Effect of chewing rawhide and cereal biscuit on removal of dental calculus in dogs

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Summary: The effect of chewing rawhide and cereal biscuit on removal of dental calculus was studied in 67 dogs. Two methods were used to measure supragingival calculus and calculus removal as a function of time and acceptability. Trial 1 used a quantitative method based on actual measurement of the area of calculus on a tooth, and trial 2 used a quantitative method based on an arbitrary grading system to establish a supragingival calculus index. Analysis was performed, using 2-factor (trial 1) and a 3-factor (trial 2) analysis of variance.

Results indicated that dogs removed calculus from their teeth by chewing rawhide; some teeth were cleaned better than others. The optimal amount or frequency of rawhide treatment was not necessarily determined.

It was determined that regular consumption of up to 3 rawhide strips/d for 3 weeks was safe. Processed biscuits were sometimes effective in removing calculus from dog's teeth; however, biscuits were not as effective as the rawhide in removing supragingival calculus.

In dogs, hard dental calculi are formed from microbial plaque by growth and death of bacterial populations, secretion of bacterial mucopoly saccharides, and deposition of calcium carbonate and small amounts of apatite. These factors are correlated with gingivitis, periodontitis, and plaque. For a long time, oral debris has been thought to be associated with gingivitis, and it has been stated that if teeth are kept clean, periodontal disease will not develop. Saxe et al found that in areas of the mouth of dogs, where debris and calculus are permitted to accumulate, the health of the periodontium rapidly deteriorates; in areas kept clean, little change occurs. Sorensen et al determined in Beagles that calculus scores tended to parallel gingivitis scores, and that the observed pattern of distribution of calculus and similar pattern and severity of gingivitis with age agrees with findings of others.

It has been documented that dogs have clinical and histologic signs of periodontal disease earlier and to a greater degree when maintained on a soft rather than hard diet.

Previous studies have confirmed that in dogs, dental calculus accumulation can be decreased by regular feeding of rawhide, and that it is feasible to prevent the accumulation of dental calculus in Beagles by regular weekly feedings of rawhide. These studies indicate that the mechanical action of chewing firm to hard substances regularly may remove dental calculus and prevent calculus accumulation in dogs.

The purposes of the study reported here were to determine the effect of rawhide chew treats and baked cereal biscuits on the removal of dental calculus in Beagles and to determine whether any harmful effects might be observed as a consequence of regular offering of rawhide to dogs.

Materials and Methods

Study population—Retired breeding Beagles (n = 67; either gender) were allotted to 2 groups for the study. In trial 1, 16 dogs were offered rawhide and 16 were offered biscuit. In trial 2, 20 dogs were offered rawhide and 15 were offered biscuit. In addition to the rawhide or biscuit supplements, at 4:30 PM daily all dogs were fed a commercial dry dog food that was adjusted for caloric intake according to body weight. Dogs offered biscuit had their dog food diet reduced by the amount of calories provided by the biscuit. Water was provided ad libitum.

The dogs were offered rawhide or biscuit 3 times daily for 3 weeks—at 9:00 AM, 1:00 PM, and 4:00 PM as follows: dogs given biscuit were given 10 pieces daily divided into 3, 4, or 3 pieces for the respective time points. Dogs given rawhide were given one piece at each time point.

Acceptability scoring—Immediately before any new rawhide or biscuit was given at the next time

From the Animal Resources Center, Harvard Medical School, 655 Huntington Ave, Boston, MA 02115.

*Chew-eez, For Small and Medium Dogs, Superior Brands Inc, Quincy, Mass.
*bMilk Bone, Medium Biscuit, National Biscuit Co, New York, NY.
*Agway Prolab Canine 2000 Dry Kibbled Dog Food, Agway Inc, Syracuse, NY.
Statistical evaluation — The teeth were paired (right and left) and grouped according to the following scheme for statistical analysis: maxillary fourth premolars; maxillary second and third premolars; mandibular third and fourth premolars; maxillary canine teeth; and all teeth examined (as one group). In addition, a subpopulation of dogs was identified that had a complete set of premolar teeth. Only premolar teeth in this subpopulation were evaluated and grouped into maxillary second and third premolars and mandibular third and fourth premolars.

Results were expressed as percentage change in calculus area (trial 1) and CI (trial 2) relative to calculus area or index (CalAI) at time 0 weeks (T₀), or time from 1 to 3 weeks (Tₓ), that is % change (Tₓ - 100 × [CalAI(Tₓ) - CalAI(T₀)]/CalAI(T₀). If a negative value was obtained, the result expressed removal of dental calculus; if positive, the result equaled dental calculus deposit. The data for percentage change were, essentially, normally distributed.

The first set of analyses tested to see whether there was a change in amount of calculus after either treatment. Analysis was performed, using a 2-factor analysis of variance, where factor 1 was time in treatment and factor 2 was dog. To control for multiple measurements (2 to 4 teeth from each dog was studied in each analysis of variance), a variable representing tooth was “nested” in the dog factor. Pairwise t tests compared the means fitted by the model for each week, and P values required to achieve significance were adjusted based on the number of pairwise comparisons made (eg, for 3 comparisons, P = 0.05/3 = 0.167).

The second set of analyses tested to see whether there was a difference in the change in amount of calculus between the 2 treatment groups. Again, analysis of variance was used, here with 3 factors: factor 1 was treatment group, factor 2 was time in treatment, and factor 3 was dog. Tooth was again “nested” in dog to control for multiple measures contributed by each dog. The t tests were performed as for the first analyses.

Results of the effect of time on calculus change/removal were constructed as bar graphs. The height of the bar represents the means fitted by the statistical model, and the error bars represent the SEM.

All statistical analyses were performed, using a statistical program² and a personal³ or mainframe computer.

Results

Effect of Rawhide and Biscuit on Removal of Dental Calculus as a Function of Time

Maxillary fourth premolar — Rawhide and biscuit each had a significant effect on removal of dental calculus from dogs of trial 1 (Fig 1). After 3
weeks of treatment, rawhide had removed a mean of 62.6% of the calculus, whereas biscuit had reduced 6.3% of calculus (rawhide $P = 0.0011$ and biscuit $P = 0.0366$). The effect of rawhide was significantly ($P = 0.0002$) greater than that of biscuit. Rawhide removed dental calculus at a significantly ($P = 0.0024$) higher rate (change in calculus coverage per time unit). In dogs of trial 2, only rawhide had a significant ($P = 0.0001$) effect, removing 33.1% of calculus after 3 weeks.

**Maxillary second and third premolars**—In dogs of both trials, rawhide had a significant effect on removal of calculus; after 3 weeks, 45.6% ($P_1 = 0.0002$) and 32.5% ($P_2 = 0.0004$) of calculus were removed (Fig 2). Such effect was not attributable to biscuit in the first trial and only at borderline significance ($P = 0.0793$) in trial 2, with 5.9% removed after 3 weeks. A significant ($P = 0.0001$) difference in effect between rawhide and biscuit in trial 2 was evident (rawhide had greater effect).
whereas in trial 1, rawhide was associated with a significantly ($P = 0.0014$) higher rate of calculus removal.

**Mandibular third and fourth premolar**—The effect of rawhide and biscuit on removal of calculus from these teeth was not significant in trial 2 (Fig 3), although an overall decrease in calculus could be observed. In trial 1, biscuit had a significant ($P = 0.0031$) effect on removal of calculus from these teeth, with 17.3% of the calculus removed after 3 weeks. In neither study was any significant difference between rawhide and biscuit observed, either in total effect or in rate of removal.

**Maxillary canine teeth**—The effect of rawhide and biscuit on calculus removal from these teeth was minor (Fig 4); however, gradual reduction of calculus was seen in dogs fed rawhide in both trials. Only in trial 1 was the result borderline significant ($P = 0.040$), with 15.6% of the calculus removed after 3 weeks. Biscuit had a borderline significant ($P = 0.0205$) effect on removal in trial 2, with 4.2% of calculus removed after 3 weeks.

**All teeth examined (appraised as one group)**—The overall effect of rawhide and biscuit on the entire dental sets examined indicated that rawhide decreased calculus considerably, although only significantly ($P = 0.0001$) so in trial 2, with 19.4% removed after 3 weeks. In trial 1, there was a borderline significant ($P = 0.0704$) difference between rawhide and biscuit in favor of rawhide, whereas in trial 2, rawhide had significantly ($P = 0.0001$) more effect and at a significantly ($P = 0.0179$) higher rate of removal (Fig 5).

**Dogs With Complete Premolar Dental Sets**
In a subpopulation of dogs, the maxillary second and third premolars and mandibular third and fourth premolars were compared with those teeth in dogs of the total population. One difference observed between this subpopulation of dogs and the total population was significant: the effect of rawhide on removal of calculus from mandibular third and fourth premolars in both trials (Fig 5). After 3 weeks, 28.8% of calculus was removed in trial 1 ($P = 0.0403$) and 20.8% was removed in trial 2 ($P = 0.0003$); in trial 2, rawhide was significantly ($P = 0.0254$) more effective at a significantly ($P = 0.0091$) higher rate of removal than was biscuit. The effect of biscuit on dental calculus on mandibular third and fourth premolars for this subpopulation was similar to that in the total population in both trials.

The effect of rawhide and biscuit on calculus
change on the maxillary second and third premolars was similar to that found in the total dog population in both trials (Fig 7).

ACCEPTABILITY OF DIETARY SUPPLEMENTS AS A FUNCTION OF TIME

Results of both trials revealed a strong relationship between acceptability and treatment time for rawhide. In trial 1, acceptability during week 1 (0.443) was significantly smaller than that (0.610) during week 2 ($P = 0.0001$), and acceptability during week 2 was significantly ($P = 0.0001$) smaller than during week 3 (0.776). In trial 2, acceptability of rawhide was significantly ($P = 0.0005$) smaller during week 1 (0.592) than during week 2 (0.705), whereas significant difference between week 2 and week 3 was not detectable (Fig 8). In both studies, mean acceptability of biscuit was significantly higher than that of rawhide ($P_1 = 0.0001$ and $P_2 = 0.0109$).

OBSERVATION FOR ADVERSE EFFECTS

There were no detectable adverse effects from chewing and/or consuming rawhide. Undigested pieces of rawhide were not found in the feces.
Discussion

If rawhide and cereal biscuits are indeed products that, when chewed, have the ability to remove dental calculus, one would expect to find a relation between calculus removal and their use as a function of time and acceptability. In the study reported here, we found strong evidence to support this premise for rawhide and some evidence for biscuit.

In our study, using 2 methods, we were able to measure supragingival calculus and calculus removal as a function of time and acceptability. Because some dogs had a great deal of calculus at baseline measurement and others had little, the change in the absolute amount of calculus during the course of treatment did not capture the true effectiveness of treatment. This aspect of the data was dealt with by expressing the calculus values as percentage changes from baseline, which accommodated the varying amounts of calculus at baseline. All dogs served as their own controls on the basis of establishment of time-zero baseline value.

A second issue was lack of independence among the measurements (eg, 2 studies, 2 treatment groups, and 7 teeth groups). This "nested" situation must be accommodated and "controlled" in statistical testing, and to ignore it would lead to understimating the variability among teeth. Analysis of variance was used to address this issue.

The rationale for using 2 methods to measure accumulation of dental calculus was as follows: Trial 1 used a quantitative method based on the actual measurement of the area of calculus on a tooth. Trial 2 used a quantitative method based on an arbitrary grading system to establish a supragingival CI. We chose the method of trial 1 on the assumption that an actual measurement of calculus may yield a more exact picture of any change in calculus amount. We chose the method of trial 2 because indexing systems have been used in past dental studies of human beings and dogs. The purposes of both methods were to provide an objective basis for evaluating the amount of calculus, to establish a baseline, and to determine a change in amount of calculus over time. Both methods indicated similar trends in the results. The indexing method (trial 2) was much less time consuming.

On the basis of precedence,14 we decided to use a selective sampling of teeth, which was based on available information regarding the prevalence of calculus13 and periodontitis14 in Beagles, as well as providing adequate numbers of teeth for statistical evaluation. Previous studies9,20 indicated that oxtails and biscuits had the greatest and most rapid effect on the molar teeth, but had less of an effect on incisors, canine teeth, and premolars. Therefore, we wanted to evaluate more non-molars and only one functional molar (maxillary fourth premolar) tooth. In addition to tooth selection, we chose to study nonoccluding surfaces (buccal) on which calculus would be least affected by normal mastication.

To evaluate the effect that rawhide and biscuit had on calculus removal, it was necessary to assess change as a function of time. Because these products work by mechanical action, it was hypothesized that with longer use and increased acceptability, there should be greater calculus removal. Both these findings were true for rawhide, similar to findings for chewing of oxtails in a previous study.8 In that oxtail study, oxtail use had prophylactic as well as therapeutic value. We believe it is reasonable to expect that rawhide also would have prophylactic value, because its therapeutic value was documented in our trials.

Our study did not necessarily establish the amount and frequency of rawhide or biscuit feeding required to obtain optimal effectiveness of calculus removal; however, it did establish that there was effective removal over the 3-week period at the dose used (3/day) for rawhide.

Calculation was removed from the buccal surfaces of maxillary premolars to a greater extent with rawhide than with biscuit. It is interesting that calculus was effectively removed from a nonoccluding surface (ie, a surface not in function). Neither product removed a great deal of calculus from the canine teeth. This presumably is attributable to the fact that dogs do not chew with their canine teeth, but rather with their premolars and molars.

Contrary to what was observed for the maxillary premolars, the rawhide seemed to have no effect on removal of calculus on the mandibular third and fourth premolars for the total population, whereas a great effect was seen in the subpopulation of dogs with complete premolar dental sets. Conditions were not set on dogs used in the study, except that they were retired breeding dogs, with some degree of dental calculus, and no dogs were excluded from the study. It was noticed during routine examinations that some dogs were missing one or more of the maxillary second and third premolars and/or the mandibular third and fourth premolars, but none of the other examined teeth were missing. When results of statistical analysis were available (no data processing was done until the end of trial 2), the difference in effect of the additives between maxillary and mandibular true premolars surprised us. It was sensible to search for some explanation of this difference in the available data. To prevent the generation of "false-positive results" ascribed to an excess number of comparisons (5 of 100 comparisons will by chance indicate some level of significance if the 95% bracket is used), we decided only to look at dogs with complete premolar dental sets. Because data from each examined tooth were entered separately into the database, it was possible to separate dogs with complete premolar dental sets from dogs with one or more missing premolars. Results of calculus removal on mandibular third and fourth premolars in
this subpopulation were more in line with those seen for the second and third maxillary premolars. Whether these results were attributable to a true difference in effect or just an expression of statistical manipulation is unclear, but it is our opinion that the results are valid. The difference of effect in the subpopulation was seen only in dogs fed rawhide.

Even when the data were analyzed for all teeth measured as one group, it was clear that rawhide removed calculus considerably better than did biscuit for the study period.

A strong relationship between acceptability and time for rawhide was evident, whereas biscuit was accepted from the start. Some dogs would never chew or indicate any interest in rawhide; other dogs would chew it readily from the start, but would not consume it; others would consume it completely.

Results of our study indicate that this type of rawhide product is safe for dogs. Not a single detectable complication from consuming rawhide was found, even in dogs that consumed 3 rawhide strips/d for 3 consecutive weeks.

References