



MONITORING THE PREVALENCE AND PREDICTORS OF DENTAL DISEASES IN DOGS

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Summary

Bilyi, D. D. & U. I. Voloboieva, 2025. Monitoring the prevalence and predictors of dental diseases in dogs. *Bulg. J. Vet. Med.*, **28**, No 3, 482–500.

The increase in the share of dogs with dental pathology against the background of the appearance of new probable risk factors (in particular, the introduction of new diets in feeding), determine the relevance of regular monitoring of the spread and predictors of oral cavity diseases. The determination of diseases of the oral cavity, as well as risk factors for their occurrence and progression was based on the analysis of anamnestic data, comprehensive assessment of the results of visual inspection, palpation, probing, and radiography. The obtained results indicated that among 990 dogs with dental pathology, 57.7% were small, 26.4% were medium, and 15.9% were large and giant breeds. Dogs had the highest risk of developing dental diseases, including plaque/calculus (17.2–40.5%), dental caries (20.4–31.9%), retained deciduous teeth (5.1–18.6%), traumatic injuries/fractures of teeth (1.9–19.1%), and abnormal wear (1.8–24.8%). Small dogs were most prone to plaque/calculus (40.5%), dental caries (31.5%), and retained deciduous teeth (18.6%); large and giant breeds were most prone to traumatic injuries/fractures of teeth (19.1%) and teeth attrition (24.8%). There was a correlation with age for certain dental diseases: the average age of small breed dogs was significantly ($P < 0.001$) younger than that of large and giant breeds for plaque/calculus (3.3 ± 0.6 vs 8.9 ± 1.2 years), dental caries (4.2 ± 0.8 vs 8.5 ± 0.8 years), and dental trauma/tooth fractures (2.8 ± 0.6 vs 9.1 ± 1.7 years). In terms of dental disease, the feeding regimen was one of the prognostic factors for increased risk of plaque/calculus formation, dental caries development, tooth trauma/fracture, and abnormal tooth wear. Regardless of breed, the best option was to use dry commercial feeds, and the worst one: the biologically appropriate raw food (BARF) feeding system. The susceptibility of breeds to dental diseases was proven: Yorkshire terriers to the formation of plaque/calculus (14.4%), dental caries (12.5%), and retained deciduous teeth (17.5%); German/Eastern European Shepherds to dental injuries/fractured teeth (13.2%) and teeth attrition (12.6%); Chihuahuas and Papillons to malocclusions (7.3%); Maltese dogs and Papillons to enamel hypoplasia (13.6%). Thus, a high incidence rate of oral cavity diseases in dogs was established, and breed and age susceptibility to the most common dental pathology was determined. The relationship between the feeding regimen and diet composition with the risk of developing oral cavity diseases was shown. Attention was focused on the importance of an individual diagnostic approach for dental diseases in dogs. The prospect of further research is the clinical implementation of computed tomography with the aim of a more accurate assessment of pathological changes in tissues due to dental diseases in dogs.

Key words: dogs, dental diseases, feeding regimen, prognostic factors, veterinary dentistry

INTRODUCTION

Currently, dental diseases in dogs remain an urgent problem in veterinary medicine. Diseases of the oral cavity are characterised by a variety of clinical manifestations. According to Justine & Makungu (2024), dental deposits, tooth loss, periodontal disease, teeth attrition and dental abrasion were frequently observed dental diseases. Kyllar & Witter (2005) reported periodontitis, calculus, tooth loss, and teeth attrition among the most often recorded dental pathology. The frequency of oral cavity diseases, determined by Allmuca *et al.* (2016), indicates a predominance of periodontitis, calculus, tooth loss, and teeth attrition. An examination of dogs conducted by Şengöz Şirin *et al.* (2023) showed the presence of calculus, gingivitis, and traumatic maxillofacial injuries in most dogs. According to Sauer *et al.* (2018), the majority of 59 examined dogs had not a single, but several dental diseases, primarily a combination of retained deciduous teeth, tooth fractures, and teeth attrition. In geriatric dogs (over 10 years), the rate of dental disease, exceeded that of diseases of the auricles, kidneys, liver, and respiratory infections (Jain *et al.*, 2015). The relevance of monitoring studies and the exploration of the correlation between dental diseases and external/internal factors stem from the significant variety in skull sizes and configurations. This variability complicates the clinical and radiological interpretation of normal and pathological conditions. Despite the recommendations of The American Animal Hospital Association for scheduled dental examinations in dogs starting from one-two years of age (Enlund *et al.*, 2020) consistent with the human dentistry procedures to prevent oral diseases before irreversible disorders occur, in veterinary medicine they are not

followed in most cases. The lack of timely diagnosis and early treatment of dental diseases lead to the involvement of adjacent tissues. In particular, tartar covered with plaque is the cause of disease progression leading to the initiation of inflammation cascades, and the development of gingivitis (Garanayak *et al.*, 2019). There is a possibility that gingivitis can progress to periodontitis. Against the backdrop of promising results in human dentistry, these results cannot be used in veterinary medicine without correction taking into account the anatomical and physiological characteristics of animals. In particular, supragingival dental calculus in dogs, compared to humans, contains more organic substances, calcium carbonate (CaCO_3) and carbonate apatite (CO_3Ap) (Chiba-Ohkuma *et al.*, 2024).

Among the causes of visual absence of a tooth are the so-called "unerupted" teeth, which in the future can be the cause of complex odontomas and/or odontoid bones, causing significant bone destruction, pathological fractures, loss of adjacent teeth (Feuer & Mulherin, 2023). Tooth eruption is a complex, not fully understood process. Currently, there is strong evidence that tooth follicle initiates eruption, but with the simultaneous interaction of many mechanisms (Babbitt *et al.*, 2016). Tooth development begins in the embryo with the formation of the dental plate, which eventually forms the dental arches. Deciduous teeth are formed as a result of plate invagination, the outgrowths of the dental plate primordium form the permanent dentition. There are three stages: pre-eruptive (tooth eruption includes movement of the tooth germ, accumulation of cells that eventually form the tooth), pre-functional (the period between the formation of the crown and the

root) and functional (from the occlusion of the tooth to its loss, ankylosis or death) (Domnick, 2014). Supernumerary teeth that have not erupted are closely associated with the root structure of adjacent teeth and require removal, as they can be the cause of root resorption of erupted or unerupted teeth. Currently, four possible causes of unerupted teeth have been proven: mechanical splitting of the tooth germ; retention of the deciduous tooth; a genetic mutation that causes the formation of an additional tooth; return to the initial state (Mulherin & White, 2021). Ectodermal dysplasia in hairless dog breeds is characterised by abnormal tooth morphology, which manifests itself as their absence or abnormal shape and is explained by a semidominant duplication of 7 base pairs in the first exon of the I3 gene (FOXI3). In addition, unlike dogs of the "wild" type, hairless animals are characterised by early loss of permanent canines, premolars, and to a certain extent incisors of both the upper and lower jaws (Kupczik *et al.*, 2017).

Dental caries, early diagnosis of which is very important, is registered in dogs much less often than in humans due to the higher pH of saliva. The main factors that affect the progression of the disease include the remineralisation ability of the oral cavity, the cariogenic potential of the microbiota, and the presence of acidogenic substrates. Dental caries is classified by the location of the lesion: pit, fissure, smooth surface caries, or root surface caries (Hale, 2009). Dental caries is a relatively rare disease in dogs, with a prevalence of 3.1–5.3%. It is most commonly found on the occlusal surface of the first molar teeth. Although dental caries is diagnosed much less frequently than dental calculus and periodontal disease in dogs, it can lead to tooth loss if not detected

early (Kolsuz *et al.*, 2023). Dental caries is caused by the demineralisation of enamel and dentin. It can have a wide range of clinical and radiographic presentations. Depending on the location, it can be visualised as defects in the tooth tissue of various sizes and shapes, with an associated radiolucent area (Duncan, 2010).

Traumatic dental injuries (TDI) can be defined as injuries to the anatomical structures of teeth, including enamel, dentin, cementum, and pulp, as well as their supporting structures, including alveolar bone and the periodontal ligament. Diagnosis is based on the performance and interpretation of dental radiographs (Thatcher, 2020). The fourth premolars of the upper jaw and the first molars of the lower jaw (the "carnivorous teeth") are typically used during chewing, so they are subjected to higher forces than canines. Fractures of the fourth premolars of the upper jaw are often complex fractures of the crown with pulp exposure (Soltero-Rivera *et al.*, 2019). Fractures of the lower jaw account for 1.5–6% of all fractures in dogs. The location of the fracture site is often correlated with structures such as the periodontal ligament. In older dogs and small breeds, periodontal disease is a common cause of pathological jaw fractures (Scherer *et al.*, 2019).

Enamel hypoplasia is a general term to define quantitative defects of enamel, which manifest as areas of reduced enamel thickness. There are two main causes of enamel hypoplasia: incomplete or impaired matrix synthesis and "inadequate" mineralisation. Focal enamel hypoplasia (also known as Turner's hypoplasia) is associated with environmental factors (such as poorly performed extraction of deciduous teeth), while diffuse hypoplasia usually develops as a result of systemic diseases with fever or direct in-

fection with microorganisms that actively produce enamel (Fulton & Fiani, 2011). Enamel hypoplasia in young dogs can accompany the course of canine distemper. The effect of the pathogen on dental enamel cells has been proven (Sauer *et al.*, 2018). In some dog breeds, enamel hypoplasia is associated with genetic disorders and is considered a hereditary pathology. In particular, in the Samoyed breed, enamel hypoplasia can be caused by gene mutations that cause autosomal recessive imperfect amelogenesis (ARAI) and manifests immediately after tooth eruption (Pedersen *et al.*, 2017).

Abnormal tooth wear occurs through friction caused by contact between teeth with each other, as well as with foreign objects (food, bones, stones). Wear occurs on the occlusal surface and can affect all teeth. The degree of tooth wear depends on external factors such as the type of food consumed, the peculiarities of its grinding in the oral cavity, and age. In addition, wear occurs due to malocclusion and usually occurs in the front teeth (incisors and canines). As the teeth wear, a thin layer of enamel is removed, which causes the formation of reparative dentin, which can be brown to black in colour. Tooth wear can be considered a physiological process if it does not impair function (Schernig-Mráz *et al.*, 2023). Abnormal tooth wear, resulting from friction and contact with foreign objects, can lead to exposure of dentinal tubules and the development of pulpitis and/or inflammatory root resorption (Fiani & Arzi, 2010).

Retained deciduous teeth are those that have not fallen out by the time of eruption of permanent successors. As a result, they cause crowding of teeth, changes in the contour of the gums, accelerated periodontitis, and changes in the place of eruption of deciduous teeth. In the vast major-

ity of cases, they are found in small dog breeds (Winer & Verstraete, 2017). One of the common dental anomalies in animals, including dogs, is malocclusion. Its main causes, in addition to hereditary predisposition, may include general (nutritional, endocrine and toxic) and local factors (retained deciduous teeth, their inconsistent eruption and trauma) (Berman *et al.*, 2023).

Malocclusion can occur due to a mismatch in jaw length, and malocclusion of teeth can occur due to changes in tooth position, more often combined. It can cause potentially serious consequences depending on the type of malocclusion and the affected teeth: from minor soft tissue trauma to severe damage to teeth and bones. The internal risk of developing malocclusion may be associated with low genetic diversity (Martins *et al.*, 2022). Class I malocclusion involves a normal relationship between the length of the upper and lower jaws with incorrect placement of individual teeth in their arches; class II – distocclusion of the lower jaw with abnormal rostrocaudal relationship (Thatcher, 2019); and class III – relative prognathism of the lower jaw (Tjepkema, 2019).

The study of the impact of the biologically appropriate raw food (BARF) feeding system on dental pathology is of particular interest. There are many potential advantages and disadvantages of BARF diet: a raw diet is considered the most natural and least processed, but it can pose health risks to pets due to potential nutrient imbalances and microbial contamination (Główny *et al.*, 2024). Claims of improved oral health with the BARF diet remain controversial, inconsistent with a number of published findings suggesting a reduced risk of periodontal disease with raw feeding (Steenkamp & Gor-

rel, 1999). Marx *et al.* (2016) reported effective calculus removal when dogs were fed raw beef bones.

Thus, the descriptive nature of publications devoted to veterinary dentistry in most cases, against the background of the absence of a single methodological approach to the diagnosis of oral pathology, justifies the need for a more detailed study of the problem of tooth diseases. Therefore, the purpose of our study is to determine the prevalence and predictors of dental diseases in dogs.

MATERIALS AND METHODS

The study was conducted during 2022–2023 at the Department of Veterinary Surgery and Reproduction of the Dnipro State Agrarian and Economic University (Dnipro, Ukraine), state and private veterinary clinics in Dnipro, Zaporizhia, and Kropyvnytskyi, Ukraine.

The study was approved by the Bioethics Committee of the Dnipro State Agrarian and Economic University (Protocol No. 1 of September 15, 2022).

A total of 990 dogs were included in the study: 571 small dogs, 262 medium-size, 157 large and giant dogs. The group of small breeds included: Chihuahua (n=65), Spitz (n=64), Shih Tzu (n=63), Poodle (n=60), Yorkshire Terrier (n=58), Maltese (n=55), Papillon (n=54), Maltipoo (n=53), Biewer Yorkshire Terrier (n=50), and Chinese Crested (n=49); medium breeds included: Pug (n=44), Jack Russell (n=43), Dachshund (n=36), French Bulldog (n=35), American/English Cocker Spaniels (n=31), Beagle (n=26), Airedale Terrier (n=15), Australian Shepherd (n=11), Basset Hound (n=8), Bearded Collie (n=6), Bull Terrier (n=4), Dalmatian (n=3); large and giant breeds included: German/Eastern European Shep-

herd (n=40), Central Asian Shepherd Dog (n=35), and Labrador Retrievers (n=31), Akita (n=13), Belgian Sheepdog (n=10), Bernese Mountain Dog (n=7), Cane Corso (n=7), Doberman Pinscher (n=6), Irish Wolfhound (n=5), Neapolitan Mastiff (n=3). The diagnosis of dental diseases included analysis of anamnesis data, visual examination of the oral cavity, palpation, and radiography. The study of the history is necessary to establish the etiological factors, duration, and individual characteristics of the course of the disease. Using the examination, the nature of the tissues of the teeth, their number and location; the state of the mucous membrane of the oral cavity; the presence and localisation of hypertrophied or necrotic areas, deposits on the tooth enamel (plaque, calculus) were determined. Palpation allowed establishing the strength of fixation of the teeth in the sockets, the presence of a painful reaction. Radiological examination was performed to diagnose diseases of the structural components of the tooth, primarily of inflammatory genesis. X-ray images (Xprime device, PCMAX-20VB(led) model) were taken in two projections: frontal and lateral (maximum power: 90 kV/20 mA, adjusted individually).

To ensure optimal conditions for diagnosis, xylazine hydrochloride (Xyla, Interchemie werken De Adelaar BV, Netherlands) with sedative, analgesic, and muscle relaxant effects was used at a dose of 0.15 mL/kg, intravenously or intramuscularly.

In determining the role of feeding in the development of dental diseases in dogs, three types of diets were taken into account: commercial, home-cooked, and BARF. The commercial diet involved the use of dry commercial feeds such as Royal Canin, Josera, Brit, Pro Plan according to

the manufacturer's recommendations. The basis of the home-cooked diet was meat broth (poultry, beef, rabbit) and various cereals (buckwheat, barley, wheat, corn, rice) with the addition of vegetables. Bones were introduced into the diet periodically, not regularly. The BARF feeding system involves the use of raw natural products of animal and plant origin. The approximate structure of such a diet is as follows: 60–70% meat and/or fish, including 8–20% offal and bones; 15–20% dairy products and eggs; 15–20% fruits, roots, herbs, berries, and vegetables. The use of cereals in this diet is categorically contraindicated.

For statistical processing, the Statistica 10 software (StatSoft Inc., USA, 2011) and the analysis of variance with the Bonferroni correction were used. The average values of age susceptibility are presented as means and their standard deviations (SD). Categorical variables of other indicators were presented in numbers, their ratio is expressed in percentages and 95% confidence interval (CI).

RESULTS

The results of the study showed that the prevalence of dental diseases in dogs was higher in small dog breeds (57.7%) than in medium (26.4%) and large and giant (15.9%) breeds (Table 1). This difference was statistically significant ($P < 0.05$). Monitoring the prevalence of dental disease in dogs has shown that the incidence of dental plaque/calculus and dental caries correlates with dog breed and body weight. In the structure of morbidity, the highest level was observed in small breeds – 40.5% and 31.9%, respectively. An increase in body weight of dogs correlated with a decrease in these indicators, which in medium-sized breeds were 29.0% and

30.5%, and in large and giant breeds – 17.2% and 20.4%. The proportion of mechanical damage to teeth and their fractures correlated with the size of dogs, namely: in small breeds – 1.9%, medium – 10.3%, and large and giant – 19.1%. Abnormal tooth wear was also more common in medium (14.5%) and large and giant (24.8%) dogs. Delayed replacement of milk teeth was characteristic of small breeds (18.6%), while in larger animals it was about 5%. The frequency of registration of other pathologies (hypoplasia of enamel, malocclusions, tooth loss) did not depend on the body weight of animals, and the patterns of their development were not established.

Clinical cases of dental diseases in dogs are presented on Fig. 1–9.

Based on the study of the breed susceptibility of dogs to dental diseases, the structure of morbidity was determined (Table 2). Dental plaque/calculus was most commonly diagnosed in small, and medium-sized breeds, namely: Yorkshire terriers: 14.4% of cases; Chihuahuas: 13.5%; Spitz: 11.7%; Shih Tzu: 9.0%; Poodle: 8.1%; Pugs: 6.6%. A significant risk of developing dental caries was established in dogs of the following breeds: Yorkshire terrier: 12.5%; Poodle: 10.9%; Pug: 8.2%; Chihuahua: 6.1%; French bulldog: 5.1%. Most commonly, traumatic injuries/fractures of teeth were diagnosed in German/East European Shepherds (13.2%), Central Asian Shepherds (8.8%), Jack Russell Terriers (5.9%), and Dachshunds (5.9%). Enamel hypoplasia was found in three dogs of the Maltese and Papillon breeds and two of the Maltipoo breed, which was 13.6% and 9.1% of the total number of animals with this pathology, respectively. In 12.6% of cases, abnormal teeth attrition was diagnosed in German/East European Shepherds, 9.2%

Table 1. Prevalence of dental diseases depending on the size of dogs

Diseases	Breeds								
	Small			Medium			Large and giant		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Dental plaque/calculus	231	40.5	38–42	76	29.0	24–34	27	17.2	15–19
Dental caries	182	31.9	28–36	80	30.5	25–37	32	20.4	18–23
Mechanical damage to teeth and their fractures	11	1.9	1–2	27	10.3	8–13	30	19.1	16–22
Hypoplasia of enamel	3	0.5	0.5–1	12	4.6	3–7	7	4.5	3–6
Abnormal tooth wear	10	1.8	1–2	38	14.5	12–18	39	24.8	21–29
Delayed eruption of deciduous teeth	106	18.6	15–19	12	4.6	3–7	8	5.1	4–6
Malocclusions	19	3.3	2–5	13	5.0	3–7	9	5.7	4–8
Tooth loss	9	1.6	1–2	4	1.5	1–2	5	3.2	2–4
Total (n = 990)	571	100		262	100		157	100	
		57.7	52–64		26.4	21–32		15.9	12–20



Fig. 1. Combined pathology in Central Asian Shepherd: abnormal tooth, significant endodontic disease (black colour of exposed root), incompletely erupted tooth.



Fig. 2. Pulp necrosis in a German Shepherd



Fig. 3. Incisor trauma in a German Shepherd.



Fig. 4. Abnormal tooth wear in a 3-year-old Jack Russell Terrier.

in Labrador Retrievers, 7.8% in American/English Cocker Spaniels, and 7.6% in Beagles. The maximum risk of delayed eruption of deciduous teeth was characteristic of small breeds, primarily Yorkshire Terrier, Chihuahua, Spitz, Papillon, and Biewer Yorkshire Terrier. Their share ranged from 9.5 to 17.5%. Malocclusion was observed in a significant number of breeds, often in the form of isolated cases. Therefore, the established malocclusion in three Chihuahuas and Papillons, as well as two Spitz, did not allow to assert the presence of breed susceptibility. The pathology, defined as the absence of teeth, is relatively rare, and breed susceptibility was not pronounced. In particular, two cases (11.1% each) were diagnosed in

dogs from the Chinese Crested and Biewer Yorkshire Terrier breeds.

The results of the study showed patterns in the development of certain dental diseases in dogs of different age groups (Table 3). Specifically, statistically significant differences ($P < 0.001$) were observed in the mean age of onset of dental plaque and calculus in dogs of medium (5.8 ± 0.7 years) and large and giant (8.9 ± 1.2 years) breeds, compared to small breeds (3.3 ± 0.9 years). Dental caries was diagnosed in large and giant breeds significantly later (8.5 ± 0.8 years, $P < 0.001$), compared to small breeds (4.2 ± 0.8 years). Traumatic injuries of teeth (in some cases, fractures) were observed in small breeds at a younger age (2.8 ± 0.6). The mean age

Table 2. Dog breeds most susceptible to dental diseases

Breed	n	%	95% CI (%)
<i>Dental plaque/ calculus (n=334)</i>			
Yorkshire terrier	48	14.4	12–19
Chihuahua	45	13.5	11–17
Spitz	39	11.7	9–14
Shih Tzu	30	9.0	7–11
Poodle	27	8.1	7–13
Pug	22	6.6	5–8
<i>Dental caries (n=294)</i>			
Yorkshire terrier	37	12.5	10–16
Poodle	32	10.9	7–14
Pug	24	8.2	7–10
Chihuahua	18	6.1	4–9
French bulldog	15	5.1	4–7
<i>Traumatic injuries /fracture of teeth (n = 68)</i>			
German / Eastern European Shepherd	9	13.2	10–14
Central Asian shepherd dog	6	8.8	7–12
Jack Russell	4	5.9	4–8
Dachshund	4	5.9	3–9
<i>Enamel hypoplasia (n=22)</i>			
Maltese	3	13.6	12–16
Papillon	3	13.6	12–15
Maltipoo	2	9.1	7–12
<i>Abnormal tooth wear (n=87)</i>			
German / Eastern European Shepherd	11	12.6	10–15
Labrador Retrievers	8	9.2	6–13
American/English Cocker Spaniels	8	9.2	7–11
Beagle	8	9.2	7–12
<i>Delayed loss of temporary teeth (n=126)</i>			
Yorkshire terrier	22	17.5	14–20
Chihuahua	21	16.7	15–19
Spitz	18	14.3	12–18
Papillon	17	13.5	12–17
Biewer Yorkshire Terrier	12	9.5	8–11
<i>Malocclusions (n=41)</i>			
Chihuahua	3	7.3	5–9
Papillon	3	7.3	5–10
Spitz	2	4.9	4–6
<i>Tooth loss (n=18)</i>			
Chinese Crested	2	11.1	8–14
Biewer Yorkshire Terrier	2	11.1	9–13



Fig. 5. Retained deciduous teeth case of in a 1.5-year-old Yorkshire Terrier.



Fig. 6. Radiographic image of delayed eruption of deciduous teeth in a 9-month-old Yorkshire Terrier.

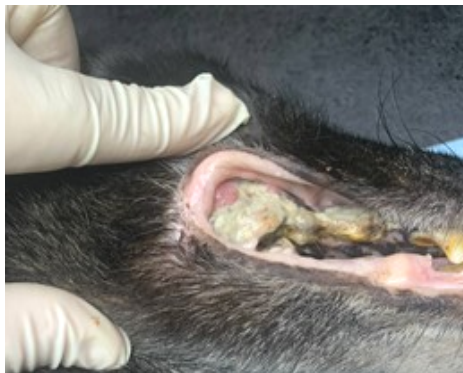


Fig. 7. Calculus complicated by periodontitis and tooth resorption in a German Shepherd



Fig. 8. Loss of teeth in German Shepherd.

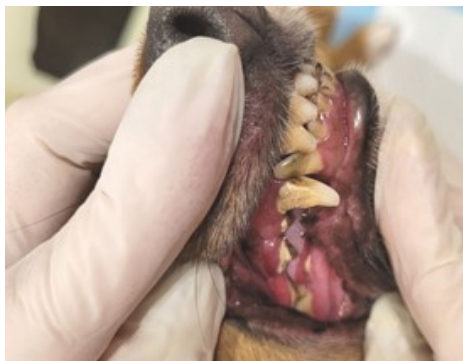


Fig. 9. Dental calculus complicated by periodontitis in a 10-year-old mixed breed

of onset of mechanical teeth injuries was significantly greater in larger dogs ($P < 0.001$) – medium breeds: 7.0 ± 1.3 years, large and giant breeds: 9.1 ± 1.7 years.

Considering the possible correlation, diet was considered as a risk factor for the development of certain dental diseases (plaque/calculus; caries; traumatic injuries/fractures; abnormal wear) in dogs of

different body weights (Table 4). The BARF feeding system was associated with a higher risk of morbidity than feeding commercial dry foods or home-prepared diets.

The likelihood of plaque and calculus was higher with BARF than with home-

prepared diets and commercial dry foods in dogs of small breeds: 2.4 and 3.8 times (59.3% vs 25.1% and 15.6%, respectively); medium breeds: 1.5 and 2.6 times (48.7% vs 32.9% and 18.4%, respectively); large and giant breeds: 1.1 and 1.8 times (40.8% vs 37.0% and 22.2%, re-

Table 3. Age susceptibility to dental diseases (years, mean $\pm$ SD)

Diseases	Breeds		
	Small	Medium	Large and giant
Dental plaque/calculus	3.3 $\pm$ 0.6	5.8 $\pm$ 0.7***	8.9 $\pm$ 1.2***
Dental caries	4.2 $\pm$ 0.8	6.1 $\pm$ 0.9	8.5 $\pm$ 0.8***
Mechanical damage to teeth and their fractures	2.8 $\pm$ 0.6	7.0 $\pm$ 1.3***	9.1 $\pm$ 1.7***
Hypoplasia of enamel	0.7 $\pm$ 0.2	1.2 $\pm$ 0.3	1.4 $\pm$ 0.5
Abnormal tooth wear	6.9 $\pm$ 1.5	8.8 $\pm$ 1.7	9.2 $\pm$ 1.1
Delayed eruption of deciduous teeth	1.0 $\pm$ 0.3	1.3 $\pm$ 0.5	1.5 $\pm$ 0.3
Malocclusions	1.0 $\pm$ 0.2	1.2 $\pm$ 0.4	1.6 $\pm$ 0.4
Tooth loss	0.6 $\pm$ 0.3	0.8 $\pm$ 0.3	0.8 $\pm$ 0.4

Note: ***P<0.001 compared to dogs of small breeds.

Table 4. The frequency of dental diseases in dogs depends on the diet

Diseases	Diet								
	Commercial dry feeds			Home-prepared			BARF		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
<i>Dental plaque/calculus</i>									
Small (n=231)	36	15.6	13–19	58	25.1	22–29	137	59.3	54–65
Medium (n=76)	14	18.4	15–22	25	32.9	27–39	37	48.7	45–53
Large and giant (n=27)	6	22.2	19–24	10	37.0	33–41	11	40.8	37–45
<i>Dental caries</i>									
Small (n=182)	32	17.6	14–21	49	26.9	22–33	101	55.5	51–62
Medium (n=80)	16	20.0	17–23	25	31.3	27–35	39	48.7	43–55
Large and giant (n=32)	8	25.0	22–28	9	28.1	26–31	15	46.9	44–50
<i>Traumatic injuries /fracture of teeth</i>									
Small (n=11)	1	9.1	7–12	1	9.1	7–12	9	81.8	78–85
Medium (n=27)	3	11.2	8–15	8	29.6	26–33	16	59.2	57–62
Large and giant (n=30)	3	10.0	7–13	6	20.0	16–24	21	70.0	65–75
<i>Abnormal tooth wear</i>									
Small (n=10)	2	20.0	17–23	3	30.0	28–32	5	50.0	46–54
Medium (n=38)	7	18.4	16–21	13	34.2	32–37	18	47.4	43–51
Large and giant (n=39)	9	23.0	20–26	15	38.5	34–43	15	38.5	34–43

spectively). Depending on the size of the animals, the risk of developing dental caries was highest with BARF feeding: 46.9–55.5%, then with the use of home-prepared feed (26.1–31.3%), and commercial dry diets (17.6–25.0%). The frequency of mechanical tooth damage with dry food feeding was within 10–11%, BARF – 80%. The fact of tooth injury and/or their fractures in small breeds was indicative: 9.1% of cases with the use of commercial and prepared feed in, 81.8% with BARF. Abnormal tooth wear was independent of dog size, and was minimal with a commercial diet (18.4–23.0% of cases). The use of prepared diets increased the risk of its development 1.5–1.9 times (up to 30.0–38.5%), BARF – 1.4–1.7 times (up to 38.5–50.0%).

DISCUSSION

According to Wallis *et al.* (2021), very small (<6.5 kg) dog breeds had up to five times ($P<0.0001$) greater risk of dental disease than giant breeds (>25 kg), and the majority of dogs diagnosed with dental disease belonged to the small (6.5–9 kg), and medium-small (9–15 kg) categories. Among additional risk factors, the authors indicated age, excess body weight, regularity of weighing, and hygienic brushing of teeth. Our results are consistent with the data of Wallis *et al.* (2024) regarding a significant prevalence of retained deciduous teeth in dogs weighing up to 6.5 kg (up to 15%, $P<0.001$). At the same time, the information from Wallis *et al.* (2024) regarding the reliable correlation of the risk of retained deciduous teeth with the body mass index was not confirmed: low level – according to the body condition indicator below ideal (odds ratio 0.57–0.89, $P<0.0001$), high level – according to the indicator above ideal (odds

ratio 1.11–1.60, $P<0.0001$). Kim *et al.* (2013) showed that the first molars of the lower jaw (74.5% on the left and 63.9% on the right) and the fourth premolars of the upper jaw (40.5% on the left and 38.2% on the right) are most often affected in Shih Tzu, and the disease of the premolars of the lower jaw was genetically determined. We did not establish such associations. Brachycephalic dogs had a significantly higher prevalence of malocclusion (odds ratio 1.93; 95% CI 1.36–2.75), tooth loss (odds ratio 3.63; 95% CI 2.71–4.91), fractured teeth (odds ratio 1.95; 95% CI 1.24–3.04) and a lower prevalence of gingival recession (odds ratio 0.30; 95% CI 0.15–0.55) compared to non-brachycephalic dogs. Mixed breeds were 2.77 times more likely to have fractured teeth compared to miniature poodles. Compared to mixed breeds, the risk of gingivitis is 2.46, 2.01, and 1.83 times higher in Maltese, Bichon Frise, and Pomeranian, respectively. The frequency of malocclusion in Shih Tzu, Pomeranian Spitz, and Maltese, compared to miniature poodles, is 10.41, 3.47, and 2.95 times higher, respectively. Compared to the Bichon Frisé, the probability of tooth loss was higher in the Yorkshire Terrier – 11.43 times, the Maltese – 5.85 times, and the Chihuahua – 5.21 times (Ryu *et al.*, 2024). Brachycephalic skull configuration is characterised by shortening of the upper jaw and lower jaw bones, which leads (especially in small breeds) to developmental disorders of the orofacial structures and specific dental disorders, such as crowding, rotation of teeth, their displacement, persistent deciduous teeth (Döring *et al.*, 2023). Our observations confirm the significant prevalence of malocclusion in dogs and are consistent with data on possible etiological factors: genetic, endocrine, infectious, toxic, dietary,

mechanical. Among them, the most common cause of malocclusion is lingual displacement of the lower jaw teeth (Storliet *et al.*, 2018). Fractures near the teeth of the lower jaw (usually the cuspids of the first molars), which are more often diagnosed in small breed dogs, are in most cases mediated by chronic periodontitis, can be directly caused by mild (tooth extraction, playful behavior, eating) and severe (car accidents, sports injuries). A traumatised tooth without a fracture can be a cause of pulpitis and pulp necrosis (Niemiec *et al.*, 2020).

The results of the study are consistent with the data of Garanayak *et al.* (2019), who reported that small dog breeds have more than 85% of pathological changes in the gums and teeth, of which periodontal disease, tartar, tooth loss, and abnormal wear account for 60%, 61%, 33%, and 5%, respectively. The findings confirm the information of Mateo *et al.* (2020) regarding the high level of susceptibility to such dental diseases as dental plaque/calculus and dental caries, and their severe course in small dog breeds. It is likely that the significant difference in the incidence of dental caries in dogs is due to the fact that caries is difficult to diagnose in the early stages and often goes unnoticed until a dental evaluation is performed under general anaesthesia (Ramsden, 2023). Dental caries can lead to recontamination of obturated root canals, thereby causing a delay in the placement of a filling on the crown, reducing its fixation strength, and in some cases, a fracture of the crown (Moazami *et al.*, 2020). Fractures are most commonly diagnosed in the upper jaw premolars when chewing hard objects. Key prognostic factors for enamel, dentin, and pulp fractures are the type and location of the tooth in the oral cavity. Working hunting dogs typically

show enamel defects. The direction of crack propagation is usually perpendicular to the direction of mechanical loading and perpendicular to the surface (Bilyard *et al.*, 2023). Dental crown fractures and gingival and buccal mucosal injuries can be caused by malocclusion due to abnormal contact between the teeth and/or soft tissues of the oral cavity (Hoyer & Rawlinson, 2019). One of the causes of incomplete dentin coverage with enamel with exposure of the endodontic structure and subsequent development of endodontic disease can be dens invaginatus (DI), also known as dens in dente (Thatcher, 2020). In our study, this pathology was not registered, although radiography was included in the diagnostic measures complex in addition to clinical examination.

Published data indicate breed and age susceptibility of dogs to diseases of the oral cavity. However, in our opinion, it is advisable to evaluate the influence of these factors comprehensively, simultaneously taking into account the diet, feeding regimen, and genetic susceptibility. Age-related susceptibility to diseases of the oral cavity in dogs is reliably related to the incidence of dental diseases, but significantly depends on the breed. Additionally, the lack of a single methodological approach to the diagnosis of oral cavity diseases causes significant differences in published results. In dogs, the frequency and severity of oral diseases, particularly periodontal disease, increase with age, but animals in the younger age group can also suffer from a number of dental diseases (Hale, 2005). Older large and giant breed dogs may have healthier oral cavity, less plaque/calculus build-up, and a lower risk of periodontal disease compared to younger small breeds (Harvey *et al.*, 1994). Aswathy *et al.* (2019) indicate the maximum frequency of registration of

dental diseases (24.1%) in one- to three-year-old dogs without indicating a correlation with breeds. A higher incidence of dental lesions in dogs older than two years is reported by Vani *et al.* (2007): in 1–3-month-old animals – 1.15%, 4–12-month-old animals – 11.56%, 1–4-year-old animals – 30%, 4–8-year-old animals – 36.4%, older than 8 years – 20.8%. Similar results were obtained by Blume *et al.* (2023): frequency of detection of oral cavity diseases in dogs under one year – 2.7%, from one to five years – 21.8%, from six to ten years – 39.8%, from eleven to fifteen years – 22.6%, older than sixteen years – 2.7%. Similar information is provided by Thakur *et al.* (2021), which found that dental disease is the main health problem in dogs older than 5 years. According to Whyte *et al.* (2021), in dogs, the most common oral problems were dental plaque/calculus (75%), tooth fracture and dental attrition (68.75%), tooth loss (34.37%), gingival recession (31.25%), and periodontal disease (15.62%). Evaluation of pathological changes in teeth and abnormalities of the oral cavity in dogs, conducted by Butković *et al.* (2001), certified the frequency of registration of oligodontia at the level of 45.17%, periodontitis – 44.40%, tooth fracture – 19.30%, tooth rotation – 11.59%, retained deciduous teeth – 5.40%, and supernumerary teeth – 3.86%. Their dependence on the age of the animals was also demonstrated: the highest incidence of oligodontia, tooth rotation, retained deciduous teeth, and supernumerary teeth was observed in the younger age group ($P < 0.001$), tooth fracture – in the middle age group ($P < 0.001$), and periodontitis – in the middle and oldest age groups ($P < 0.001$). One of the factors that affects the health of the oral cavity is the physical properties of the feed, especially its texture. Dry food promotes

tooth attrition surface due to the need for mechanical effort through chewing, in contrast to soft food, which facilitates the accumulation of plaque and calculus formation (Pinto *et al.*, 2020). We partially agree with this interpretation, because the authors did not take into account the anatomical and physiological features in the "cross-section" of dog breeds. The BARF feeding system is becoming increasingly popular among dog owners in Ukraine, so we presented our view on the feasibility of its use. Although existing publications demonstrate an improvement in the condition of teeth already after 12 months after switching to the BARF diet due to feeding on bones (Abel *et al.*, 2016), our data indicate the opposite situation. Feeding BARF diet increases the risks of developing dental diseases, including their mechanical damage. Given the high prevalence of tartar, its key role in the initiation of gingivitis, and the association with dietary regimes in dogs, it is important to evaluate the impact of feeding rations on its accumulation (Hennet *et al.*, 2006). In addition, many products have been proposed for the removal of plaque, and clinical and laboratory tests of their specific mechanical properties are currently underway (Jank, 2021). It should be noted that raw feeding regimes are aimed at the prevention of oral diseases, including teeth. With the proven effect of diet on the likelihood of developing oral cavity diseases, encouraging results have been published regarding the reduction of plaque deposition (17.3%) and calculus accumulation (45.8%) when using a specially developed hygienic chewing products together with dry commercial feed (Hennet *et al.*, 2006). The Oral Health Index (OHI) proposed by Buckley *et al.* (2011) allowed establishing an increase in the probability of oral health problems when

feeding home-prepared food ($P<0.001$) compared to dry commercial feed. However, Kocabağlı *et al.* (2019) found that most dogs older than 4 years of age had oral health problems when fed dry commercial feeds ($P<0.05$) against the background of a statistically significant relationship with age, type of diet, and condition of the oral cavity ($P<0.05$). In our opinion, this issue needs additional study. Our data are consistent with the information of Elseddawy *et al.* (2023) regarding the significant prevalence of dental plaque and the severe course of periodontal diseases caused by it when feeding soft foods, due to the intensive accumulation of bacterial biofilm. Periodontal disease caused by plaque is usually accompanied by progressive loss of alveolar bone. The probability of dental caries progression correlates with diet: in particular, its intensive development is associated with the regular intake of refined carbohydrates (found in cookies). Dental caries can spread to teeth located next to the affected one (Johnston, 2012).

CONCLUSION

Dental diseases in dogs are a common problem, with a prevalence of 15.9% to 57.7%. The most common diseases are dental plaque/calculus (17.2–40.5%), dental caries (20.4–31.5%), retained deciduous teeth (4.6–18.6%), traumatic injuries/fractures (1.9–19.1%), and abnormal wear of teeth (1.8–24.8%). Breed susceptibility is a risk factor for dental diseases. Dogs of small breeds have a 2.2-fold and 3.6-fold higher risk of dental diseases than dogs of medium, large, and giant breeds, respectively. Small dogs are most susceptible to dental plaque/calculus (40.5%), dental caries (31.9%), and retained deciduous teeth (18.6%); large and giant

breeds are most susceptible to traumatic injuries/fractures (19.1%) and abnormal wear of teeth (24.8%). Of the breeds included in this study, Yorkshire Terriers, Chihuahuas, Spitz, Poodles, Pugs, and German/East European Shepherds had the highest prevalence of dental diseases. An important predictor of dental diseases in dogs is the correlation between breed and age ($P<0.001$). Dental plaque/calculus, dental caries, and traumatic injuries/fractures are diagnosed in small breed dogs at an average age of 3.3 ± 0.6 , 4.2 ± 0.8 , and 2.8 ± 0.6 years, respectively, and in large and giant breed dogs at an average age of 8.9 ± 1.2 , 8.5 ± 0.8 , and 9.1 ± 1.7 years, respectively. One of the main factors that affects oral health, including the condition of teeth, is diet. Commercial dry diets minimise the risk of dental diseases, while the BARF diet, on the other hand, increases the risk of dental pathology, regardless of the breed. The prognosis for the development of dental diseases and the course of their progression should be based on an individual analytical assessment of the correlations between breed, body weight, age, and diet in each patient.

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Whyte, A., J. Whyte, L. V. Monteagudo, A. García-Barrios & M. T. Tejedor, 2021. Periodontal and dental status in packs of Spanish dogs. *Animals*, **11**, 1082.

Paper received 27.05.2024; accepted for publication 02.09.2024

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