AJVR

Initial screening for dental abnormalities identified by labial and buccal photographs in dogs and cats

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OBJECTIVE
To evaluate the dental abnormalities by visually assessing the labial and buccal photographs in dogs and cats and analyze their prevalence based on age and breed.

ANIMALS
1,096 client-owned dogs and 775 client-owned cats.

METHODS
Data were collected from patients who visited 26 private veterinary clinics from January to December 2022. Each animal was evaluated through dental photographs taken from the labial and buccal sides. Correlations between the prevalence of the identified dental abnormalities and age, craniofacial type, and breed, were analyzed.

RESULTS
Calculus, discoloration, epulis, fractured teeth, gingival recession, gingivitis, malocclusion, missing teeth, and persistent deciduous teeth could be identified by analyzing the dental photographs in both dogs and cats. Enamel defects in dogs and tooth resorption in cats could be identified. Brachycephalic dogs had a significantly higher prevalence of malocclusion (OR, 1.93; 95% CI, 1.36 to 2.75) and missing teeth (OR, 3.63; 95% CI, 2.71 to 4.91) compared to nonbrachycephalic dogs. Brachycephalic cats had a significantly higher prevalence of fractured teeth (OR, 1.95; 95% CI, 1.24 to 3.04) and a lower prevalence of gingival recession (OR, 0.30; 95% CI, 0.15 to 0.55) compared to nonbrachycephalic cats. Calculus, persistent deciduous teeth, and possibly gingivitis could be identified in dogs and cats by analyzing labial and buccal photographs. The assessment of some dental abnormalities such as fractured teeth, missing teeth, and tooth resorption can be limited without a complete dental examination under anesthesia.

CLINICAL RELEVANCE
Although the assessment of dental conditions may be underestimated, the data on the prevalence of the dental abnormalities evaluated through the photographs could be utilized for screening dental diseases.

Keywords: brachycephalic, breed, cat, dental, dog

Various epidemiologic studies[1–3] have reported that dental abnormalities are among the most common abnormalities in dogs and cats. Recent studies[2,3] in the United Kingdom showed that the prevalence of dental abnormalities in dogs and cats was 14.10% and 21.2%, respectively. Dental abnormalities can lead to general health problems, including pain and stress, and can cause systemic effects and histologic changes in distant organs in companion animals.[4–6] Even in the absence of overt clinical signs, these conditions can have an impact on the quality of life, longevity, and animal interactions with their owners.[4] However, epidemiological studies of these dental abnormalities have rarely been reported in Asia.[7,8]

The full extent of the oral conditions is assessed by history, physical examination, and conscious and unconscious evaluation of the oral cavity.[4] Although periodontal probing and intraoral radiographic evaluation that require general anesthesia are necessary

Received March 20, 2024
Accepted May 30, 2024
Published online June 20, 2024

doi.org/10.2460/ajvr.24.03.0085

to accurately diagnose oral disease, a visual assessment can be very informative to clinicians.[4] The conscious dental assessment is an important first step in anticipating the extent of the procedure and is used to prepare and educate the owners about the expected findings under general anesthesia.[4] The severity of gingivitis and calculus and the presence of missing teeth, gingival recession, and root exposure can be grossly assessed in conscious animals.[4,9]

Several studies[10–15] have reported age as a risk factor for periodontal disease in dogs. In addition, breed has been studied as another risk factor for periodontal disease in dogs.[10,11,13,15,16] Similarly, in cats, there have been some studies[17–19] indicating age as a risk factor for periodontal disease and resorptive lesions. However, there has been little research on breed-specific associations.[20–22] In both dogs and cats, there is a lack of research on dental conditions associated with brachycephalic breeds, although there has been an increase in research in recent years.[22–24]

The purpose of this study is to evaluate dental abnormalities using labial and buccal photographs and to determine the prevalence of dental abnormalities identified after evaluation in dogs and cats. Furthermore, this study determined a correlation between the prevalence of dental abnormalities and age, brachycephalic breed, and specific breeds.

Methods

Study design and data collection

This epidemiological study had a multicenter, cross-sectional design. Dental photographs of dogs and cats were collected from veterinary clinics in the Republic of Korea from January 2022 to December 2022. Random client-owned dogs and cats who attended 26 veterinary clinics in and around Seoul, Republic of Korea, were included in the study, even if no dental disease was suspected. A total 3 of dental images taken from 3 each different directions (right buccal, labial, and left buccal views) in a standing or sitting position for all animals included were collected using a cellphone camera with software designed for data labeling and annotation (Lime Research; Lime Solution Corp). For the labial view, the free gingival margins of all maxillary and mandibular incisors were exposed in dogs and cats with the mouth closed. For the buccal view of dogs, at least the free gingival margins were exposed from the canine to the fourth premolar in the maxilla and from the canine to the first molar in the mandible. For the buccal view of cats, at least the free gingival margins were exposed from the canine to the third premolar teeth in the maxilla and from the canine to the first molar teeth in the mandible. Cases were excluded if the photographs were too light or dark or if the free gingival margins were not sufficiently exposed for accurate dental evaluation. The photographs and data (age, breed, and sex) were uploaded by clinicians at each of the 26 veterinary clinics through the software. All uploaded photographs of each animal were evaluated by a veterinarian (KS) in a working environment with the same conditions for dental abnormalities **(Figure 1)**. Visual assessment of each dental abnormality was performed according to the American Veterinary Dental College recommendations.[25] The identified dental abnormalities were marked in the form of colored polygons or rectangles by the same veterinarian (KS).

Dogs were divided into 4 groups based on the American Animal Hospital Association (AAHA) canine life stage,[26] as follows: puppy (≤ 1 year old), young adult (1 to 4 years old), mature adult (4 to 11 years old), and senior (> 11 years old). Cats were grouped according to AAHA/American Association of Feline Practitioners feline life stage,[27] as follows: kitten (≤ 1 year old), young adult (1 to 6 years old), mature adult (6 to 10 years old), and senior (> 10 years old). Breeds were categorized into brachycephaly and nonbrachycephaly based on craniofacial type, which were selected based on breeds commonly included in brachycephaly studies.[22,23,28,29] The brachycephalic breeds of dogs included American Bulldog, Boston Terrier, Chihuahua, English Bulldog, French Bulldog, King Charles Spaniel, Maltese, Miniature Pinscher, Pekingese, Pug, Shih Tzu, and Yorkshire Terrier. The brachycephalic cat breeds included British Shorthair, British Shorthair crossed, Exotic Shorthair, Himalayan, Scottish Fold, Scottish Fold crossed, Selkirk Rex, and Persian. In the analysis for the prevalence of dental abnormalities according to brachycephalic status, mixed breeds of dogs (n = 136) and cats (18) were excluded.

Statistical analysis

Seoul National University Statistical Research Institute commissioned the collected data for statistical analysis. All statistical analyses were performed using R version 4.3.1 (The R Foundation) and RStudio version 2023.09.0 + 463. The Cochran-Armitage test was used to determine trends in the prevalence of dental abnormalities among the ordinal age groups. The χ^2-test or Fisher exact test was used to compare the prevalence of dental abnormalities between brachycephalic and nonbrachycephalic breeds. Among the 10 most frequent breeds in this study, a log-linear model was used to analyze the effect of breed factors on the prevalence of certain dental abnormalities. In addition, the χ^2-test for homogeneity or Fisher exact test was used to compare the prevalence differences between breeds based on the breed with the lowest prevalence of each disorder. For all statistical analyses, a P value less than .05 was considered significant.

Results

Dogs

The study population consisted of 1,096 dogs of 48 different breeds. The most common breeds were Maltese (225/1,096 [20.5%]), Toy Poodle (163/1,096 [14.9%]), and Bichon Frise (145/1,096 [13.2%]) **(Table 1)**. Regarding age distribution, mature adults

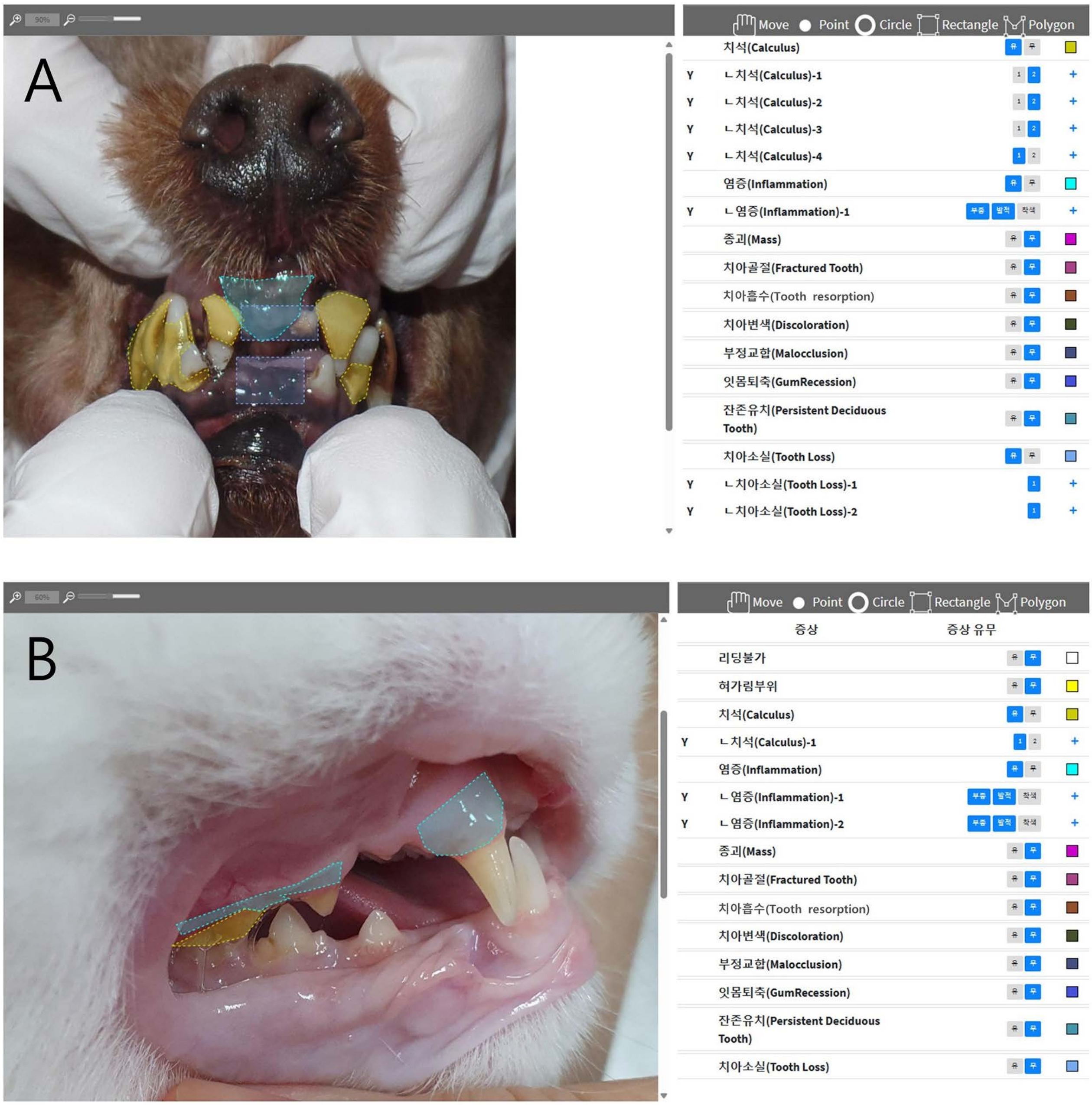

Figure 1—User interface of software designed for data labeling and annotation (Lime Research; Lime Solution Corp) to assess the collected dental photographs of the dogs and cats. All dental photographs were evaluated by a single veterinarian. The identified dental abnormalities were presented in the form of colored polygons or rectangles using the software designed for data labeling and annotation by the same veterinarian. A—The labial dental view of the dog. Lesions on teeth 101, 102, 201, and 202 were assessed as gingivitis and marked with cyan areas, while some maxillary and mandibular incisors were assessed as missing teeth and marked with purple areas. In addition, dental calculus was identified on teeth 103, 203, and 403 and marked with yellow areas. B—The right buccal dental view of the cat. Lesions on teeth 104, 107, and 108 were assessed as gingivitis and marked with cyan areas. In addition, the lesion on tooth 108 was assessed as dental calculus and marked with yellow areas.

(573/1,096 [52.3%]) were most common, followed by young adults (273/1,096 [24.9%]), seniors (138/1,096 [12.6%]), and puppies (112/1,096 [10.2%]).

Calculus, discoloration, enamel defects, epulis, fractured teeth, gingival recession, gingivitis, malocclusion, missing teeth, and persistent deciduous teeth could be identified in the photographs and analyzed. The abnormalities with the highest prevalence among the 1,096 dogs were dental calculus (892/1,096 [81.4%]), missing teeth (643/1,096 [58.7%]), and gingivitis (621/1,096 [56.7%]). The prevalence of calculus (P < .001), discoloration (P = .022), epulis

Table 1—Top 10 breed distributions of dogs and cats in this study.

Breed	No. (%)
Dog	
Maltese	225 (20.5)
Toy Poodle	163 (14.9)
Bichon Frise	145 (13.2)
Mixed breed	136 (12.4)
Pomeranian	82 (7.5)
Miniature Poodle	57 (5.2)
Yorkshire Terrier	42 (3.8)
Medium Poodle	38 (3.5)
Chihuahua	35 (3.2)
Shih Tzu	25 (2.3)
Other breeds	148 (13.5)
Total	1,096 (100.0)
Cat	
Domestic shorthair	338 (43.6)
Persian	57 (7.4)
Scottish Fold	55 (7.1)
Russian Blue	35 (4.5)
British Shorthair	31 (4.0)
Siamese	31 (4.0)
Ragdoll	30 (3.9)
American Shorthair	27 (3.5)
Turkish Angora	25 (3.2)
Abyssinian	23 (3.0)
Other breeds	123 (15.9)
Total	775 (100.0)

(P = .015), gingivitis (P < .001), and missing teeth (P < .001) significantly increased in the older age groups **(Table 2)**. In contrast, the prevalence of persistent deciduous teeth (P < .001) decreased significantly in older age groups.

In this study, 360 dogs were brachycephalic (360/960 [37.5%]) and 600 dogs were nonbrachycephalic (600/960 [62.5%]); 136 mixed-breed dogs were excluded. The prevalence of malocclusion (OR, 1.93; 95% CI, 1.36 to 2.75; P < .001) and missing teeth (OR, 3.63; 95% CI, 2.71 to 4.91; P < .001) in the brachycephalic dogs was significantly higher than in the nonbrachycephalic dogs **(Table 3)**.

In the comparison of the prevalence of dental abnormalities by breed, fractured teeth, gingivitis, malocclusion, and missing teeth had significant differences between certain breeds **(Table 4)**. Mixed breeds had 2.77 (38/136 [27.9%]; 95% CI, 1.15 to 6.65; P = .023) times the odds for fractured teeth compared with Miniature Poodle (7/57 [12.3%]) **(Supplementary Table S1)**. For gingivitis, Maltese, Bichon Frise, and Pomeranian breeds had 2.46 (150/225 [66.7%]; 95% CI, 1.59 to 3.81; P < .001), 2.01 (90/145 [62.1%]; 95% CI, 1.25 to 3.24; P = .004), and 1.83 (49/82 [59.8%]; 95% CI, 1.05 to 3.18; P = .033), respectively, times the odds compared with mixed breeds (61/136 [44.9%]) **(Supplementary Table S2)**. For malocclusion, Shih Tzu, Pomeranian, and Maltese had 10.41 (11/25 [44.0%]; 95% CI, 2.87 to 37.71; P < .001), 3.47 (17/82 [20.7%]; 95% CI, 1.10 to 10.92; P = .034), and 2.95 (41/225 [18.2%]; 95% CI, 1.01 to 8.62; P = .048), respectively, times the odds compared with Miniature Poodle (4/57 [7.0%]) **(Supplementary Table S3)**. For missing teeth, Yorkshire Terrier, Maltese, and Chihuahua had 11.43 (37/42 [88.1%]; 95% CI, 4.24 to 30.80; P < .001), 5.85 (178/225 [79.1%]; 95% CI, 3.68 to 9.29; P < .001), and 5.21 (27/35 [77.1%]; 95% CI, 2.21 to 12.27; P < .001), respectively, times the odds compared with Bichon Frise (57/145 [39.3%]) **(Supplementary Table S4)**.

Table 2—Prevalence of dental abnormalities evaluated by photographs according to age groups of dogs and cats.

	Prevalence (frequency [%])					
Dental abnormalities	Puppy or kitten	Young adult	Mature adult	Senior	Overall prevalence	P value[a]
Dog (n)	112	273	573	138	1,096	
Calculus	39 (34.8%)	211 (77.3%)	510 (89.0%)	132 (95.7%)	892 (81.4%)	< .001[b]
Discoloration	3 (2.7%)	2 (0.7%)	19 (3.3%)	8 (5.8%)	32 (2.9%)	.022[c]
Enamel defects	4 (3.6%)	11 (4.0%)	37 (6.5%)	6 (4.3%)	58 (5.3%)	.325
Epulis	0 (0.0)	0 (0.0)	8 (1.4%)	3 (2.2%)	11 (1.0%)	.015[c]
Fractured teeth	22 (19.6%)	59 (21.6%)	114 (19.9%)	24 (17.4%)	219 (20.0%)	.505
Gingival recession	4 (3.6%)	9 (3.3%)	37 (6.5%)	9 (6.5%)	59 (5.4%)	.065
Gingivitis	28 (25.0%)	126 (46.2%)	362 (63.2%)	105 (76.1%)	621 (56.7%)	< .001[b]
Malocclusion	13 (11.6%)	37 (13.6%)	95 (16.6%)	17 (12.3%)	162 (14.8%)	.465
Missing teeth	50 (44.6%)	123 (45.1%)	363 (63.4%)	107 (77.5%)	643 (58.7%)	< .001[b]
Persistent deciduous teeth	22 (19.6%)	16 (5.9%)	12 (2.1%)	1 (0.7%)	51 (4.7%)	< .001[b]
Cat (n)	164	352	167	92	775	
Calculus	23 (14.0%)	207 (58.8%)	123 (73.7%)	70 (76.1%)	423 (54.6%)	< .001[b]
Discoloration	2 (1.2%)	8 (2.3%)	7 (4.2%)	8 (8.7%)	25 (3.2%)	< .001[b]
Epulis	0 (0.0)	1 (0.3%)	0 (0.0%)	1 (1.1%)	2 (0.3%)	.242
Fractured teeth	9 (5.5%)	56 (15.9%)	19 (11.4%)	22 (23.9%)	106 (13.7%)	.001[c]
Gingival recession	0 (0.0)	52 (14.8%)	37 (22.2%)	37 (40.2%)	126 (16.3%)	< .001[b]
Gingivitis	82 (50.0%)	247 (70.2%)	125 (74.9%)	67 (72.8%)	521 (67.2%)	< .001[b]
Malocclusion	1 (0.6%)	6 (1.7%)	2 (1.2%)	0 (0.0)	9 (1.2%)	.669
Missing teeth	40 (24.4%)	141 (40.1%)	111 (66.5%)	66 (71.7%)	358 (46.2%)	< .001[b]
Persistent deciduous teeth	6 (3.7%)	1 (0.3%)	0 (0.0)	0 (0.0)	7 (0.9%)	< .001[b]
Tooth resorption	1 (0.6%)	20 (5.7%)	18 (10.8%)	19 (20.7%)	58 (7.5%)	< .001[b]

[a]Statistical analysis to determine trends in the prevalence of dental abnormalities among ordinal age groups using the Cochran-Armitage trend test. [b]Significantly different (P < .001). [c]Significantly different (P < .05).

Table 3—Comparative prevalence values of dental abnormalities evaluated by photographs between brachycephaly and nonbrachycephaly, using the χ^2-test or Fisher exact test.

	Prevalence (frequency [%])				
Dental abnormalities	**Brachycephaly**	**Nonbrachycephaly**	**OR**	**95% CI**	***P* value**
Dog (n)	360	600			
Calculus	300 (83.3%)	482 (80.3%)	1.22	0.87–1.73	.247
Discoloration	14 (3.9%)	12 (2.0%)	1.98	0.90–4.43	.081
Enamel defects	17 (4.7%)	35 (5.2%)	0.80	0.43–1.44	.462
Epulis	5 (1.4%)	5 (0.8%)	1.68	0.38–7.33	.515
Fractured teeth	73 (20.3%)	108 (18.0%)	1.16	0.83–1.61	.382
Gingival recession	16 (4.4%)	36 (6.0%)	0.73	0.39–1.32	.393
Gingivitis	223 (61.9%)	337 (56.2%)	1.27	0.97–1.66	.079
Malocclusion	76 (21.1%)	73 (12.2%)	1.93	1.36–2.75	< .001[a]
Missing teeth	280 (77.8%)	294 (49.0%)	3.63	2.71–4.91	< .001[a]
Persistent deciduous teeth	14 (3.9%)	31 (5.2%)	0.75	0.38–1.40	.365
Cat (n)	168	589			
Calculus	87 (51.8%)	328 (55.7%)	0.86	0.61–1.21	.370
Discoloration	5 (3.0%)	20 (3.4%)	0.87	0.25–2.45	>. 99
Epulis	0 (0.0)	2 (0.3%)	0	0.000–18.70	>. 99
Fractured teeth	35 (20.8%)	70 (11.9%)	1.95	1.24–3.04	< .001[a]
Gingival recession	11 (6.5%)	113 (19.2%)	0.30	0.15–0.55	< .001[a]
Gingivitis	117 (69.6%)	387 (65.7%)	1.20	0.83–1.74	.340
Malocclusion	1 (0.6%)	7 (1.2%)	0.50	0.01–3.92	.692
Missing teeth	63 (37.5%)	287 (48.7%)	0.63	0.44–0.90	.010[b]
Persistent deciduous teeth	0 (0.0)	7 (1.2%)	0	0.00–2.43	.358
Tooth resorption	5 (3.0%)	51 (8.7%)	0.32	0.10–0.83	.012[b]

[a]Significantly different (*P* < .001). [b]Significantly different (*P* < .05).

Cats

The study population comprised 775 cats of 31 different breeds. The most common breeds were the domestic shorthair (338/775 [43.6%]), Persian (57/775 [7.4%]), and Scottish Fold (55/775 [7.1%]) (Table 1). Regarding age distribution, young adults (352/775 [45.4%]) were the most common, followed by mature adults (167/775 [21.5%]), kittens (164/775 [21.2%]), and seniors (92/775 [11.9%]).

Calculus, discoloration, epulis, fractured teeth, gingival recession, gingivitis, malocclusion, missing teeth, persistent deciduous teeth, and tooth resorption could be identified in the photographs and analyzed. The abnormalities with the highest prevalence for all 775 cats were gingivitis (521/775 [67.2%]), calculus (423/775 [54.6%]), and missing teeth (358/775 [46.2%]). The prevalence of calculus (*P* < .001), discoloration (*P* < .001), fractured teeth (*P* = .001), gingival recession (*P* < .001), gingivitis (*P* < .001), missing teeth (*P* < .001), and tooth resorption (*P* < .001) significantly increased in the older age groups (Table 2). In contrast, the prevalence of persistent deciduous teeth (*P* < .001) decreased significantly in older age groups.

In this study, 168 cats were brachycephalic (168/757 [22.2%]) and 589 cats were nonbrachycephalic (589/757 [77.8%]); 18 mixed-breed cats were excluded. The prevalence of fractured teeth (OR, 1.95; 95% CI, 1.24 to 3.04; *P* < .001) in the brachycephalic cats was significantly higher than in the nonbrachycephalic cats. In contrast, the prevalence of gingival recession (OR, 0.30; 95% CI, 0.15 to 0.55; *P* < .001), missing teeth (OR, 0.63; 95% CI, 0.44 to 0.90; *P* = .010), and tooth resorption (OR, 0.32; 95% CI, 0.10 to 0.82; *P* = .012) in the brachycephalic cats was significantly lower than in the nonbrachycephalic cats (Table 3).

The prevalence of calculus, gingivitis, missing teeth, and tooth resorption was significantly different between certain breeds (Table 4). Siamese, Russian Blue, and American Shorthair had 13.71 (24/31 [77.4%]; 95% CI, 4.06 to 46.85; *P* < .001), 8.73 (24/35 [68.6%]; 95% CI, 2.78 to 27.41; *P* < .001), and 8.00 (18/27 [66.7%]; 95% CI, 2.41 to 26.57; *P* < .001), respectively, times the odds for calculus compared with Ragdoll (6/30 [20.0%]) **(Supplementary Table S5)**. For gingivitis, Siamese, Scottish Fold, and Abyssinian had 6.18 (26/31 [83.9%]; 95% CI, 1.93 to 19.81; *P* = .002), 4.26 (43/55 [78.2%]; 95% CI, 1.69 to 10.71; *P* = .002), and 3.37 (17/23 [73.9%]; 95% CI, 1.07 to 10.56; *P* = .038), respectively, times the odds compared with Russian Blue (16/35 [45.7%]) **(Supplementary Table S6)**. For missing teeth, Russian Blue, Persian, Siamese, and domestic shorthair had 4.513 (22/35 [62.9%], CI 1.822 to 11.175, *P* = .001), 3.94 (34/57 [59.6%]; 95% CI, 1.78 to 8.73; *P* < .001), 3.69 (18/31 [58.1%]; 95% CI, 1.46 to 9.34; *P* = .006), and 3.15 (183/338 [54.1%]; 95% CI, 1.68 to 5.92; *P* < .001), respectively, times the odds compared with Scottish Fold (15/55 [27.3%]) **(Supplementary Table S7)**. For tooth resorption, Turkish Angora and Siamese had 17.68 (6/25 [24.0%]; 95% CI, 2.00 to 156.44; *P* = .010) and 13.44 (6/31 [19.4%]; 95% CI, 1.54 to 117.58; *P* = .019), respectively, times the odds compared with Persian (1/57 [1.8%]) **(Supplementary Table S8)**.

Table 4—Prevalence of dental abnormalities evaluated by photographs in the top 10 breeds of dogs and cats in this study and comparative results for dental abnormalities prevalence between breeds based on the breed with the lowest prevalence for each disorder determined using the χ^2-test for homogeneity or Fisher exact test.

Breed	Prevalence (frequency [%]) Calculus	Discoloration	Enamel defects	Epulis	Fractured Tooth	Gingival recession	Gingivitis	Malocclusion	Missing teeth	Persistent deciduous tooth	Tooth resorption
Dog											
Maltese (n = 225)	189 (84.0%)	9 (4.0%)	13 (5.8%)	3 (1.3%)	43 (19.1%)	12 (5.3%)	150 (66.7%)[b]	41 (18.2%)[c]	178 (79.1%)[b]	10 (4.4%)	N/A
Toy Poodle (n = 163)	133 (81.6%)	1 (0.6%)	11 (6.7%)	1 (0.6%)	30 (18.4%)	9 (5.5%)	77 (47.2%)	20 (12.3%)	86 (52.8%)[c]	13 (8.0%)	N/A
Bichon Frise (n = 145)	115 (79.3%)[a]	1 (0.7%)	11 (7.6%)	0 (0.0)[a]	24 (16.6%)	7 (4.8%)	90 (62.1%)[c]	18 (12.4%)	57 (39.3%)[a]	7 (4.8%)	N/A
Mixed breed (n = 136)	110 (80.9%)	6 (4.4%)	6 (4.4%)	1 (0.7%)	38 (27.9%)[c]	7 (5.1%)	61 (44.9%)[a]	13 (9.6%)	69 (50.7%)	6 (4.4%)	N/A
Pomeranian (n = 82)	68 (82.9%)	3 (3.7%)	4 (4.9%)	0 (0.0)[a]	20 (24.4%)	1 (1.2%)	49 (59.8%)[c]	17 (20.7%)[c]	59 (72.0%)[b]	8 (9.8%)	N/A
Miniature Poodle (n = 57)	48 (84.2%)	2 (3.5%)	1 (1.8%)	1 (1.8%)	7 (12.3%)[a]	2 (3.5%)	33 (57.9%)	4 (7.0%)[a]	29 (50.9%)	1 (1.8%)[a]	N/A
Yorkshire Terrier (n = 42)	39 (92.9%)	1 (2.4%)	2 (4.8%)	1 (2.4%)	9 (21.4%)	1 (2.4%)	20 (47.6%)	4 (9.5%)	37 (88.1%)[b]	2 (4.8%)	N/A
Medium Poodle (n = 38)	34 (89.5%)	1 (2.6%)	1 (2.6%)	0 (0.0)[a]	7 (18.4%)	4 (10.5%)	20 (52.6%)	5 (13.2%)	19 (50.0%)	1 (2.6%)	N/A
Chihuahua (n = 35)	28 (80.0%)	0 (0.0)[a]	1 (2.9%)	1 (2.9%)	5 (14.3%)	1 (2.9%)	16 (45.7%)	7 (20.0%)	27 (77.1%)[b]	1 (2.9%)	N/A
Shih Tzu (n = 25)	22 (88.0%)	2 (8.0%)	0 (0.0)[a]	0 (0.0)[a]	6 (24.0%)	0 (0.0)[a]	16 (64.0%)	11 (44.0%)[b]	18 (72.0%)[c]	1 (4.0%)	N/A
Cat											
Domestic shorthair (n = 338)	194 (57.4%)[b]	12 (3.6%)	N/A	1 (0.3%)	47 (13.9%)	84 (24.9%)	231 (68.3%)[c]	5 (1.5%)	183 (54.1%)[b]	6 (1.8%)	29 (8.6%)
Persian (n = 57)	33 (57.9%)[c]	4 (7.0%)	N/A	0 (0.0)[a]	13 (22.8%)	3 (5.3%)	36 (63.2%)	0 (0.0)[a]	34 (59.6%)[b]	0 (0.0)[a]	1 (1.8%)[a]
Scottish Fold (n = 55)	31 (56.4%)[c]	1 (1.8%)	N/A	0 (0.0)[a]	9 (16.4%)	4 (7.3%)	43 (78.2%)[c]	1 (1.8%)	15 (27.3%)[a]	0 (0.0)[a]	1 (1.8%)
Russian Blue (n = 35)	24 (68.6%)[b]	0 (0.0)[a]	N/A	0 (0.0)[a]	2 (5.7%)	4 (11.4%)	16 (45.7%)[a]	1 (2.9%)	22 (62.9%)[c]	0 (0.0)[a]	1 (2.9%)
British Shorthair (n = 31)	10 (32.2%)	0 (0.0)[a]	N/A	0 (0.0)[a]	7 (22.6%)	2 (6.5%)	19 (61.3%)	0 (0.0)[a]	9 (29.0%)	0 (0.0)[a]	1 (3.2%)
Siamese (n = 31)	24 (77.4%)[b]	2 (6.5%)	N/A	0 (0.0)[a]	5 (16.1%)	10 (32.3%)	26 (83.9%)[c]	0 (0.0)[a]	18 (58.1%)[c]	0 (0.0)[a]	6 (19.4%)[c]
Ragdoll (n = 30)	6 (20.0%)[a]	1 (3.3%)	N/A	0 (0.0)[a]	4 (13.3%)	0 (0.0)[a]	19 (63.3%)	0 (0.0)[a]	11 (36.7%)	1 (3.3%)	2 (6.7%)
American Shorthair (n = 27)	18 (66.7%)[b]	4 (14.8%)	N/A	0 (0.0)a	3 (11.1%)	4 (14.8%)	17 (63.0%)	0 (0.0)[a]	10 (37.0%)	0 (0.0)[a]	2 (7.4%)
Turkish Angora (n = 25)	14 (56.0%)[c]	0 (0.0)[a]	N/A	0 (0.0)[a]	1 (4.0%)[a]	4 (16.0%)	12 (48.0%)	0 (0.0)[a]	12 (48.0%)	0 (0.0)[a]	6 (24.0%)[c]
Abyssinian (n = 23)	11 (47.8%)[c]	0 (0.0)[a]	N/A	0 (0.0)[a]	4 (17.4%)	3 (13.0%)	17 (73.9%)[c]	0 (0.0)[a]	9 (39.1%)	0 (0.0)[a]	3 (13.0%)

[a]The baseline for each disorder, which is the lowest prevalence of the disorder among the top 10 breeds visited in dogs and cats, respectively. [b]Significantly different from the baseline breed ($P < .001$). [c]Significantly different from baseline breed ($P < .05$).

Discussion

In this study, several known dental abnormalities could be identified in dogs and cats by analyzing labial and buccal photographs. This epidemiological study reported the prevalence of dental abnormalities identified through the photographs in the Republic of Korea, with a focus on small breed dogs and cats. The results revealed the prevalence of dental abnormalities by age and brachycephalic groups, and breed from statistical analysis, which confirmed an association between age, brachycephaly, and certain breeds with some dental abnormalities. Utilizing this method using dental photographs to screen for dental diseases should make clinicians and owners more aware of the diseases that can be detected and treated at an early stage in the future.

The program used in the diagnostic procedure was created to collect large amounts of data in the process of developing a learning model for future diagnosis using artificial intelligence. In this study, it was not directly involved in diagnosis but was used only as a tool to collect data and mark lesions. This approach to assessment could be applied to new electronic charting systems and used as a tool to screen for the development of dental disease and monitor the changes in the size of dental lesions in the future. The data only included age, breed, and sex and did not collect further information such as the chief complaint for the visit. The data were collected from 26 veterinary clinics, but the actual diagnosis was made by a single veterinarian who evaluated all the photographic data, zoned, and annotated the identified lesions. Therefore, a large number of cases were handled by a single veterinarian who directly evaluated all the photos, ensuring that the diagnosis was consistent. In addition, in all cases, because there is a record of the diagnosis in the form of a photograph, the correct evaluation is considered to have been made.

In this study, the 1-year prevalence rates of gingivitis and gingival recession in 1,096 dogs were 56.7% (621/1,096) and 5.4% (59/1,096), respectively. The overall prevalence of periodontal disease in 60 purebreds of 517,113 dogs during a 5-year period was 18.2% in the US,[15] and the 1-year prevalence of periodontal disease in a random sample of 22,333 dogs was 12.52% (2,797/22,333) in the United Kingdom.[2] This difference was likely due to the prospective nature of this study, which allowed for a more thorough dental examination, and the Asian region has a greater number of small breed dogs than North America and Europe. A study[13] of 408 dogs in the Czech Republic reported a periodontal disease of 60%, and a similar retrospective study[30] of 468 dogs in Spain reported a periodontal disease prevalence of 59.6% (279/468); both used full-mouth examinations. Based on the finding that only 82% (94/114) of periodontal disease cases were assessed by visual examination compared with full-mouth examination under anesthesia,[31] these findings are consistent with the results of this study. However, comparisons with previous studies are limited because only the labial and buccal surfaces were evaluated without dental radiography and the grade of the disease was not evaluated using either the periodontal or the gingival index system. Especially in the case of gingivitis, which is stage 1 periodontal disease, because it can be reversible, a direct comparison with the prevalence of periodontal disease is difficult. The overall prevalence of calculus was 81.4% (892/1,096), higher than the 61.3% of 408 dogs in the Czech Republic,[13] and 34.8% to 95.7% in different age groups, compared to the 7.4% to 87.5% of 251 dogs in Japan.[7]

The prevalence of periodontal disease[10–14] and missing teeth[12,13] tends to increase with age. In this study, increasing age was significantly associated with epulis and discoloration as well as calculus, gingivitis, and missing teeth. Discoloration can occur with irreversible damage, including pulp necrosis, intrapulpal hemorrhage, and traumatic injury.[32] It is necessary to evaluate not only periodontal disease but also epulis and discoloration by full assessment, including dental radiography, in the mature adult period, especially because prevalence is considered to be significantly higher in this age group than in the young adult period.

This study found that malocclusion (OR, 1.93; 95% CI, 1.36 to 2.75; P < .001) and missing teeth (OR, 3.63; 95% CI, 2.71 to 4.91; P < .001) were significantly higher in brachycephalic dogs than in nonbrachycephalic dogs. In a previous study,[23] the probability of dental abnormalities as a grouped disorder for brachycephalic (n = 4,169) compared with nonbrachycephalic (18,079) dogs found no significant differences using univariable and multivariable methods. This difference might be attributed to the fact that this study evaluated individual dental abnormalities, which might have led to more specific results. Class III malocclusion is a condition seen primarily in brachycephaly, especially in small brachycephaly breeds, crowding and rotation of teeth, congenitally missing teeth, and impacted or embedded teeth are common.[33,34] Although class III malocclusion is generally considered normal in brachycephaly, monitoring is necessary for brachycephaly because the presence of malocclusion is susceptible to periodontal disease and any occlusal trauma requires treatment.[33] The occlusion of the labial view was accurately assessed with the mouth closed. However, the assessment of occlusion in the buccal view may have been underestimated because the mandibular teeth were obscured by the maxillary teeth in some cases. In addition, this study only evaluated the presence or absence of malocclusion, as it was difficult to accurately determine the class of malocclusion based on the photographs.

The causes of missing teeth include congenital, previously extracted or exfoliated, fractured below the gingival margin, and impacted or embedded teeth.[35] In this study, the results are considered to include both truly missing and not truly missing cases, such as retained roots and embedded teeth, as they were visually assessed. The marked difference between brachycephalic and nonbrachycephalic dogs in the prevalence of missing teeth was considered to be due to the fact that embedded teeth are common in the first and second premolars in brachycephalic cases.[35] In addition, the possibility that roots may remain after crown fracture was also considered in this study, which had a relatively high proportion of small dogs. In fact, when classified as a small brachycephaly breed, Shih Tzus and Maltese had a higher prevalence of malocclusion, and Yorkshire Terriers, Maltese, Chihuahuas, and Shih Tzus had a higher prevalence of missing teeth. Pomeranians, classified as nonbrachycephalic, have a higher risk of malocclusion and missing teeth.

When comparing the 10 most-visited breeds based on the breed with the lowest prevalence of each condition, significant results were found for fractured teeth, gingivitis, malocclusion, and missing teeth. The overall prevalence of fractured teeth in this study was 20.0% (219/1,096). Since the results were visually assessed, the fractured teeth were defined as any crown fractures in traumatic dentoalveolar injuries (TDI). In addition, the results would be underestimated, because only the labial and buccal surfaces of the teeth were evaluated and the maxillary teeth overlapped the mandibular teeth in some cases. In a study of 2,523 patients anesthetized for oral treatment, the overall prevalence of TDI was 26.2% (660/2,523); among all 14 TDI classes, the total prevalence of crown and enamel fractures was 78.8% (756/959).[36] However, since both dogs and cats were included in this study, these results are not directly comparable.[36] A study[37] that evaluated the teeth of 63 dogs after anesthesia found a 27% prevalence of crown fractures, which is similar to the present study. In contrast, other studies[30,38] found a prevalence of dental fractures from 2.6% (139/5,370) to 7.7% (36/468), which is much lower than the present study. Although previous studies have found differences in prevalence rates based on various assessment methods and study conditions, there have been consistent findings for a higher prevalence of dental fractures in large-breed dogs. In a Spanish study,[30] of the 36 dogs with fractured teeth, 36.1% (13/36) were medium breeds and 52.8% (19/36) were large breeds; the Slovakian study[38] showed a higher prevalence of crown damage in large breeds than in medium and small breeds. Similarly, in the present study, a higher prevalence of fractured teeth was found in mixed breeds (38/136 [27.9%]; OR, 2.77; 95% CI, 1.15 to 6.65; $P = .023$), which consisted mostly of Jindo-mixed dogs compared to other breeds in the Republic of Korea. Tooth fractures are mainly caused by trauma, and mixed-breed dogs, which mostly live outdoors in the Republic of Korea, are considered to have a higher prevalence because they are more susceptible to trauma from activities and hunting.

Maltese and Pomeranian breeds had a higher prevalence of gingivitis, malocclusion, and missing teeth than the other breeds in this study. These results suggest that Malteses are particularly susceptible to periodontal disease because it is a small brachycephalic breed with congenital oral structural problems and a high prevalence of gingivitis.[34] Although the Pomeranian breed was not classified as a brachycephalic breed in this study, the statistical analysis showed that the OR of gingivitis, malocclusion, and missing teeth was higher than that of other breeds; therefore, it was considered a breed that should be monitored for periodontal disease along with Maltese. A retrospective analysis of over 3 million canine medical records in the US showed that the extra-small, small, and small to medium breeds had a 2 to 3 times greater prevalence of periodontal disease than the medium to large, large, and giant breeds.[15] However, direct comparisons were difficult because breeds such as the Papillon, Dachshund, and Cavalier King Charles Spaniel were not included in the top 10 most visited breeds in this present study, it was similarly found that the Maltese, Bichon Frise, and Pomeranian breeds had a higher risk of gingivitis than other breeds. In this study, Yorkshire Terriers were the most affected breed in terms of calculus (39/42 [92.9%]) and missing teeth (37/42 [88.1%]) in this study. A longitudinal study[39] of periodontal disease with 49 Yorkshire Terriers determined this breed was susceptible to developing periodontitis and needed effective treatment such as tooth brushing or alternative methods to prevent the disease from an early age.

In the present study, the prevalence rates of gingivitis and gingival recession were 67.2% (521/775) and 16.3% (126/775), respectively, for cats. Various studies[3,17,19–21,40] have reported the prevalence of periodontal disease to range from 13.9% to 96%, depending on different diagnostic methods. The results of a random sample of 18,249 cats from a retrospective analysis[3] based on clinical electronic patient records in the United Kingdom reported that the 1-year prevalence of periodontal disease was 15.2% (2,780/18,249). However, a study[21] of 109 healthy cats that assessed full dental examination including clinical probing and dental radiography under anesthesia reported that only 4.0% (4/109) of the cats were free from gingival inflammation and all cats had some form of periodontal disease; the differences of the results are considered due to the fact those cats were living in colonies at the feed company's centers and received annual dental scaling but not homecare such as teeth brushing. Furthermore, the results of the present study were based only on visual assessments, which could be another explanation for these differences.

In cats, age was significantly associated with the prevalence of most dental abnormalities, except for epulis and malocclusion. These results are consistent with previous studies that reported the prevalence of periodontitis and feline odontoclastic resorptive lesions increased with age.[17,18] In addition, a study[19] on the frequency and risk factors for periodontal disease in cats in the United Kingdom found that age was the strongest factor in the increasing presence and severity of periodontal disease. Discoloration and fractured teeth were also found to increase in prevalence with age in the present study.

In this study, the prevalence of fractured teeth not only increased with age but was also significantly higher in brachycephalic cats than in nonbrachycephalic cats. A few previous studies[36,41,42] have investigated dental trauma in cats. In a retrospective study[41] of high-rise syndrome in cats, the prevalence of dental trauma was 71.4% (10/14) and the mean age of cats was 36.9 months with approximately three-quarters aged 48 months or younger. In another study[42] of the prevalence and nature of dentoalveolar injuries among a total of 43 dogs and cats with maxillofacial fractures, younger patients were much more likely to suffer dentoalveolar injuries when maxillofacial fractures were present than older patients. These findings that traumatic injury was generally more likely to occur at younger ages were in contrast to the present study results. This difference might be due to previous studies having analyzed data at the time of trauma, whereas the present study included patients with no history of trauma or dental disease. Although the increasing strength of teeth after dentinogenesis or the active behavioral characteristics of younger patients may explain the high incidence of trauma at a young age,[42] careful evaluation of dental trauma is necessary even in old patients because of the possibility of unrecognized damage or incidental findings.[38]

In this study, the prevalence of fractured teeth was 20.8% (35/168) in brachycephalic cats and, 11.9% (113/589) in nonbrachycephalic cats. This finding was consistent with a prospective study of 50 brachycephalic cats in which the prevalence of dental fractures was 22% (11/50).[22] A Flemish survey[18] of 753 cats that included 617 domestic shorthairs and domestic longhairs classified as nonbrachycephaly reported a 10.8% tooth fracture incidence, which is similar to the present study. When the angle between the canine teeth and the hard palate in domestic shorthairs and Persians was assessed by CT scan, it was significantly higher in the Persian than in domestic shorthair breeds.[24] The majority of traumatic tooth injuries occur in the canine teeth,[38] which are dorsally displaced in the brachycephaly,[24] suggesting that they may be more susceptible to trauma.

Except for fractured teeth, there were no significant differences in most dental abnormalities, and gingival recession, missing teeth, and tooth resorption were significantly lower in the brachycephaly group. Persian and Exotic cats might have a predisposition to dental diseases such as tooth resorption and periodontal disease in the previous study.[22] In addition, the lack of space in the jaw of brachycephalic cats could cause crowding and impaction of teeth.[24] Although this dental malalignment might also be a risk factor for periodontal disease, no association was found between brachycephaly and the clinical signs such as gingivitis or periodontal ulceration from that malalignment.[24] Thus, because feline periodontal disease is influenced by a multifactorial interaction of genetic and environmental factors, further research is needed to confirm the association between periodontal disease and craniofacial type.

The Siamese breed had a significantly higher prevalence of calculus, tooth resorption, gingivitis, and missing teeth. In addition, the Russian Blue breed had a significantly higher prevalence of calculus and missing teeth, whereas the domestic shorthair breed had a significantly higher prevalence of gingivitis and missing teeth. A study[20] that evaluated the teeth of 147 cats via dental radiographs found no difference in the prevalence of periodontitis or odontoclastic resorption lesions between purebred and mixed-breed cats. However, a study[21] of 109 healthy cats in France found a significant breed effect for gingivitis in Burmese, Bengal, Somali, Maine Coon, Bobtail, and Abyssinian and for periodontitis in Persian, Maine Coon, Burmese, Bengal, Somali, and Bobtail breeds. In comparison, the present study indicated a notable effect for gingivitis in Siamese, Scottish Fold, Abyssinian, and domestic shorthair breeds, and gingival recession in Siamese and domestic shorthair breeds. Although each sample size was larger than those of the French study, it was difficult to make direct comparisons because of the different breed compositions. However, as mentioned in the previous study,[20,21] it is possible to suggest a potential genetic influence on the identified effects.

In this study, epulis was defined clinically as a localized swelling on the gingiva, not in a specific histopathologic assessment. The prevalence of epulis was 1.0% (11/1,096) in dogs and 0.3% (2/775) in cats. In previous studies,[43,44] the incidence of oral neoplasia was 0.07% to 0.49% in dogs and 0.05% to 0.49% in cats. This difference is considered to be due to the small number of cases evaluated compared to previous studies and the fact that only the labial and buccal surfaces were evaluated in this study. Furthermore, the results might be underestimated due to the presence of masses on the lingual side or on the mucosal side of the oral cavity, which could not be evaluated on dental photographs.

Enamel defects are the loss of structural integrity of the enamel and can be identified in dental caries, resorptive lesions, and amelogenesis imperfecta such as enamel hypoplasia and enamel hypomineralization.[45] The lesions of enamel defects were distinguished from dental fractures not only by the loss of structure, but also by the pitted, rough, and discolored brown appearance of the defects.[45] In this study, the prevalence of enamel defect was found to be 5.3% (58/1,096) in dogs. However, the results may have been underestimated because our evaluation was limited to external lesions on the labial and buccal surfaces of the crown. In addition, it was not possible to differentiate the exact cause without an individual patient history and evaluation of a complete dental examination including dental radiography. Regardless of the cause, teeth with enamel defects are susceptible to tooth fracture, periodontal disease, and subsequent pulp pathology, requiring a complete dental examination when the lesions are identified.[45]

This study has several limitations. First, a complete examination, including dental radiography and probing, was not performed; therefore, root fractures and resorptive lesions of the root could not be diagnosed, and the stages of dental disease could not be assessed in detail. Therefore, the prevalence of several dental conditions may have been underestimated. Second, only the buccal surfaces of the tooth were evaluated. Third, in some cases, the crown of mandibular teeth was partially obscured by the maxillary teeth, or an entire portion of the crown was covered by severe calculus, which limited the assessment of some coronal abnormalities such as discoloration, fractured teeth, gingival recession, and tooth resorption. Finally, well-known risk factors for periodontal disease, such as body weight,[11,15] dietary factors,[12,46–49] and systemic health conditions[5,6] were excluded.

In conclusion, this study demonstrated that the presence of calculus, persistent deciduous teeth, and possibly gingivitis could be identified in dogs and cats by analyzing labial and buccal photographs. The assessment of fractured teeth, missing teeth, and tooth resorption can be limited without a complete dental examination performed with probing and radiography under general anesthesia. Trends in the development of dental abnormalities according to age were determined, differences in the prevalence of brachycephaly and nonbrachycephaly were compared and analyzed, and the specific breeds that had a higher prevalence of dental abnormalities were identified. Although there were dental abnormalities that could be undiagnosed because dental radiography and complete oral examinations were not performed and only the labial and buccal surfaces were evaluated, the prevalence of dental abnormalities was determined based on visible lesions in this study. The results of the analysis according to breed and craniofacial type-specific predispositions for dental abnormalities could provide more information to clinicians. The study was intended to provide data as an important step in proceeding with a complete dental examination, including dental radiography, following a visual assessment. The findings could also be used in the future for big data collection and analysis to create a program that uses image processing to predict the likelihood of disease from photographs. Furthermore, the method evaluated for dental abnormalities through the labial and buccal surfaces may be useful for clinicians for initial screening of dental diseases in dogs and cats.

Acknowledgments

None reported.

Disclosures

The authors have nothing to disclose. No AI-assisted technologies were used in the generation of this manuscript.

Funding

This study was supported by AIFORPET Corp. In addition, this research was supported by BK21 FOUR Future Veterinary Medicine Leading Education and Research Center and the Research Institute for Veterinary Science, College of Veterinary Medicine, Seoul National University.

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Supplementary Materials

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