The total mesial, central, and distal scores were summed to obtain the “total tooth score”. The sum of the 18 total tooth scores was divided by the number of evaluated teeth (n = 18) to obtain a “mean mouth score” for each dog.

Aggregated datasets were created for analysis. Histograms were inspected for each of the variables to check for normality. Halitosis was right skewed and was log transformed prior to analysis. All other variables showed histograms consistent with normal distributions. Baseline measurements for gingivitis and halitosis were entered as a covariate. Data was analyzed in an approach appropriate for crossover designs. Analyses were performed using PROC mixed with fixed effects coding for treatment, period, and sequence and a random effect coding for animal nested within sequence. Repeated-measure ANOVA and analysis of variance tests were used. Data is expressed as mean ± SEM. P values < 0.05 were considered significant.

Results
The time taken by each dog to consume the chew ranged from 2.2 to 10-minutes (6.82 ± 2.31). Three dogs chewed for an average of < 5-minutes and 13 dogs chewed for between 5.9 to 10-minutes. The chewing time on the left and right sides of the mouth was 1.1 to 6.0-minutes (3.28 ± 1.27) and 1.1 to 5.5 minutes (3.54 ± 1.20), respectively (Table 1).

The mean gingival score was lower (11.25%) when the dogs were given the chew (1.12 ± 0.05) compared to when they were fed only the dry diet (1.26 ± 0.05). There was a significant (P = 0.0137) reduction in mean gingival score when the dogs received the vegetable chew. There was no association between the pre-trial gingival score and subsequent scores during the trial (P = 0.87) [Table 1 and Fig. 3].

The mean halitosis score was lower (6.6%) when the dogs were given the chew (3.40 ± 0.23) compared to when they were fed only the dry diet (3.64 ± 0.23), however this result was not significant (P = 0.41) [Table 1 and Fig. 4].

There was evidence of a significant sequence effect on plaque, therefore a restricted analysis was performed using only data from the first period to avoid any possible impact of a sequence effect on the results. The mean plaque score was lower (37%) when the dogs were given the chew (3.00 ± 0.54) compared to when they were fed only the dry diet (4.76 ± 0.39). There was a significant (P = 0.014) mean reduction in plaque when the dogs received the vegetable chew (Table 1 and Fig. 5). There was evidence of a significant sequence effect on calculus, therefore only data from the first period were analyzed. The mean calculus score was lower (70.2%) when the dogs were given the chew (0.50 ± 0.24) compared to when they were fed only the dry diet (0.50 ± 0.24). When the dogs received the vegetable chew, there was a significant (P = 0.0005) mean reduction of calculus accumulation (Table 1 and Fig. 6).

A sequence effect between the first and second groups was observed with respect to plaque and calculus accumulation. While there is no definitive current scientific explanation, possible reasons for this observation include an effect related to deposition of some material from the dental chew on the tooth surface during chewing which is not removed during scaling and polishing, or modification of the microbiological
or local immunological environment resulting in a decreased bacterial population. Clinically, there is no evidence that a non-medicated dental chew should have any long-lasting effect on the reduction of plaque and calculus accumulation for a period of time after cessation of the chew. Any residual plaque deposits that may be attached to the tooth surface should have been removed following scaling and polishing. The accumulation of plaque is independent of previous accumulations as well as independent of the gingivitis present or halitosis present, leading to a possible conclusion that chewing may result in modification of the local immunological environment, or microbial populations. Certainly, this result warrants further scientific investigation.

**Discussion**

Dental plaque has been shown to be the primary contributor to the initiation of gingivitis and in the development of calculus in dogs. An assumed hypothesis and general belief amongst veterinarians and pet owners is that when a dog chews, there is a direct inverse correlation between time spent chewing the product and accumulation of dental substrates present on the tooth surface. It is also assumed that if a product is able to demonstrate a significant reduction in plaque accumulation, a logical consequence of events would be a decreased host immune response proportional to reduced bacterial load, inflammation and gingivitis, and reduced calculus accumulation.

There has been considerable research time and funds dedicated to investigating the most efficient methods of preventing the accumulation of dental deposits utilizing mechanical techniques. The effects of a dental chew have been reported in a number of breeds, other than toy-breed dogs. A significant reduction in plaque was achieved in one study by giving a dental chew twice daily to Beagle dogs, which also demonstrated a significant difference between mean plaque scores for maxillary and mandibular teeth when compared to a control group. A significant reduction in plaque was also demonstrated in another study where Beagle dogs were fed a dental hygiene chew once daily. However, in two other studies in small breed dogs (mean = 7 kg), no significant reduction in plaque accumulation was reported with the same chew, yet feeding the same chew to large dogs (minimum 23 kg) did show significant reductions in plaque accumulation.

**Table 1**

Comparison of gingivitis, plaque and calculus indices, and chewing times in dogs fed a vegetable chew.

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<th>Combined Mouth</th>
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</table>

**Figure 5**

Mean plaque scores*.

* = Statistically Significant
The chew used in this study was specifically designed with ingredients, chew size, shape, and texture for toy-breed dogs and for a market sector preferring not to feed a meat-based chew. The chew was formulated with the vegetable ingredients, corn starch, glycerin, soya protein, rice flour, sorbitol, corn derivatives, water, and potassium sorbate, into a unique Z-shaped design, intended to enhance prehension and increase chewing time. The palatability of the chew was excellent and all dogs chewed with consistency throughout the study. There was no observed change in the dogs’ health or stool consistency throughout the study.

As dogs were selected from the general population, some commenced the study with gingivitis and therefore, a predetermined gingival index. Paired t-tests were used to compare gingival and halitosis indexes between the two sequences of dogs prior to the start of the trial. The results indicated that there was no statistical difference between the sequence groups, with respect to either of these parameters, which supports the hypothesis that there was no difference between these randomly allocated groups at the start of the trial.

 Owners were asked to record the total time spent chewing the vegetable chew, as well as the proportion of chewing on each side of the mouth. Each owner reported that the dogs chewed on an individual end of the chew, with the opposite end being extra-oral and visible, making it possible for the owner to record the side of the mouth on which the chewing was done. The total chewing time was therefore believed to be accurate, as well as the proportion attributed to each side.

Halitosis is a commonly diagnosed condition affecting dogs and is often the first clinical sign of dental disease noticed by the dog’s owner. Halitosis at any point in time may be an indicator of periodontal disease since bacteria associated with periodontal disease, in particular Porphyromonas sp., Bacteroides sp., Fusobacterium sp. and spirochetes produce volatile sulfur compounds. Volatile sulfides arise from a number of different locations, including plaque biofilms on the teeth, the oral tissues including the tongue, gingiva, pharynx, tonsils, and reflux from the stomach. We have hypothesized that the halitosis reading would be primarily associated with the accumulation of plaque on the tooth surface and as such, it would be significantly reduced by cleaning the teeth and reducing plaque accumulation by the daily offering of a vegetable chew. In one previous study, gingivitis was associated with elevated levels of oral malodor. In this study, we did not confirm this observation, with some dogs recording a dramatic decrease in halitosis (up to 90% reduction), but in others there was a smaller decrease or no decrease at all. Discrepancies between individual dogs and the lack of a significant decrease overall may be best explained by a disproportionate reduction of plaque bacteria associated with the teeth, compared to the levels of sulfides generated from the other surfaces (tongue, pharynx, gingiva, stomach, etc). This was consistent with a previous review, which suggested the majority of plaque-producing volatile sulfurs are found on all surfaces within the oral cavity. Therefore, the reduction reported in this study may only reflect the removal of plaque on the teeth while the greatest proportion of halitosis is produced by bacteria elsewhere in the oral cavity.

Plaque accumulates on the tooth surface immediately following cleaning. Mechanical abrasion of the tooth surface immediately after cleaning results in minimal accumulation of plaque and in turn, a reduction in calculus accumulation. If calculus is reduced, there is less roughened surface area for further plaque to accumulate, and in turn, less calculus accumulates, effectively providing a self-regulating process. We propose that a chew that directly acts to prevent plaque accumulation should have a direct and indirect effect in reducing calculus accumulation and gingivitis, thereby improving the oral health of the individual dog.

The significant plaque and calculus reductions reported here are consistent with recent studies on meat-based chews, which have published plaque reductions in the range of 13.1 - 38% and calculus reductions in the range of 45.8 - 63.3%. However, it is difficult to accurately compare these reductions, as each study uses a different base diet and different trial design making direct comparisons inappropriate.

Client owned toy-breed dogs are predisposed and as such, over-represented in the cohort of dogs that are affected by periodontal disease. Anecdotally, these dogs are often fussy eaters and difficult to pill and administer dental homecare. Toothbrushing, the gold standard of human dental homecare, is often ineffective in controlling plaque in dogs based on difficulty administering the technique or poor compliance. Therefore, a product that can be easily administered by the owner and is readily accepted by the dog should increase and improve oral health. In this study, we found the unique vegetable dental chew to be very well accepted, reducing dental substrates and gingivitis. Thus, the daily addition of the vegetable chew should decrease the prevalence of periodontal disease and improve the oral health in toy breed dogs.
Hills Science diet (small breed maintenance), Hills, Toptica, USA

C.E.T. VeggieDent Chews, Virbac Animal Health, Fort Worth, USA

Temgenic Injection, Rockitt Benckiser, West Ryde, NSW, Australia

A.C.P. 2, Delvet, Seven Hills, NSW, Australia

Atropine Injection, Apex Laboratories, Somersby, NSW, Australia

Hartmann, Baxter, Old Toongabbie, NSW, Australia

Alfaxan-CD RTU, Ierons, Rutherford, NSW, Australia

Isorane, Baxter Healthcare, Old Toongabbie, NSW, Australia

Sonic scaler, NSK, Japan

Polishing paste, Dentaiale, California, USA

Halimeter, Interscan Co., Chatsworth, California, USA

Plaque disclose gel, Professional Dentist Supplies, Bayswater North, Australia.

SAS Institute, SAS Campus Drive, Cary, NC, USA

References


