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J Vet Res 63, 141-148, 2019
DOI:10.2478/jvetres-2019-0002

Occurrence and distribution of canine cutaneous mast cell tumour characteristics among predisposed breeds

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Received: September 5, 2018 Accepted: January 10, 2019

Abstract

Introduction: Breed predisposition to cutaneous mast cell tumours (MCT) in a population of dogs in Poland affected by various skin tumours was assessed, and the distribution of MCT characteristics such as histological grading, sex, age, and location, in predisposed breeds was evaluated. **Material and Methods:** The retrospective epidemiological study included 550 dogs affected by cutaneous MCTs with a reference group of 2,557 dogs diagnosed with other skin tumours. **Results:** A univariable logistic regression analysis was performed to determine the odds ratios (ORs) with 95% confidence intervals. The risk of high-grade MCTs was the highest for Shar-Peis (OR: 26.394) and American Staffordshire Terriers (OR: 2.897). Boxers (OR: 6.619), Labrador Retrievers (OR: 2.630), French Bulldogs (OR: 2.050), Golden Retrievers (OR: 1.949), and American Staffordshire Terriers (OR: 2.592) were mainly affected by low-grade MCTs. The high risk of MCT was calculated to be at the age of 4–6 years for Labrador Retrievers (OR: 2.686) and 7–10 years for Boxers (OR: 2.956) and French Bulldogs (OR: 9.429). MCTs were significantly more often located on the trunk in French Bulldogs (OR: 4.680), American Staffordshire Terriers (OR: 2.520), and Labrador Retrievers (OR: 1.948). There was no statistically significant correlation between gender and the occurrence of MCTs in the breeds. **Conclusions:** The breed-predicated differences in the clinical course of MCTs suggest a genetic background for the tumours.

Keywords: dogs, mast cell tumour, breed, predisposition.

Introduction

In dogs the number of diagnosed tumours that are one of the main causes of fatalities is constantly increasing (1, 6, 11, 29, 31). Statistical data reveal that 50% of dogs reaching 10 years of age die of neoplastic diseases (5). Skin tumours are diagnosed most frequently, and 7%–21% of cases are mast cell tumours (MCTs) (11, 33). A number of studies have evidenced breed-related predispositions to specific tumour types, including skin neoplasia (6). For instance, an increased risk of malignant histiocytosis has been reported in the Bernese Mountain Dog, anal sac gland carcinoma in the English cocker spaniel, or malignant melanomas in the Schnauzer (6, 9, 10, 26). The highest risk for MCTs has been noted in Boxers (18, 33). In previous reports, an increased risk for MCTs was noted in the case of breeds like Bullmastiff, Boston Terrier, Staffordshire Bull Terrier, Shar-Pei, Rhodesian Ridgeback, Pug, Weimaraner, Labrador Retriever, Beagle, Golden Retriever, Staffordshire Bull Terrier, and Vizsla (20, 27, 31, 32, 34). The prevalence of skin tumours in these breeds is often associated with the geographical area in which the analysed populations live. Although breed predispositions have been described in detail, there is insufficient information about the relationship between

the breed and the clinical features of the disease. Recent literature data revealed a milder course of MCTs in the Boxer and Pug (20). The multifocal form of MCT has been reported in Golden Retrievers, whereas a more aggressive course of MCTs has been observed in young Shar-Peis (7, 17, 19). To date, there have been no epidemiological studies about the development of mast cell tumours in individual breeds in relation to the malignancy grade location, animal age, and sex.

A comparison of the clinical presentation of MCT within individual breeds will provide more details about the complex biology of MCT and, simultaneously, be the basis for genetic research on its aetiology. So far, c-kit mutations within exons 11, 8, and 9 in the nuclear DNA have been identified (28). Mutations and polymorphisms in the D-loop region, which is a non-coding mitochondrial DNA (mtDNA) fragment, have been documented as well (30). The aim of this study was to assess breed predisposition to MCT development in a defined population of dogs affected by various skin tumours and to evaluate the distribution of MCT characteristics such as histological malignancy grade according to Kiupel's classification (16), sex, age, and location, in predisposed breeds.

Material and Methods

The analysed group included a population of various purebred and crossbreed dogs diagnosed with primary cutaneous MCTs. Individuals were selected based on a histopathological assessment of skin tumour cases diagnosed in dogs at the Sub-Department of Pathomorphology and Forensic Veterinary Medicine, University of Life Sciences in Lublin, Poland, in the years from 2003 to 2017. The tumour samples for histopathological evaluation were collected from dogs treated with surgical resection of the skin tumour, which was performed at the Veterinary Clinic, University of Life Sciences in Lublin and at private veterinary clinics in Poland. The analysis involved 550 dogs diagnosed with cutaneous MCT, which were selected based on a histopathological assessment of 3,107 canine skin tumour cases. Clinical data on the dogs' breed, age, sex, and tumour location derived from written records and referrals delivered to the academic veterinary pathology unit, and together with this data were the resected tumours for histopathological examination. Only dogs with a complete set of data were qualified for the study. Cases with incomplete data and, considering the Kiupel grading system, cases with diagnosed subcutaneous MCT were excluded from the analyses. The retrospective analyses were performed on skin tumours diagnosed in an individual for the first time. A total of 39 individuals with MCTs and 483 dogs with skin tumours other than MCTs were classified into one group, *i.e.* other breeds. The analysis was conducted on 26 purebreed and crossbreed dogs, and on a group of other breeds rare in Poland. Tissue samples for microscopic examination were routinely formalin-fixed, paraffin-embedded, and stained with haematoxylin and eosin as well as toluidine blue. The histopathological evaluation of MCTs was performed according to the two-grade malignancy scale of Kiupel (16). Tumours sampled before 2011 and evaluated according to the Patnaik scale (24) were reclassified based on the Kiupel grading system by three independent histopathologists.

The risk of MCT development according to breed, sex, location, and age was determined by univariable logistic regression analysis based on the odds ratio (OR) with a 95% confidence interval (CI). The control group comprised dogs diagnosed with skin tumours other than MCT with the restriction that cases with a diagnosed tumour of subcutis were excluded from the analysis. Individuals were divided into four age groups: (1) 0–3 years, (2) 4–6 years, (3) 7–10 years, and (4) 11–16 years. Three tumour locations were distinguished: head and neck, trunk, and limbs (pectoral and pelvic). The analysis was conducted using the Statistica 9.1 programme (StatSoft, Cracow, Poland). Values of $P < 0.05$ were considered significant.

Results

MCTs accounted for 17.7% of all the analysed skin tumours. The greatest number of MCTs were diagnosed in Boxers (18.36% of all examined individuals) followed by Labrador Retrievers, American Staffordshire Terriers, Golden Retrievers, French Bulldogs, Dachshunds, and Shar-Peis (ranging from 10.36% to 2.55%, respectively).

The highest predisposition to MCT development, rather than skin tumours of other kinds, was detected in six breeds, namely Shar-Peis, Boxers, American Staffordshire Terriers, Labrador Retrievers, French Bulldogs, and Golden Retrievers.

Data on the frequency of MCT diagnosis according to age, sex, and location in six breeds predisposed to MCT development are presented in Table 3.

The highest mean age of 8.8 ±2.6 years was noted in American Staffordshire Terriers, while the lowest age of 6.1 ±2.3 years was recorded in Shar-Peis. The greatest proportion of male dogs occurred among French Bulldogs, Golden Retrievers, Shar-Peis, and American Staffordshire Terriers. Female dogs were dominant among Boxers and Labradors affected by MCT. The most frequent location for MCT development was the trunk area among French Bulldogs and the limbs among Shar-Peis (Table 3).

The risk of high-grade MCT development was found to be highest in Shar-Peis and American Staffordshire Terriers. Additionally, in American Staffordshire Terriers, a predisposition to low-grade

MCT development was noted. Four breeds, namely Boxers, Labrador Retrievers, French Bulldogs, and Golden Retrievers were at high risk of developing low-grade MCT.

Evident predisposition to develop MCT was revealed for Labrador Retrievers aged from 4 to 6 years; for Boxers and French Bulldogs the predisposition to develop MCT was found to be higher at the age of 7–10 years compared to dogs of other breeds. For three breeds, *i.e.* French Bulldogs, American Staffordshire Terriers, and Labrador Retrievers, a tendency to develop MCTs on the trunk was noted. There was no sex-related predilection for MCT development in any of six examined breeds (Table 4).

Table 1. Frequency of MCTs in various breeds of dogs according to the Kiupel grading system

Breed	All MCTs		Kiupel grade				Control group†	
			Low		High			
	Number	%	Number	%*	Number	%**	Number	%
Boxer	101	18.36	97	96.04	4	3.96	110	4.30
Labrador Retriever	57	10.36	47	82.46	10	17.54	116	4.54
American Staffordshire	32	5.82	24	75.00	8	25.00	58	2.27
Golden Retriever	25	4.55	22	88.00	3	12.00	70	2.74
French Bulldog	18	3.27	14	77.78	4	22.22	42	1.64
Dachshund	14	2.55	5	35.71	9	64.29	100	3.91
Shar-Pei	14	2.55	1	7.14	13	92.86	11	0.43
Bernese Mountain Dog	15	2.73	11	73.33	4	26.67	53	2.07
German Shepherd	9	1.64	6	66.67	3	33.33	241	9.43
Miniature Schnauzer	7	1.27	6	85.71	1	14.29	63	2.46
Irish Setter	6	1.09	6	100.00	0	0.00	25	0.98
Standard Schnauzer	5	0.91	3	60.00	2	40.00	31	1.21
Bull Terrier	5	0.91	5	100.00	0	0.00	19	0.74
Cocker Spaniel	4	0.73	4	100.00	0	0.00	111	4.34
Doberman	4	0.73	3	75.00	1	25.00	40	1.56
Maltese	5	0.91	5	100.00	0	0.00	9	0.35
Pug	3	0.55	3	100.00	0	0.00	4	0.16
Polish Tatra Sheepdog	3	0.55	2	66.67	1	33.33	7	0.27
Siberian Husky	3	0.55	3	100.00	0	0.00	39	1.53
Weimaraner	3	0.55	1	33.33	2	66.67	8	0.31
Saint Bernard	2	0.36	2	100.00	0	0.00	14	0.55
Jack Russell Terrier	2	0.36	1	50.00	1	50.00	9	0.35
Miniature Poodle	2	0.36	1	50.00	1	50.00	5	0.20
Yorkshire Terrier	3	0.55	3	100.00	0	0.00	93	3.64
Caucasian Shepherd	2	0.36	2	100.00	0	0.00	7	0.27
Standard Poodle	2	0.36	2	100.00	0	0.00	26	1.02
Other breeds	39	7.09	31	79.49	8	20.51	483	18.89
Crossbreed	165	30.00	113	68.48	52	31.52	763	29.84
Total	550	17.70***	423	76.91	127	23.09	2557	82.30

* Percentage of dogs with low-grade MCT in a specific dog breed
** Percentage of dogs with high-grade MCT in a specific dog breed
*** Percentage of dogs with low/high grade MCT among all tested dogs
† Total number of dogs with other skin tumours in a specific dog breed

Table 2. Odds Ratios (ORs) and 95% confidence intervals (CIs) for MCT in various dog breeds

Breed	MCT	
	OR (95% CI)	p
Shar-Pei	6.045 (2.730–13.390)	< 0.001
Boxer	5.004 (3.751–6.676)	< 0.001
American Staffordshire Terrier	2.662 (1.711–4.140)	< 0.001
Labrador Retriever	2.433 (1.747–3.389)	< 0.001
French Bulldog	2.026 (1.157–3.547)	0.013
Golden Retriever	1.692 (1.061–2.697)	0.027
Siberian Husky	0.354 (0.109–1.150)	0.084
Maltese	2.597 (0.867–7.780)	0.088
Miniature Schnauzer	0.510 (0.232–1.120)	0.094
Pug	3.500 (0.781–15.685)	0.102
Dachshund	0.642 (0.364–1.131)	0.125
Doberman	0.461 (0.164–1.294)	0.141
Standard Poodle	0.355 (0.084–1.501)	0.159
Polish Tatra Sheepdog	1.998 (0.515–7.750)	0.317
Bernese Mountain Dog	1.325 (0.741–2.368)	0.343
Weimaraner	1.747 (0.462–6.608)	0.411
Miniature Poodle	1.863 (0.360–9.626)	0.458
Standard Schnauzer	0.748 (0.289–1.931)	0.548
Saint Bernard	0.663 (0.150–2.925)	0.587
Bull Terrier	1.225 (0.456–3.296)	0.687
Caucasian Shepherd	1.330 (0.275–6.417)	0.723
Irish Setter	1.117 (0.456–2.736)	0.809
Jack Russell Terrier	1.033 (0.223–4.795)	0.967
Cocker Spaniel	0.161 (0.059–0.440)	< 0.001
German Shepherd	0.160 (0.082–0.313)	< 0.001
Yorkshire Terrier	0.145 (0.046–0.460)	0.001

Table 3. Frequency of MCT according to the age, sex, and location in six purebred dogs predisposed to MCT development

	Variable	Dog breeds											
		Boxer		Labrador Retriever		American Staffordshire Terrier		French Bulldog		Shar-Pei		Golden Retriever	
		N	%	N	%	N	%	N	%	N	%	N	%
Age (years)	0–3	5	4.95	0	0.00	1	3.13	0	0.00	2	14.29	2	8.00
	4–6	25	24.75	22	38.6	5	15.62	7	38.89	7	50.0	11	44.0
	7–10	67	66.34	31	54.38	18	56.25	11	61.11	5	35.71	7	28.0
	11–16	4	3.96	4	7.02	8	25.0	0	0.00	0	0.0	5	20.0
	M ± SD	7.3 ± 2.0		7.3 ± 2.2		8.8 ± 2.6		7.2 ± 2.2		6.1 ± 2.3		6.9 ± 3.1	
	min – max	2.0–11.0		3.5–13.0		3.0–13.0		4.0–10.0		2.0–10.0		2–12	
Sex	male	48	47.52	28	49.12	18	56.25	14	77.78	8	57.14	15	60.0
	female	53	52.48	29	50.88	14	43.75	4	22.22	6	42.86	10	40.0
Location	head & neck	16	15.84	11	19.3	3	9.38	4	22.22	2	14.29	6	24.0
	limbs	33	32.67	13	22.81	8	25.0	1	5.56	9	64.29	6	24.0
	trunk	52	51.49	33	57.89	21	65.63	13	72.22	3	21.43	13	52.0

M – average
SD – standard deviation

Table 4. Odds Ratios (ORs) and 95% confidence intervals (CIs) for Kiupel grades of MCT, sex, age, and MCT location in six purebred dogs predisposed to MCT development

Variable		Dog breeds											
		Boxer		Labrador Retriever		American Staffordshire Terrier		French Bulldog		Shar-Pei		Golden Retriever	
		OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Kiupel grade of MCT	low	6.619 (4.921–8.903)	< 0.001	2.630 (1.843–3.755)	< 0.001	2.592 (1.592–4.219)	< 0.001	2.050 (1.109–3.787)	0.022	0.548 (0.071–4.259)	0.566	1.949 (1.194–3.183)	0.008
	high	0.723 (0.262–1.994)	0.531	1.799 (0.918–3.522)	0.087	2.897 (1.352–6.204)	0.006	1.947 (0.687–5.517)	0.210	26.394 (11.572–60.202)	< 0.001	0.860 (0.267–2.768)	0.800
Sex	male	1 (base)	–	1 (base)	–	1 (base)	–	1 (base)	–	1 (base)	–	1 (base)	–
	female	1.325 (0.771–2.277)	0.309	1.416 (0.749–2.677)	0.284	1.102 (0.461–2.636)	0.827	0.514 (0.143–1.846)	0.308	0.900 (0.183–4.415)	0.897	0.889 (0.351–2.252)	0.804
Age (years)	0–3	0.153 (0.056–0.413)	< 0.001	–	–	0.124 (0.015–1.000)	0.050	–	–	0.750 (0.088–6.388)	0.792	0.293 (0.062–1.381)	0.121
	4–6	1.244 (0.653–2.370)	0.506	2.686 (1.324–5.446)	0.006	1.157 (0.345–3.887)	0.813	2.036 (0.623–6.655)	0.239	0.833 (0.171–4.058)	0.821	1.964 (0.764–5.052)	0.161
	7–10	2.956 (1.685–5.185)	< 0.001	1.003 (0.531–1.896)	0.993	1.045 (0.438–2.492)	0.922	9.429 (2.615–33.998)	0.001	1.481 (0.265–8.267)	0.654	0.848 (0.310–2.326)	0.749
	11–16	0.261 (0.084–0.816)	0.021	0.654 (0.201–2.126)	0.480	2.889 (0.902–9.250)	0.074	–	–	–	–	1.208 (0.379–3.856)	0.749
MCT location	head and neck	0.579 (0.291–1.152)	0.119	0.967 (0.434–2.153)	0.934	0.397 (0.103–1.526)	0.179	0.346 (0.097–1.227)	0.100	1.667 (0.131–21.195)	0.694	0.645 (0.227–1.834)	0.411
	limbs	0.849 (0.481–1.500)	0.574	0.466 (0.226–0.960)	0.038	0.587 (0.224–1.538)	0.279	0.250 (0.029–2.165)	0.208	3.150 (0.608–16.311)	0.171	1.158 (0.393–3.413)	0.790
	trunk	1.654 (0.957–2.857)	0.071	1.948 (1.024–3.704)	0.042	2.520 (1.029–6.171)	0.043	4.680 (1.397–15.682)	0.012	0.227 (0.040–1.299)	0.096	1.286 (0.515–3.211)	0.589

Discussion

In a previous epidemiological study representing a 10-year observation period from 2003 to 2013, the occurrence of MCTs was substantially lower at 13.24% (29). The current results indicate an increase in the occurrence of MCTs in recent years. However, the incidence of MCT diagnosis can be related to the increased compliance of owners in submitting their dog to clinical examination and surgery. Additionally, awareness among owners about oncological problems in their pets has recently been raised. Differences in the

general prevalence of predisposed breeds in recent years in Poland also could have an impact on the results.

The results of the present study indicate an increased predisposition to MCT development in six breeds, *i.e*. Shar-Peis, Boxers, American Staffordshire Terriers, Labrador Retrievers, French Bulldogs, and Golden Retrievers (Table 2). Similar results were reported in investigations conducted in the UK, where the highest risk was noted in the cases of Boxers, Labrador Retrievers, Golden Retrievers, and Staffordshire Bull Terriers (32). It should be emphasised that the risk of tumour development in the breeds analysed by Warland and Dobson (32) was assessed in three control groups, *i.e*. an insured population, dogs registered in the kennel club, and hospitalised dogs. Although a reference group composed of dogs with skin tumours other than MCTs was included in the present study, similar results were obtained, and the predisposition to MCT development in these four breeds was confirmed.

The present analysis exhibited a six-fold higher predisposition to MCT development in Shar-Peis than that in other breeds diagnosed with skin tumours (Table 2). An increased risk of development of MCT in Shar-Peis was reported in investigations conducted in the USA (31). In the present study, Shar-Peis also exhibited a high risk for high-grade MCT development (Table 4). The present results confirm previous reports of the increased incidence of poorly differentiated MCT in this breed (19). The study conducted by Miller demonstrated the prevalence of these tumours in younger dogs. In comparison with other breeds, the present study revealed frequent occurrence of MCT in Shar-Peis at a mean age of 6.1 ± 2.3 years, and the youngest affected representative of this breed was a 2-year-old dog (Table 3). Despite the recent interest in Shar-Pei breeding, the population of these dogs is still very small. In 1972, the Shar-Pei was the least numerous breed worldwide. The breed was popularised in Europe in the 80's and registered in the American Kennel Club in 1992 (19). The small size of the population carries the risk of loss of genetic variability and gene divergence, and this loss promotes the development of various hereditary diseases, including neoplasia (6).

Boxers exhibit the highest predisposition to MCT development (6, 33). This has been confirmed by both the present investigations and previous epidemiological studies conducted in different geographical regions (18, 20, 31, 33). Literature data show the frequent incidence of low-grade MCT in Boxers, which was documented in the present study as well (20). An increased predisposition to develop low-grade MCT was clearly demonstrated in this study (Table 4). The Bullenbeisser as well as the English Bulldog are ancestors of the Boxer. Breeds related to the Bulldogs, for instance American Staffordshire Terriers, established an elevated odds ratio for MCT in the present study (Table 2). An increased predisposition to low-grade and high-grade MCT development was noted in this breed (Table 4). As indicated in literature reports, MCTs with a milder presentation occur in dog breeds that are phylogenetically related to the Bulldog (20). This was also confirmed for the French Bulldog in the present study (Table 4). The American Staffordshire Terrier is a crossbreed between the Bulldog and the Terrier (23), which may be at an increased risk of high-grade MCT development.

In the present study another dog breed characterised by a higher frequency of MCT diagnosis was the Labrador Retriever. These results are in agreement with previous epidemiological reports (6, 31, 34). There are only few literature reports on the clinical presentation of MCT in Labrador Retrievers (7, 19). Some literature data describe the development of more aggressive tumours in Labrador Retrievers (7, 33). However, this was not confirmed in the present study. The statistical analysis demonstrated a higher risk of low-grade MCT development in the Labrador Retrievers (Table 2). Evidently, this dog breed requires further observations and research in this field.

The Golden Retriever is a breed with a higher risk of developing tumours (8). A predisposition for melanomas, soft-tissue sarcomas, and lymphomas has been noted in this dog breed (4) besides an increased risk of MCT, which epidemiological studies conducted in the UK and USA have demonstrated in the breed (27, 31, 32, 34). Currently, there are few reports available on the clinical presentation of MCT in this dog breed, as in the case of the Labrador Retriever. The scant reports available emphasise the occurrence of multifocal form among MCTs (7). Our epidemiological studies have documented for the first time the increased risk for the development of low-grade MCT in Golden Retrievers (Table 4). Interesting results of molecular analyses of the genome of European and American Golden Retriever populations have been published: the polymorphisms in the GNAI2 gene and hyaluronidase genes have been associated with the risk of MCT development (2).

MCTs can develop at any age, with the highest incidence between 7.5 and 9 years of life (7, 21, 33). The greatest numbers of MCT cases in this age group were noted for Boxers, French Bulldogs, and American Staffordshire Terriers in the present study as well (Table 3). Age-related biases are complicated by breed variation in longevity associated with body size and other factors (22). Different pure breeds with contrasting lifespans were examined, which were the French Bulldog with average life expectancy of nine years and the Staffordshire Terrier with average life expectancy of 12–16 years. Moreover, the lifespan of Shar-Pei is much shorter than average for large breeds with a median age at death of only 6.3 years (1). The oldest dog diagnosed with MCT at the time of delivery of the tumour for histopathological examination was 16, hence the final age range is 11–16 years in the

current study. As expected, there was a highly significant positive effect of age on number of MCT diagnoses. The statistical analysis confirmed the increased frequency of MCT diagnosis in the 7–10-year-old group in the two breeds: Boxer and French Bulldog (Table 4). In turn, an increased risk of MCT at a younger age (4–6 years) was documented for the first time in the Labrador Retriever (Table 4). The other three examined breeds, *i.e.* American Staffordshire Terrier, Shar-Pei, and Golden Retriever, did not exhibit statistically significant relationships in any of the four age groups (Table 4). This result may be associated with the insufficient number of dogs in the particular age groups. It should be emphasised, however, that the absence of French Bulldogs and Shar-Peis in the 11–16 years age group may be related to the shorter life expectancy in these breeds. Additionally, an interval period from skin tumour mass onset and owner decision to bring dog to the veterinary clinic also may have some influence on the results.

To date, no correlation has been found between the sex of an animal and MCT occurrence (7, 25, 33). This was also confirmed in the present study of the different dog breeds (Table 4). Some literature data describe a relationship between MCT incidence and sterilisation or castration status of the animal (20, 34, 35). As this study population was limited to animals with unknown neutered status, the results may not generalise well to the overall dog population. However, the role of sex hormones in the MCT development has not been fully elucidated.

Although MCT can be located in any part of the body, many studies hypothesised a possible prognostic significance for several tumour sites, *i.e*. digit, scrotal, inguinal, or perianal (7, 33). A single study indicated that tumour localisation can be related to a better or worse prognosis (25). However, MCT is most frequently located on the trunk (50%–60%), limbs (25%–40%), and head and neck (10%) (33). A similar proportionality in the tumour location was noted in Boxers in the present study (Table 3). MCT was mainly located on the trunk in French Bulldogs and on limbs in Shar-Peis. The French Bulldog, American Staffordshire Terrier, and Labrador Retriever were characterised by MCTs more frequently developing on the trunk (Table 3). There are very few reports on the location of MCTs in different dog breeds. Some studies have reported an increased frequency of MCT on the hind legs in Boxers, Staffordshire Terriers, and Boston Terriers, on the tail in Rhodesian Ridgebacks, and on the head and hind legs in Setters (21, 33, 35).

Summarising, the differences observed in the clinical presentation of MCT between predisposed dog breeds suggest a genetic background of MCT. Despite the progress in the development of MCT treatment methods and MCT prognostic factors, the aetiology of this tumour has not been fully elucidated yet (3, 12–15, 28). Retrospective analyses have indicated breed predispositions to MCT development. It should be emphasised that modern dog breeds were created through a broad selection of specific phenotypic traits. Inbreeding practices and the use of popular reproducers reduce genetic variation, which results in the development of various hereditary diseases, including neoplasia. This is the first study indicating the relation of breed predisposition to canine MCT development and distribution of MCT characteristics among predisposed breeds.

Conflict of Interests Statement: The authors declare that they have no conflict of interests regarding the publication of this article.

Financial Disclosure Statement: This research was financed by the Faculty of Veterinary Medicine, University of Life Sciences in Lublin.

Animal Rights Statement: None required.

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