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SMALL ANIMALS

Raw beef bones as chewing items to reduce dental calculus in Beagle dogs

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Objective Evaluate the effect of raw bovine cortical bone (CB) (medullary bone cross-sectioned) and marrow or epiphyseal 'spongy' bone (SB) as chew items to reduce dental calculus in adult dogs.

Methods Eight 3-year-old Beagle dogs were observed in two study periods. In the first study, the dogs each received a piece of bovine femur CB (122 ± 17 g) daily and in the second study, a piece of bovine femur SB (235 ± 27 g). The first study lasted 12 days and the second 20 days. Dental calculus was evaluated using image integration software.

Results At the start of the studies, dental calculus covered 42.0% and 38.6% of the dental arcade areas, respectively. In study one, the chewing reduced the established dental calculus area to 27.1% (35.5% reduction) after 3 days and after 12 days the dental calculus covering was reduced to 12.3% (70.6% reduction). In study two, the dental calculus covered 16.8% (56.5% reduction) after 3 days, 7.1% (81.6% reduction) after 12 days and 4.7% (87.8% reduction) after 20 days. The CB remained largely intact after 24 h, but SB was reduced to smaller pieces and in some cases totally consumed after 24 h. No complications such as tooth fractures, pieces of bone stuck between teeth or intestinal obstructions were observed during the studies.

Conclusions Chewing raw bovine bones was an effective method of removing dental calculus in dogs. The SB bones removed dental calculus more efficiently in the short term.

Keywords dental calculus; dogs; oral health; raw beef bones; teeth

Abbreviations CB, cortical bone; PD, periodontal disease; SB, 'spongy' bone

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Periodontal disease (PD) is the most common oral disease observed in dogs (*Canis familiaris*). It has a reported prevalence of 50% and 88% in dogs older than 3 and 5 years, respectively, and affects as many as 95% of dogs older than 12 years.[1,2] It has been described as an inflammatory disease of microbial origin, involving gingiva, alveolar mucosa, periodontal ligament and cementum.[3] Symptoms associated with PD include halitosis, dental plaque and calculus, inflammation and gingival bleeding, tooth mobility and migration, alveolar bone losses and gingival recession in addition to animal behavioural disorders.[4,5] Tooth loss is common in advanced PD.[6] Dental plaque is the start of PD and consists of approximately 80% water and 20% organic and inorganic solids; 80% of the solid fraction is composed of bacteria.[7] Dogs have a wide range of bacteria in the oral cavity and specific species have been shown to play significant roles in the development of PD.[8] Plaque initially establishes on the tooth's enamel surface and without periodic mechanical removal, such as with appropriate chewing or tooth brushing, it becomes thicker and matures; minerals present in the saliva or in the gingival fluids, plus food materials, mineralise the plaque to form calculus.[4] The alkaline pH of dog's saliva (~7.5[9]) provides a favourable environment for mineralisation and calculus formation.[5,10,11]

Many pet dogs are fed dry extruded and wet diets that do not control plaque formation, as they are not sufficiently abrasive to keep the teeth clean.[12] It is the authors' belief that most dog owners are not willing or able to carry out tooth brushing on their dogs and therefore this serious health problem may develop and progress. Some commercial products have been introduced to reduce or prevent dental calculus formation; they generally rely on a mechanical scraping effect on the teeth, such as rawhide chews or dental diets. In addition, a few have a chemical effect (sodium polyphosphates) that interferes with the mineralisation of calculus.

Bones are a natural component in the diet of wolves and wild dogs.[13,14] Additionally, dogs have a strong desire to chew bones, which has been shown to keep calculus low.[15] The masticatory apparatus of carnivores has evolved to chew meat and bones.[14]

The objective of the present study was to compare the effect of chewing on bovine raw cortical or 'compact' bone (CB) from femur diaphysis, to bovine raw 'spongy' bone (SB) from the femoral epiphysis, as agents to reduce established calculus in adult Beagle dogs.

Materials and methods

The Animal Care Committee approved the procedure according to Brazilian national guidelines.

Animals

The study was conducted in two periods using eight healthy adult (3 ± 0.5 years) Beagle dogs (4 males, 4 females). The dogs had never undergone professional dental cleaning and did not receive any regular tooth brushing or food containing chemicals (sodium polyphosphates) to prevent dental calculus accumulation.

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Study periods and bones

The procedures in both trials were similar, except for the type of bone given to the dogs and the duration of the study.

In the first study, the dogs received a piece of CB daily for 12 days. Any remaining bone piece was removed each day before offering a new piece. The second study with SB started 7 months after finishing the first study to allow build-up of new dental calculus in the dogs. The second study lasted longer, 20 days, to see if a longer period could further improve the results.

Fresh bones were supplied from a commercial slaughterhouse registered and inspected according to Brazilian national laws. Raw bovine femur was chosen for the study because of its large and uniform size and its suitability for cutting into appropriate pieces. From practice, it is known that some owners give pieces of raw bovine femur, obtained from butchers or supermarkets, to their dogs. The CB was cut into smaller pieces using an electric band saw to obtain pieces of approximately 4 cm length (122 ± 17 g). For SB the average weight was 235 ± 27 g and approximately 5 cm in length. The reason for the weight difference between bones was mainly that the diameter was wider for the SB. These pieces were considered too large to be swallowed whole by the dogs. The bones were stored at −18°C and thawed at room temperature before being offered to the dogs.

Housing and diet

During the study, the dogs were kept individually in stainless steel cages with dimensions 80 × 70 × 90 cm (height × wide × depth) and were taken for a walk on a leash and play for 2 h/day. They were fed twice daily with a non-dental dry extruded complete commercial diet to meet their approximate daily maintenance energy requirements (130 kcal metabolisable energy × body weight $(kg)^{-0.75}$/day).[16] Water was provided ad libitum.

Calculus assessment

The surface area of the teeth covered with dental calculus was determined from initial images of the left and right sides of the dog's dental arches on day 0. Images were obtained with a semi-professional camera fixed approximately 150 mm from the dog's mouth. In addition to day 0, images were obtained on days 1, 3, 7, 9 and 12. In the second study, additional images were obtained on days 14, 17 and 20.

The teeth evaluated were the canines, premolars 1-4 and molars 1 and 2 of all arcades. The images were analysed by Image-Pro® Plus software for Windows using the integration surface tool, adapted from Abdalla et al.[17] Each image was integrated by drawing the outline area of each tooth evaluated, to calculate the dog's total dental arcade area. Next, each image was evaluated by only drawing the integrated teeth outline areas covered by calculus. Comparison of the total area and calculus-covered area was performed using the same images to assess the proportion of calculus (Figure 1). Dental examinations to reveal complications were performed daily.

Statistical analysis

All discrete data were analysed by Student's t-test and equations were generated to show the calculus reduction according to trial time. Analyses were performed using Statgraphics© Plus 4.1 for Windows and Microsoft® Office Excel 2007, and $P < 0.05$ was considered significant.

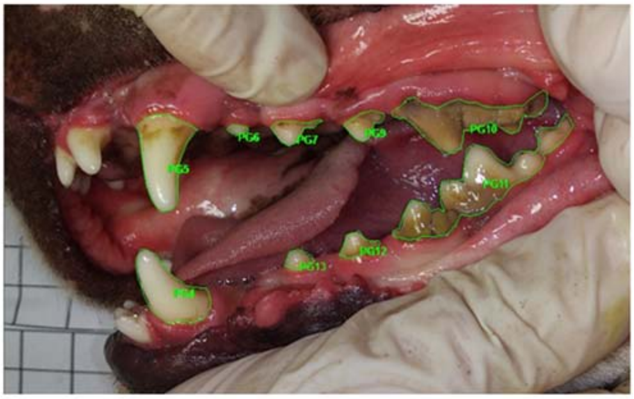
Results

All dogs accepted the bones well and started chewing on them immediately. The exact time spent on chewing was not recorded, but the general impression was that dogs spent several hours every day on this activity. The CB pieces showed only bite marks and in most cases were emptied of marrow. The SB was softer than CB and the pieces were reduced to smaller portions or sometimes completely ingested before the next piece was offered (Figure 2).

Heaviest formations of dental calculus were on the distal teeth and secondarily on canines and then the premolars. At the start of the first study with CB bones, dental calculus covered 42% of the total surface of each dog's dental arcades. After 3 days of chewing CB, a mean reduction of 35.5% ($P < 0.05$) was observed. After this period, the reduction continued and at day 12, the mean reduction was 70.6% ($P < 0.05$) and only 12.3% of the teeth area was covered by calculus.

After the first study, a 7-month period followed, which allowed a 38.6% dental calculus build-up in a similar pattern to that initially seen in the first study. After 3 days of SB supplementation, a higher

(a)



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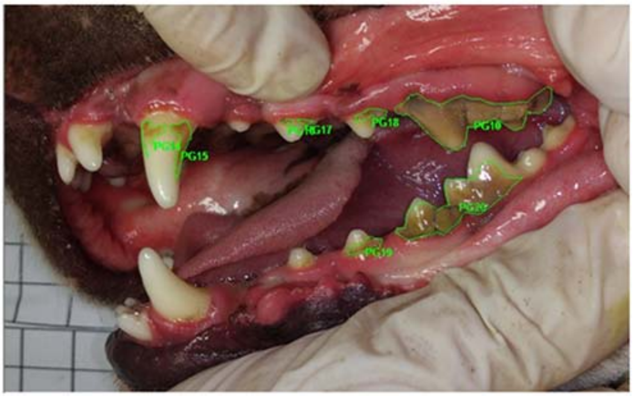

Figure 1. Lateral view of one experimental dog's dental arcade showing the use of the integration surface area software. (a) Total area of the teeth; (b) teeth area affected by calculus. Note that the maxillary PM4, M1 and M2 are not individually obvious as they are obscured by the degree of calculus present. Additionally, the mandibular PM1 is absent. PM, premolar.

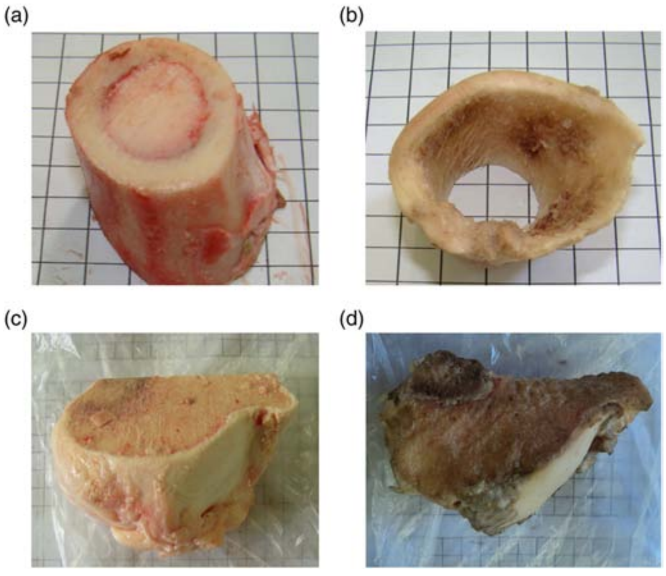

Figure 2. (a) Cortical bone portion before supplementation; (b) cortical bone portion leftover 24 h after chewing by one of the Beagle dogs. (c) Spongy bone portion before supplementation; (d) spongy bone portion leftover 24 h after chewing by one of the Beagle dogs.

mean reduction of 56.5% ($P < 0.05$) was observed. At day 12, the mean reduction was 81.6% and only 7.1% of the tooth area was covered by calculus. On day 20, the dogs had only 4.7% of the teeth area covered by calculus.

In both studies there was a significant reduction in the accumulated dental calculus after 3 days ($P < 0.05$) and SB showed better results than CB. After 12 days the reduction in dental calculus was similar between bone types ($P = 0.09$). The reductions attained by day 12 were greater than those achieved by the third day ($P < 0.05$), but as expected the reduction per day was less than during the first 3 days. Supplying SB for either 12 days or 20 days did not give any significant difference ($P > 0.05$) in calculus reduction.

Polynomial equations were generated to demonstrate the dental calculus reduction over time according to the type of bone supplied; both types presented significant reductions in the first 3 days of supplementation, with better results being observed with SB supplementation (Figure 3). A clear visual reduction in calculus accumulation was observed after the bone supplementation in the two studies (Figures 4, 5). In both studies, no complications, such as pieces of bones stuck between the teeth, dental fractures or intestinal obstructions, were observed.

Discussion

The soft texture of commercial diets promotes dental plaque and calculus formations in dogs.[12] Dietary texture has an influence on the build-up of dental plaque and calculus dependent on the mechanical forces induced on the teeth during mastication. Gawor et al. compared dry and wet foods and observed minor occurrences of mandibular lymphadenopathy (18% vs 45%), dental deposits (56% vs 83%) and PD (12% vs 55%). Dry foods may provide higher mechanical forces on the teeth during mastication compared with soft foods and it was concluded that the texture of the food can exert beneficial effects on an animal's oral health.[18] We have not found any reported evidence of the rate of calculus build-up in dogs that receive extruded dry food, so it was interesting to observe that dental calculus recurred to the same level as before the CB supplementation after only a 7-month period in this study. This fast development of dental calculus emphasises the importance of a regular home oral care program.

The effect of dietary chemical composition and pH can also influence dental calculus deposits. It has been demonstrated that a 5% oral solution of glucose or urea resulted in a decrease or increase in saliva pH, respectively.[19] Because calcium salts are more predisposed to deposit in plaque in an alkaline environment,[10] high pH can have a direct effect on dental calculus formation. Dogs and cats naturally have more alkaline oral fluids than humans and therefore they have a more favourable environment for calculus deposition.[10]

A 4-year study with Beagle dogs demonstrated that a twice-daily meticulous tooth brushing program effectively maintained the dog's

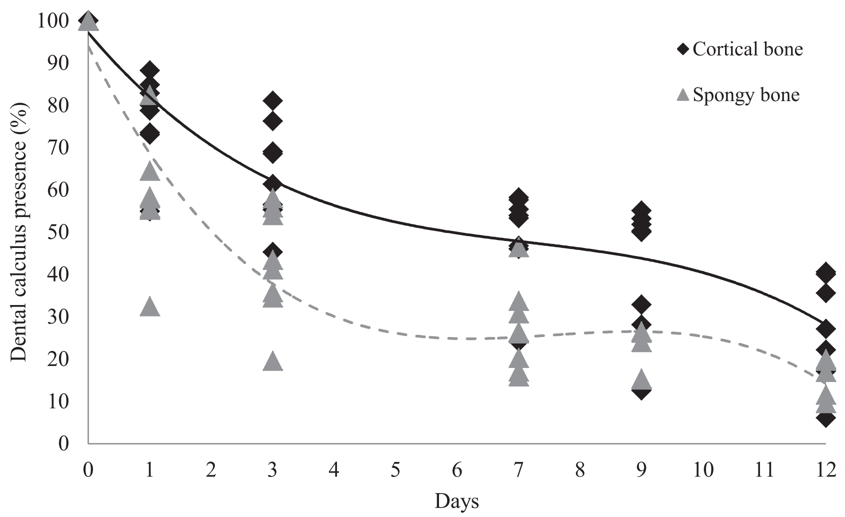

Figure 3. Dental calculus (%) related to initial presence, along the treatment period (days) according to each type of bone offered. Polynomial equations generated are: Cortical bone (black solid line): $y = -0.0996x^3 + 2.1491x^2 - 17.203x + 97.117$ ($r^2 = 0.82$). Spongy bone (grey broken line): $y = -0.1764x^3 + 3.9866x^2 - 29.078x + 93.882$ ($r^2 = 0.87$).

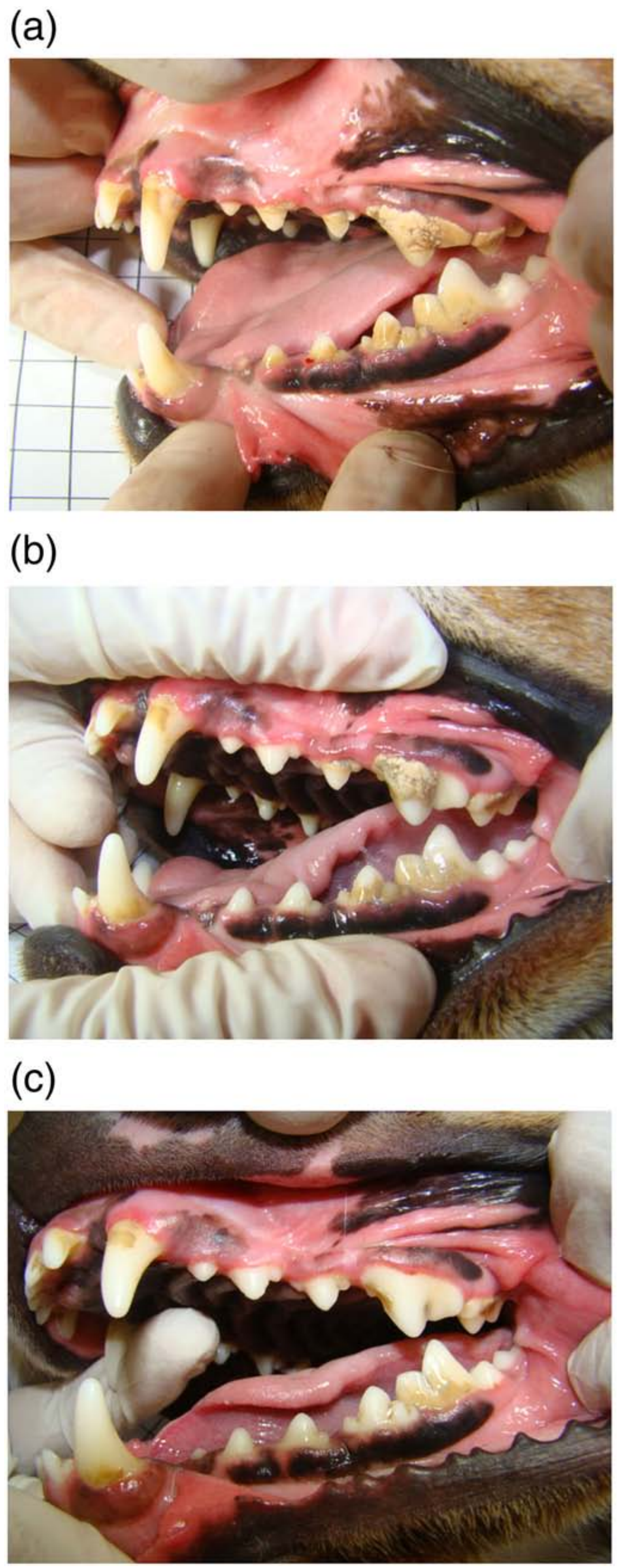

Figure 4. **Left dental arcade of the same dog at days 0, 3 and 12 (a-c, respectively) after daily raw cortical bone supplementation.**

normal healthy gingiva, including control of dental calculus.[20] As in humans, daily tooth brushing is therefore considered the most effective means to control dental calculus formation in dogs and is still the 'gold standard' in plaque control.[4] However, it has to be performed with a correct and appropriate brush and technique, otherwise the gingival tissue can be damaged[21] and the animal will become averse to the procedure. Lima et al.[22] demonstrated an effective reduction in the dental plaque index[23] in 7–12-year-old dogs with tooth brushing. The tooth brushing was performed for 1 min with two different types of brushes: a common children's soft toothbrush or a tooth stall. The dental plaque index (1–4) was reduced from 3.2 to less than 0.6 after brushing with either type of brush.[22] Another procedure that can remove moderate to heavy calculus formation is using calculus-cracking forceps followed by electromechanical scaling; however, these procedures must be performed only by veterinarians and only under general anaesthesia and must be carried out carefully to avoid damaging the oral structures.[24]

Studies that have examined dietary influences on the prevention or elimination of plaque and calculus formation in dogs have mainly used various index and score systems. The method we used has already been demonstrated to be more accurate than the traditional score or index systems.[17] More studies using this methodology are needed to standardise the procedure and to have a better base for comparing different applications for calculus prevention or reduction. The majority of studies evaluating dental calculus in companion animals are based on index evaluation systems that are difficult to compare directly with the results obtained in the present study using the integrative method. Thus, care should be taken in the comparison of the effect of various dietary supplementations on calculus prevention or reduction.

To reduce the amount of calcium involved in the mineralisation of plaque, dietary polyphosphate salts have been shown to chelate calcium salts and thereby diminish the rate of dental calculus matrix build-up.[4] In 4-week studies, a daily biscuit containing 0.6% sodium pyrophosphate reduced canine dental calculus index by 18.9%.[25] One study of daily supplementation of biscuits coated with 0.6% of sodium hexametaphosphate decreased calculus formation by 46% compared with controls,[26] and another found that the same supplementation decreased dental calculus formation in Beagle dogs by almost 80%.[27] Others have found a difference between supplements added in the mash or coated on the kibble.[28] Their 3-month study found that sodium tripolyphosphates reduced calculus by 24.2%, only when coated on the kibble and sodium hexametaphosphate reduced dental calculus formations by 34.2% when added in the mash and 47.6% as a coating.

Lage et al.[29] found that the overall effect on supragingival dental calculus removal was significantly better with supplementing rawhide chews (19.4% dental calculus reduction), compared with that of biscuits over a period of 3 weeks but the authors reported an uneven tooth cleaning effect with both products. Others found that supplementation of a soft rawhide chew product in 6–11-year-old Beagle dogs for 4 weeks reduced dental calculus scores by 28.2%, total tooth plaque scores by 18.5% and gingivitis scores by 45.7% compared with the control group.[30]

(a)

(b)

(c)

(d)

(e)

Figure 5. Left dental arcade of the same dog at days 0, 3, 12, 17 and 20 (a-e, respectively) after daily raw spongy bone supplementation.

The different histological characteristics of the bovine femurs used in the present study allowed a comparison between bones with a porous structure versus a solid or compact structure. After the first 3 days of bone supplementation, the reduction in calculus was greater with SB (56.5%) than with CB (35.5%). However, after 12 days the effect of the bone type was similar (81.6% vs 70.6% reduction, respectively). The better effect of SB at the start of the study may be explained by the way the dogs bite and chew the SB. The possibility for the dog's teeth to penetrate the bone's structure increases the area of contact between the teeth and the bone, generating sufficient mechanical friction to scrape off the calculus. With the harder CB bones this result required more work and took longer.

Compared with the other dental calculus control methods already discussed, except for tooth brushing, bone supplementation in our study showed similar, or better, effect than in studies of polyphosphate use and rawhide chews. When comparing the effectiveness of raw bones and hides, we speculate that a bone will last longer and that chewing will be more intense.

In our study, we compared two types of raw bones. We were encouraged to perform the study because of anecdotal reports from dog owners telling of the positive effects of bone supplementation on dental calculus prevention. Additionally, the teeth of wild carnivores that base their diet on whole carcases show low occurrence of dental disease.[14] Furthermore, dogs seem to enjoy bone chewing. The types of bones used in this study provided a long-lasting chew activity object for the dogs and therefore had a positive effect both on oral health and animal welfare.

We acknowledge the risk of raw bones, as for raw dog food in general, being contaminated with pathogenic bacteria such as *Salmonella*, which could infect humans.[31–34] However, the proportion of humans infected by handling raw meat intended for pets or by handling their pets contaminated environs remains unknown, even though this is a potential form of transmission.[35] Oesophageal and gastrointestinal obstructions, tooth fractures and digestive problems are also reported risk factors to consider when supplying the types of bones that we did in our studies and these are concerns that veterinarians and dog owners should appropriately consider. However, we did not observe any such complications during the course of the study.

There is ample subjective opinion, but scant scientific information, on the effects of providing raw bones as chew objects to reduce or prevent dental calculus formation in dogs. However, a review article about PD[15] described several pilot studies performed with bone supplementation for dogs and cats with the objective of maintaining an animal's oral health. In all of those studies, the authors were generally in favour of bone supplementation and considered raw bones to be safer than cooked bones.

Raw bones are a component of the wild carnivore diet and reports of wolves show that they have little dental calculus.[14] Calculus formation may still occur in wild animals, but probably not as pronounced as in domestic dogs fed only commercial diets. Many dog owners choose to give raw bones in addition to a commercial diet; a recent study showed that one-third of dog breeders from the USA and Canada offered raw bones to their dogs on a regular basis.[36]

Conclusion

The present studies have demonstrated that raw bovine femur supplementation is a viable method of reducing dental calculus formation in dogs. The SB removed calculus most efficiently in the short term. To the authors' knowledge, this is the first study to introduce an effective home oral care technique to remove established dental calculus in dogs.

Acknowledgments

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