

Dental Plaque Prevention and Control in Dogs and Cats: Current and Emerging Concepts

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Abstract: Periodontal disease is very common disease of dogs and cats where interplay between dysbiotic microbial communities organized in dental plaque and aberrant immune responses play the most important roles. To prevent periodontal disease development and/or progression, dental plaque must be disrupted as often as possible. This is primarily achieved by mechanical (active) means, combining professional oral care and daily tooth brushing at home. If an adequate technique and timing of tooth brushing is difficult to achieve, other active and passive oral homecare measures are available or being explored.

Introduction

Periodontal disease is very common disease of dogs and cats (1, 2). Gingivitis is the first stage of periodontal disease, where gingiva only is inflamed and the disease is completely reversible in this stage with removal of plaque. However, if gingivitis is left untreated, it may progress to irreversible destruction of the periodontium (periodontitis), including bone loss, and may lead to loss of tooth function and ultimately tooth loss. As opposite to gingivitis, periodontitis is only partially reversible (2). Periodontitis may develop very early in some breeds of dogs and it is in general more prevalent in small breed dogs (3, 4). The reasons for development and progression of periodontal disease are not fully understood, but an interplay between microorganisms and host response is likely playing a major role and oral care contributing significantly (2). While periodontal disease development usually has chronic course, recently, in cats, early-onset gingivitis, that can progress to aggressive periodontitis and/or stomatitis has been described (5). Such findings are not always detected clinically upon examination of an awake animal, and therefore detailed oral examination under general anaesthesia with dental radiographs (at minimum) are mandatory to fully evaluate the extent and severity of periodontitis and plan appropriate treatment (5).

Dental plaque as a cause of periodontal disease

Oral microbiome of humans and, similarly, animals is abundant with hundreds bacterial species, but also includes fungi, protozoa and viruses (6 - 11). Etiology of periodontal disease is multifactorial with interplay between dysbiotic microbial communities organized in dental plaque and aberrant immune responses having the most important roles leading to chronic inflammatory alterations of the tooth supporting apparatus (periodontium) (9, 12). Development of dental plaque is an orchestrated process, that starts with initial coating of the dental surface with a pellicle to which bacteria then adhere and start organizing into a mature biofilm (13). Plaque formation precedes calculus formation, with plaque serving as an organic matrix for the subsequent mineralization. The pathogenic potential of dental calculus is not clearly defined, but it serves as a plaque-retentive surface (14).

Dental plaque prevention and control

Professional oral care

To prevent periodontal disease development and/or progression, dental plaque must be disrupted as often as possible. Antibiotic use in patients with periodontal disease has to be carefully considered (rarely used) and the treatment is primarily mechanical (9). The treatment of periodontal disease always starts with basic periodontal therapy (professional dental cleaning) that primarily includes supra- and subgingival scaling using power and/or hand instruments (2). Polishing is debatable, but air-polishing is preferred method in humans with some potential to help remove pathogenic biofilms subgingivally (15). Some loss of the tooth structure occurs during polishing (16). Although professional oral care is by many recommended annually, there are no clear guidelines neither in veterinary nor human medicine on the most appropriate recall intervals for professional oral care and the decision should be made individually for each patient based on their periodontitis risk (17, 18).

In cases of advanced periodontal disease, basic periodontal therapy is in veterinary dentistry followed by periodontal debridement, root planing, periodontal surgery and any extractions as clinically indicated mostly under the same anaesthetic event.

Oral home care

Oral home care should be instituted early in the life of an animal (when deciduous dentition is present) and continued throughout life. Moreover, without oral home care, the benefits of professional oral care are short-lived as dental plaque starts to develop within hours after its' removal. Therefore, oral home care should be (re)instituted as soon as possible after professional oral care (2).

Active mechanical removal of plaque by daily tooth brushing (soft tooth brush), with or without a toothpaste, is still considered the gold standard of oral home care as it provides untargeted removal of the microbiota (19). The use of toothpaste is not crucial for effective tooth brushing, but it may additionally reduce the number of oral bacteria in dogs (20). If toothpaste is used, it may improve patient acceptance of oral care routine. Human toothpastes must not be used as some ingredients can be toxic to animals. Tooth brushing is more than three times as effective at controlling dental plaque accumulation compared to using a daily dental chew or dental diet alone as evaluated using a clean-tooth model (i.e., after professional oral care was performed) (21). Tooth brushing has a positive effect on the oral health in dogs as soon as 7 days after commencement, but the effects are nullified after 2 weeks without brushing (22). Tooth brushing should start at an early age and be introduced gradually. Adequate technique (brushing horizontally and then from the gingiva towards the crown

of the tooth with a tooth brush held at a 45-degree angle to the tooth) has to be employed for 30 – 60 seconds on each side of the mouth (3 – 4 strokes). Ideally, all surfaces of the teeth are brushed, but it is advisable to start with buccal surfaces of the maxillary teeth, that are the easiest to reach (23). Thiol-detection test can be used to assess tooth brushing efficacy (22). While tooth brushing performed every other day (24) or even weekly (25) is still efficient with regards to reduction of dental deposits even without prior professional oral care, the recommendation is to perform tooth brushing daily and complementing it with professional oral care (23, 26, 27). Only daily tooth brushing resulted in significant reduction of gingivitis in one study (25). Soft tooth brush can also be effectively replaced by an ultrasonic tooth brush or specifically designed clothes, as long as these are used daily (28). Also, animal owners/carers need to be regularly encouraged to keep the habit of daily tooth brushing as compliance is often lost (29, 30), particularly in cats (31).

If an adequate technique and timing of tooth brushing is difficult to achieve, other oral home care measures are often recommended. These measures may rely on mechanical action (active means), chemical or modulatory action (passive means) or a combination of both. Active ingredients as well as the form of products may vary greatly. Data on their efficacy with regards to prevention of plaque and/or calculus accumulation are known for some, although the active ingredients are not always fully described. In general, vast array of products is available on the market and the veterinarian is highly encouraged to practice evidence-based medicine also when recommending a specific oral home care product to the client. One can also look up the Veterinary Oral Health Council (VOHC) website (www.vohc.org), where certain products are listed, that meet pre-set standards regarding retardation of plaque and/or calculus accumulation. However, the efficacy of the products is usually tested relatively short-term and using a clean tooth model. At the same time, it needs to be stated, that obtaining a VOHC seal is voluntary and therefore the lack of VOHC seal on certain products does not indicate that these products are ineffective. A list of studies on specific active ingredients has recently been published by Barbosa et al. (32) and selected will also be further discussed in this review.

Chewing in general enables physiologic cleaning of the teeth, but it depends also on the chewing habits of the animal and material that is being chewed on (33, 34). Several types of diets, chews and edible treats (active means) are available for dogs and cats, but when providing chewing treat or toy to the animal, safety has to be considered as well. Hard chews may cause dental fractures and/or cause gastrointestinal obstruction if swallowed, although some data are favourable of using certain hard chews (35, 36). Soft and home-prepared diets have been associated with poorer oral health (37) and oral health-associated bacterial

taxa were lower in dogs fed wet food as compared to those fed dry food (38).

Commercially-available diets can affect dental plaque by mechanical and/or chemical action. Mechanical action is related to a diet's textural characteristics (i.e., size, shape and consistency designed to maximize contact with the tooth), while chemical action is in most diets attributable to polyphosphates added to the surface of the diet that impact calculus build-up (39, 40).

Chews and edible treats function similarly to commercially-available diets, mostly due to their mechanical and, in some cases, chemical action (27, 41 – 43). Daily addition of certain chews to the dry diet, even without previous professional oral care, was shown to significantly reduce plaque and calculus accumulation and create shifts in the oral microbiota beneficial to the oral health (44 – 47).

Dental (gingival) sealants are considered physical barriers to plaque and calculus accumulation and are meant to be applied immediately after professional oral care. Some products may need to be reapplied regularly by a veterinarian or veterinary technician. These products are considered to be safe and to reduce plaque and calculus accumulation in dogs (48 – 50). Some newer free radical-mediated (organo-selenium-containing) antibacterial light-cured resin dental sealants proven effective against plaque formation in humans (51) are now also available on the veterinary market, but there are no clinical studies available yet on the veterinary side.

Zinc ascorbate was found to decrease plaque accumulation, gingivitis and anaerobic periodontal bacteria in cats and it can also be used as an oral antiseptic gel after professional oral care (52). Similarly, adding xylitol to the drinking water was effective in reducing plaque and calculus accumulation in cats (53). Xylitol-containing products must not be used in dogs due to potential severe xylitol toxicity in this species (54).

Chlorhexidine (mostly gluconate form, 0,12% solution) has been the most commonly used oral antiseptic as it was long considered safe and efficient (55 – 57). However, data are emerging showing that chlorhexidine can cause bacterial resistance and/or tolerance, that can also affect efficacy of antibiotics (58, 59). Therefore, new concepts are being developed to overcome chlorhexidine shortcomings and still efficiently disrupt dental plaque build-up.

Emerging concepts in dental plaque prevention and control

Brown algae (*Ascophyllum nodosum*) have proven efficient in plaque and calculus control either in form of powder to be added to food or contained in edible treats. The exact mechanism of *A. nodosum* is still unclear, but changes in salivary metabolome were noted in dogs receiving the

product, which is possibly indicating inhibition or turn off of some pathways that enhance plaque and/or calculus development (60 – 62).

Nisin is a peptide produced mainly by *Lactococcus lactis*, with antimicrobial activity against several bacteria, both in their planktonic and biofilm forms. Nisin-biogel was tested first *in vitro* showing capability of disrupting plaque (polymicrobial biofilm) formation and influencing canine oral microbiome (63, 64). The potential of nisin-biogel to control plaque and help with control of periodontal disease was also initially validated in a clinical study (65). Other bacteriocins and delivery systems to improve their efficacy are also being investigated in human periodontology (9).

β -caryophyllene, a sesquiterpene plant derivative has several potential uses and has shown antimicrobial activity against canine dental plaque-forming bacteria *in vitro* and *in vivo* (66). Pomegranate extract was also tested *in vitro* as an antimicrobial agent and was found to limit the growth of certain canine oral bacterial species such as *Neisseria canis* or *Porphyromonas gulae*, even when organized in biofilms, thus showing potential as an oral care product (67). Efficacy of several other phytochemicals and nutraceuticals has also been considered and briefly explored for their antioxidant, anti-inflammatory, antibacterial, antiviral, and antifungal activities (32, 68, 69).

Daily ozonized ointment application for 7 days in dogs that received professional oral care was found to have an anti-plaque effect in a recent clinical study (70).

Modulation of oral microbiome by probiotics is another emerging concept in prevention and treatment of oral dysbiosis and periodontal disease. Certain *Lactobacillus acidophilus* isolates from dogs were shown *in vitro* and *in vivo* to be promising probiotic candidates to support oral health without systemic adverse effects in dogs (71). Similarly, dextranase enzyme and *Enterococcus faecium* probiotic were found effective as preventive agents to reduce oral biofilm in dogs without notable side effects (72). A composite probiotic used in cats was also found to modulate the feline oral microbiota by supporting beneficial or commensal bacteria and inhibiting oral pathogens (73). Further clinical studies are needed to determine efficacy and safety of probiotics for long term use.

Another emerging approach to oral microbiome modulation is via oral microbiota transplants (OMT). Although no difference in periodontal disease indices were found in one study between OMT-treated and non-treated groups of dogs with naturally occurring periodontitis, OMT was found to, at least transiently, modulate the microbiota composition in dogs and can be applied safely (74).

Conclusion

Dental plaque is recognized as a cofactor in development and progression of periodontal disease. While professional plaque control mainly bases on active mechanical measures, there is a variety of techniques and products available for oral home care, basing on passive and/or active measures. In addition, new concepts are being explored aiming also at prevention of plaque formation. Above all, client education is likely the key to providing optimum patient oral and dental care.

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Preprečevanje in nadzorovanje zobnih oblog pri psih in mačkah: trenutni in novi koncepti

A. Nemeč

Izvleček: Parodontalna bolezen je ena izmed najpogostejših boleznih psov in mačk. Pri nastanku bolezni pomembno vlogo igra predvsem mikrobiota ustne votline, organizirana v zobni plak, in imunski odgovor gostitelja. Preventiva in upočasnjevanje napredovanja parodontalne bolezni temeljita na preprečevanju nastanka zobnega plaka in/ali njegovem rednem odstranjevanju, ki je zlasti mehansko in vključuje profesionalno ustno higieno v kombinaciji z rednim dnevnim ščetkanjem zob. Če ustreznega dnevnega ščetkanja zob pri živali ni mogoče zagotoviti, pa ustno nego doma lahko zagotovimo z drugimi aktivnimi ali pasivnimi načini preprečevanja nastajanja zobnih oblog; nekateri načini so dobro opisani, nekateri pa se šele razvijajo.

Ključne besede: parodontalna bolezen; zobni plak; psi; mačke; ustna nega