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Research Article

Evaluation of cat tumors in Samsun between 2004-2022

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ABSTRACT

This study investigated the incidence of various tumors detected in 169 cat tissue and organ samples brought to the Samsun Ondokuz Mayis University, Veterinary Faculty, Department of Pathology between 2004–2022. Of the 169 specimens, five were acquired from necropsy and 164 were biopsy samples. Various tumors were evaluated retrospectively according to localization, sex, breed, and tumor origin. Tumors were common in mixed breeds (n = 96, 56.8%). Age of tumor incidence was examined; cats between 6 and 9 years of age most frequently had tumors (n = 45, 26.6%) in both sexes. In terms of tumor origin, 79 (47.0%) were mesenchymal, 83 (49.4%) were epithelial, and seven (4.2%) were of mixed components, i.e., mesenchymal and epithelial. In total, 147 (87%) tumors were classified as malignant and 22 (13%) tumors were classified as benign. Regardless of sex, the most commonly observed tumors were skin and subcutis tumors (n = 56, 32.1%). In conclusion, tumor incidence in Samsun was determined by retrospectively evaluating tumors in cats according to location, breed, sex, age range, and origin and comparing these with the literature.

INTRODUCTION

Cancer is a disease of the genome arising from DNA alterations due to mutated gene structure or function. Many agents, including viruses, chemicals, radiation damage, and altered gene expression are common features of almost all neoplasms. There is an inherent error rate in DNA replication; all multicellular organisms face the near certainty of developing a neoplasm if they survive long enough, as mutations will eventually develop (Cullen and Breen, 2017). Cats and dogs are exposed to the same environmental risk factors as humans and the complex interactions between genetic and environmental risk factors can trigger tumorigenesis. In recent years, the development of care and feeding conditions and the treatment options for various diseases has prolonged the lifespan of animals and triggered a respective increase in the frequency of neoplastic diseases in animals. In addition, the shorter lifespan of animals compared to humans causes rapid tumor progression (Cannon, 2015). Neoplastic diseases are frequently seen in domestic animals, including cats and dogs, although cats are six times less likely to develop tumors than dogs. Some dog breeds, including boxers, terriers, and bullmastiffs, are predisposed to tumor development. The predisposition of different cat breeds is controversial, but the incidence of mammary and intestinal tumors is frequently reported in Siamese cats (Egenvall et al., 2009, Egenvall et al., 2010; Rissetto et al., 2011).

Female dogs have a higher risk of developing tumors than male dogs, but this link is controversial in cats. Shida et al. (2010) reported that the frequency of tumors was substantially higher in female cats, whereas Dorn et al. (1968) observed higher frequencies in male cats. Moreover, lymphomas were more frequently seen in male cats than female cats in another study (Dorn et al., 1968) but further research found that lymphomas had no significant correlation with sex (Shida et al., 2010). In addition, one study found that the median age of tumor incidence for cats was 9.5 years old (Pérez-Enriquez et al., 2020), while another reported a median of 9.14 years old (Rafalko et al., 2022; Pinello et al., 2022b). Further research found that tumors were most often detected between 6 and 14 years of age in cats (Pamukçu, 1954; MacEwen, 1990; Gülçubuk et al., 2005; Aydın et al., 2008). Squamous cell carcinoma (SCC), mammary tumors, and fibrosarcomas are among the most frequently identified tumors in cats (Cannon, 2015).

In our country, many retrospective studies have been conducted on tumor incidence in domestic animals, including cats and dogs (Ertürk et al.,1971; Kökuslu et al., 1972; Kutsal et al., 2003; Gülçubuk et al., 2005; Atalay et al. 2007; Aydın et al.,

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2008; Kutlu et al., 2015; Kuruca et al., 2019; Aydoğan et al., 2021). This study aimed to determine the distribution of cat tumor classification according to location, tumor characteristics, sex, breed, and age of cats who attended clinics or the Samsun Ondokuz Mayis University Faculty of Veterinary Pathology Department between 2004–2022 and were examined and diagnosed by this department.

breeds, for example, orange or tabby cats (n = 96, 56.8%). In addition, six (3.6%) cats were Persian, five (3%) were Turkish Angora, and five (3%) were Turkish Van. In terms of age of tumor incidence, tumors were most common between 6 and 9 years old (n = 45 cases, 26.6%), followed by 10 to 13 years old (n = 44, 26.0%), and 1 to 5 years old (n = 34, 20.1%). There were no data available about the sex of 21 cats. The distributions of age, breed, and sex are shown in Table 1.

Table 1. Age,breed and gender incideny

Breed	Under 1 year	1-5 Age	6-9 Age	10-13 Age	14-17 Age	Unknown Age	Male	Female	Unknown Gender	General Total	Percent (%)
Mixed	-	21	25	28	8	14	29	63	4	96	56.8%
Persian	-	1	3	1	1	-	3	1	2	6	3.6%
Turkish Angora	-	1	1	2	1	1	3	3	-	5	3.0%
Siamese	-	1	2	-	-	-	2	1	-	3	1.8%
Turkish Van	-	-	2	1	2	-	3	2	-	5	3.0%
Angora-Van Mixed	-	1	1	-	-	-	1	-	1	2	1.2%
British Scottish Mixed	-	1	-	-	-	-	1	-	-	1	0.6%
British Shorthair	1	-	1	-	-	-	2	-	-	2	1.2%
Tuxedo	-	-	-	1	-	-	1	-	-	1	0.6%
Ragdoll	-	-	-	1	-	-	-	1	-	1	0.6%
Scottish	-	-	2	-	-	-	-	2	-	2	1.2%
Highlander	-	1	-	-	-	-	-	1	-	1	0.6%
Unknown	-	8	8	10	2	14	7	22	14	42	24.9%
Total (Number)	1	34	45	44	14	29	52	96	21	169	100%
Percent (%)	0.6%	20.1%	26.6%	26.0%	8.3%	17.2%	30.8%	56.8%	12.4%	100.0%	100%

MATERIALS and METHODS

The study materials originated from different ages and breeds of cats and included 164 biopsy samples and five necropsy materials. Samples were submitted to Ondokuz Mayis University Faculty of Veterinary Pathology Department from private veterinary clinics or the clinics of the Veterinary Medicine Faculty of Ondokuz Mayis University from cases recorded between January 2004 and December 2022. The samples were fixed in 10% buffered formalin solution for 48 h. Following this, the tissues were blocked in paraffin using an alcohol and xylene series, according to standard procedure for histopathological examination. Next, 5-µm thick sections were taken from the paraffin blocks, stained with Hematoxylin & Eosin, and examined under a light microscope (Nikon-Eclipse E600). Tumors were classified according to the International Histological Classification of Tumors of Domestic Animals determined by the World Health Organization (1994).

RESULTS

Tumors were most commonly seen in mixed or domestic

In female cats, 12 (12.5%) tumors were benign and 84 (87.5%) were malignant. Most benign tumors were found between 10 and 13 years old (n= 5, 15.2%), while most malignant tumors were found between 10 and 13 years old (n = 28, 84.8%). Benign and malignant tumors were mostly found between 10 and 13 years old (n = 33, 34.4%), followed by 6 to 9 years old (n = 23, 24%), then 1 and 5 years old (n = 19, 19.8%). No malignant or benign tumors were found in female cats less than 1-year-old. Most tumors were found in the mammary glands (n = 40, 41.7%), followed by the skin and subcutis (n = 22, 22.9%). No benign or malignant hemopoietic or urinary system tumors were found in female cats.

In male cats, seven (13.4%) tumors were benign and 45 (86.6%) were malignant. Benign tumors were most commonly observed in male cats between 6 and 9 years old (n = 3, 16.6%), while malignant tumors were also most often found between 6 and 9 years old (n = 15, 83.3%). Benign and malignant tumors were most commonly found between 6 and 9 years old (n = 18, 34.6%), followed by 1 to 5 years old (n = 13, 25%), and 10 to 13 years old (n = 11, 21.2%). Additionally,

most tumors were of the skin and subcutis (n = 25, 48.1%), followed by the alimentary system (n = 9, 17.3%). Mammary tumors were not found in male cats.

In terms of tumor origin, 79 (47%) were mesenchymal, 83 (49.4%) were epithelial, and seven (4.2%) were of mixed components, i.e., mesenchymal and epithelial. In total, 147 (87%) tumors were classified as malignant and 22 (13%) as benign (Figure 1). Regardless of sex, the most common tumor was of the skin and subcutis (n = 56, 33.1%), followed by mammary glands (n = 40, 23.7%), and the ears and ear canal (n = 22, 13%). The types of tumors detected in cats according to sex (male, female, and unknown), system, organ, and tissue are shown in Table 2.

Table 2. Distrubition of histopathological diagnosis for tumor according to system, organ, tissue.

System, Organ, Tissue	Histopathological Diagnose	Number of Cases By Gender			Total (Number)	Total (Percent %)
Skin and Subcutis						
		Male	**Female**	**Unknown**		
	Fibrosarcoma	12	12	3	27	16.0%
	Squamous cell carcinoma	2	7	3	12	7.1%
	Mastocytoma	3	1	-	4	2.4%
	Fibroma	2	-	-	2	1.2%
	Schwannoma	2	-	-	2	1.2%
	Lipoma	-	2	-	2	1.2%
	Liposarcoma	1	-	-	1	0.6%
	Basal cell carcinoma	-	-	1	1	0.6%
	Basosquamous cell carcinoma	-	-	1	1	0.6%
	Trichoblastoma	1	-	-	1	0.6%
	Sebaceous carcinoma	-	-	1	1	0.6%
	Feline progressive histiocytosis	1	-	-	1	0.6%
	Hemangiosarcoma	1	-	-	1	0.6%
		25	22	9	56	33.1%
Genital System						
Uterus	Leiomyosarcoma	-	1	-	1	0.6%
	Adenocarcinoma	-	2	-	2	1.2%
Ovarium	Luteoma	-	1	-	1	0.6%
	Granuloza cell tumor	-	1	-	1	0.6%
	Granuloza-Theca cell tumor	-	1	-	1	0.6%
Testis	Fibroma	1	-	-	1	0.6%
		1	6	-	7	4.1%
Mammary Gland	Cribriform carcinoma	-	15	-	15	8.9%
	Tubulopapillary adenocarcinoma	-	6	-	6	3.6%
	Tubular adenocarcinoma	-	5	-	5	3.0%

Table 2 Continue. Distrubition of histopathological diagnosis for tumor according to system, organ, tissue.

System, Organ, Tissue	Histopathological Diagnose	Number of Cases By Gender			Total (Number)	Total (Percent %)
		Male	Female	Unknown		
Mammary Gland	Fibroadenoma	-	4	-	4	2.4%
	Carcinoma and Malignant myoepithelioma	-	2	-	2	1.2%
	Ductal carcinoma	-	2	-	2	1.2%
	Adenosquamous carcinoma	-	1	-	1	0.6%
	Complex adenocarcinoma	-	1	-	1	0.6%
		-	40	-	40	23.7%
Alimentary System						
Mouth and Lips	Myxoid Liposarcoma	1	-	-	1	0.6%
	Squamous cell carcinoma	2	1	1	4	2.4%
	Fibrosarcoma	-	1	-	1	0.6%
Gingiva	Epulis	-	1	-	1	0.6%
	Fibrosarcoma	1	-	-	1	0.6%
Tongue	Squamous cell carcinoma	1	-	-	1	0.6%
Teeth	Ameloblastic fibroma	1	-	-	1	0.6%
Intestine	Leiomyosarcoma	-	1	-	1	0.6%
	B cell lymphoma	-	-	1	1	0.6%
Stomach	Gastrointestinal lymphoma	1	1	-	2	1.2%
Liver	Hepatocelluler carcinoma	-	1	-	1	0.6%
	Hepatoma	-	1	-	1	0.6%
	Mix hepatocellular and chollangiocellular carcinoma	1	-	-	1	0.6%
	Hepatic myelolipoma	1	-	-	1	0.6%
		9	7	2	18	10.7%
Respiratory System						
Nose	Poorly differentiated sarcoma	1	-	-	1	0.6%
	Nasal Adenocarcinoma	1	1	-	2	1.2%
	Fibrosarcoma	-	1	-	1	0.6%
Lungs	Papillary pulmonary carcinoma	-	1	-	1	0.6%
	Bronchoalveolar carcinoma	-	1	-	1	0.6%
	Adenosquamous carcinoma	-	1	-	1	0.6%
		2	5	-	7	4.1%

Table 2 Continue. Distrubition of histopathological diagnosis for tumor according to system, organ, tissue.

System, Organ, Tissue	Histopathological Diagnose	Number of Cases By Gender			Total (Number)	Total (Percent %)
Skeleton and Muscle System						
		Male	**Female**	**Unknown**		
Skeleton	Osteosarcoma	1	2	-	3	1.8%
	Chondrosarcoma	-	3	-	3	1.8%
		1	5	-	6	3.6%
Haematopoietic System						
Spleen	Splenic mast cell tumor	1	-	-	1	0.6%
	B cell lymphoma	1	-	-	1	0.6%
Heart	B cell lymphoma	-	-	1	1	0.6%
		2	-	1	3	1.8%
Urinary System						
Kidney	Malignant Fibrous Histiocytoma	1	-	-	1	0.6%
		1	-	-	1	0.6%
Ear and Ear Canal	Histiocytic sarcoma	1	-	-	1	0.6%
	Tubular type Adeno-carcinoma (apocrine)	1	-	-	1	0.6%
	Solar Dermal Hemangiosarcoma	1	-	-	1	0.6%
	Myofibroblastic sarcoma	-	-	1	1	0.6%
	Micropapillary type ceruminous gland carcinoma	-	1	-	1	0.6%
	Squamous cell carcinoma	3	5	5	13	7.7%
	Sebaceous epithelioma	-	-	1	1	0.6%
	Mastocytoma	-	1	-	1	0.6%
	Follicular hamartoma	1	-	-	1	0.6%
	Hemangiosarcoma	-	1	-	1	0.6%
		7	8	7	22	13.0%
Eyes and Eyelids	Rhabdomyosarcoma	1	-	-	1	0.6%
	Malign Melanoma	-	-	1	1	0.6%
	Malignant Schwannoma	-	-	1	1	0.6%
	Soft tissue sarcoma	-	1	-	1	0.6%
		1	1	2	4	2.4%

Table 2 Continue. Distrubition of histopathological diagnosis for tumor according to system, organ, tissue.

System, Organ, Tissue	Histopathological Diagnose	Number of Cases By Gender			Total (Number)	Total (Percent %)
Cardiovascular System						
		Male	**Female**	**Unknown**		
Heart and Vascular	Hemangiosarcoma	2	-	-	2	1.2%
		2	-	-	2	1.2%
Abdominal wall and abdominal cavity						
Abdomen	Malignant Fibrous Histiocytoma	1	-	-	1	0.6%
	Liposarcoma	-	1	-	1	0.6%
Omentum	Neuroendocrine carcinoma	-	1	-	1	0.6%
		1	2	-	3	1.8%
					169	100.0%

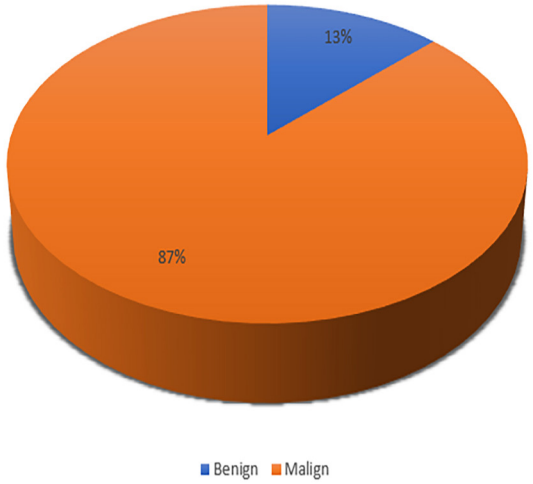

Figure 1. FeHV-1 positive cat (No. 1) with complex conjunctivitis and keratitis symptoms.

DISCUSSION

Cancer is a common cause of death for pets. However, improvements in the care and feeding of animals may lengthen their lives and increase the incidence of neoplastic diseases. Inherent DNA replication errors occur in all multicellular organisms, meaning it is almost certain that they will develop a neoplasm if they survive long enough (Cullen and Breen, 2017). Dogs develop tumors twice as frequently as humans, but cats only half as frequently. Moreover, tumor incidence depends on several variables, predominantly age, breed, sex, and geographic location (MacEwen, 1990). Various retrospective studies have been carried out on tumor incidence in domestic animals. For example, Pamukçu (1954), Ertürk et al. (1971), and Kökuslu and Akkayan (1972) identified 15 tumors over 16 years, 13 tumors from 1964 to 1970, and three tumors from 1968 to 1972, respectively. In addition, Gülçubuk et al. (2005), Vural et al. (2007), Aydın et al. (2008), and Kutlu et al. (2018) identified 132 tumors in cats between 1993 and 2004, 13 tumors from 1977 to 2005, 265 tumors from 1971 to 2005, and 394 tumors from 1985 to 2015, respectively. In our study, 169 cat tumors were found between 2004 and 2022 and were compared to other studies; the incidence of tumors in cats increased over the years. This may be due to the increased number of cats kept as pets and the increased life expectancy of such animals due to improvements in care and feeding.

The correlation between tumor incidence and cat breeds is

unclear as only Siamese cats have a reported predisposition to mammary and intestinal neoplasia (Egenvall et al., 2009; Egenvall et al., 2010). Of 132 cats with tumors examined by Gülçubuk et al. (2005), 120 (90.90%) were mixed breed and one (0.75%) was Siamese. In our study, of the 169 cats with tumors, 96 (56.8%) were mixed breed and three (1.8%) were Siamese. Of the Siamese cat tumors, one was a mammary gland tumor of the subtype tubulopapillary carcinoma, while two were skin and subcutis tumors of the subtypes schwannoma and fibrosarcoma. Although our dataset is smaller than previous studies, the most common breeds with tumors were mixed breeds in our study, which is consistent with previous findings.

The link between tumor incidence and sex in cats is controversial and has been studied several times (Kutsal et al., 2003; Gülçubuk et al., 2005; Vural et al., 2007; Aydın et al., 2008). According to Gülçubuk et al. (2005) and Aydın et al. (2008), tumors were more commonly seen in female than male cats; however Kutsal et al. (2003) and Vural et al. (2007) mostly found tumors in male rather than female cats. Our results agreed with the higher incidence of tumors in female than male cats (Gülçubuk et al., 2005; Aydın et al., 2008). Individual differences, including genetics, may trigger the formation of tumors in female cats.

Tumors are frequently observed in 6- to 14-year-old cats, with a median age of 9.1–9.5 years old (Pamukçu, 1954; MacEwen, 1990; Gülçubuk et al., 2005; Aydın et al., 2008; Rafalko et al., 2022; Pinello et al., 2022b); malignant neoplasms form a greater proportion of tumors than benign neoplasms in cats, according to Pinello et al. (2022a). Moreover, Gülçubuk et al. (2005) found malignant and benign tumors in 12 (36.36%) male cats between 6 and 10 years old and 24 (88.88%) female cats. Our data on the age range of tumor incidence in male cats is in agreement with the literature, but those on female cats are not. In this study, tumors were usually observed between 6 and 13 years of age. The mean life span of cats is between 13 and 20 years or approximately 15 years, according to several different studies (Kraft, 1998; Grimm, 2015; Cozzi et al., 2017). In addition, female cats often outlive male cats (O'Neill et al., 2015). This means that as the life span of female cats is generally longer than male cats, tumors may be observed in female cats at a higher ratio.

Various studies on tumor frequency in cats have been published (Gülçubuk et al., 2005; Shida et al., 2010; Manuali et al., 2020). Shida et al. (2010) observed that the skin and subcutis were the most common sites for tumors (n = 318, 29.7%), followed by the mammary glands (n = 182, 17.0%), and the lymphoid/hematopoietic system (n = 176, 16.5%). Manuali et al. (2020) found that skin and soft tissue tumors constituted 55.9% of all tumors, followed by mammary gland (11%) and alimentary tract (7.9%) tumors. In contrast, Gülçubuk et al. (2005) reported that mammary tumors were found in 46 cats (34.84%) regardless of sex, followed by 22 (16.16%) skeletal and muscle system tumors, and 20 (15.90%) skin and subcutis tumors. Our results were similar to Manuali et al. (2020).

Skin neoplasms generally comprise fibrosarcomas, SCCs, and basal cell tumors (Ho et al., 2018; Manuali et al., 2020). In our study, regardless of sex, the most common tumor was fibrosarcoma (n = 27, 16%), followed by SCC (n = 12, 7%), and mastocytoma (n = 4, 2.4%). However, injection, vaccination, and microchip implantation frequently cause injection site sarcomas in cats (Carminato et al., 2011; Martano et al., 2011; Martano et al., 2012; Dean et al., 2013). In our study, fibrosarcomas related to injection or vaccination were commonly observed at the injection site. In recent years, vaccinations, microchip implantation, and injections have increased because the number of cats being adopted has increased; this may have caused an increase in the incidence of fibrosarcoma in cats.

Although mammary tumors are among the most common tumors in female cats, they have also been reported in male cats (Skorupski et al., 2005). In one study, the highest tumor rates were observed in cats aged 10–11 years old (Dorn et al., 1968), whereas Gülçubuk et al. (2005) detected the highest rate of mammary tumors between 8 and 12 years old. Malignant tumors were found more frequently than benign tumors and consisted of different adenocarcinoma subtypes (Pamukçu, 1954; Kökuslu and Akkayan, 1972; Gülçubuk et al., 2005; Aydın et al., 2008; Mills et al., 2015). Therefore, our results were in agreement with the literature (Pamukçu, 1954; Kökuslu and Akkayan, 1972; Gülçubuk et al., 2005; Aydın et al., 2008; Mills et al., 2015). Hormonal changes during the estrous cycle or pregnancy could potentially trigger tumor development in mammary glands.

In the literature, the incidence of epithelial tumors is higher than that of mesenchymal tumors (Goldschmidt and Goldschmidt, 2016). Pamukçu (1954) analyzed 15 cat tumors, of which eight (53.33%) were of epithelial and seven (46.66%) were of mesenchymal origin. Similarly, Ertürk et al. (1971) reported 13 cat tumors, of which six (46.15%) were epithelial and five (38.4%) were mesenchymal in origin, as well as two (15.38%) teratomas. Kökuslu and Akkayan (1972) detected three (100%) tumors in cats of epithelial origin. Moreover, Aydın et al. (2008) observed 265 tumors; 134 (50.57%) were epithelial and 131 (49.43%) were mesenchymal in origin. Kutlu et al. (2015) detected 14 tumors in cats; nine were epithelial and five were of undefined origin. Gülçubuk et al. (2005) examined 67 mesenchymal (50.75%), 60 (45.45%) epithelial, and five (3.78%) mixed tumors. Our data are similar to the literature, except for Gülçubuk et al. (2005). However, many factors, including genetics, individual differences, and aging, may stimulate epithelial-mesenchymal or mesenchymal-epithelial transition in addition to causing tumors of different origins.

MacVean et al. (1978) reported that the incidence of feline lymphoma was 168 per 100,000 cats, which represented 41% of feline neoplasms; the sex-specific rate was higher for males than for females. Moreover, the risk of developing lymphoma in male cats was two to three times that of female cats (Dorn et al., 1968). Mooney et al. (1989) examined 103 lymphoma cases over the course of four years, while Shida et al. (2010) found 132 lymphoma cases over 23 years. Kutlu et al. (2018) recorded lymphoma in 10 cats over 31 years, of which five were male and four were female, and determined that three lymphomas were located in the intestine, two in the skin, and five in other organs and tissues. Gülçubuk et al. (2005) detected a total of three lymphomas over 11 years, two of which

were in the small intestine, that is, alimentary lymphoma, and one was located in the lymph node; two cats were of unknown sex and one was female. In the current study, five lymphoma cases were found over 18 years; two (1.2%) tumors were in the intestine, one (0.6%) in the stomach, one (0.6%) in the spleen, and one (0.6%) in the heart. Lymphomas were less frequently reported in our country than in other countries (Mooney et al., 1989; Shida et al., 2010; Kutlu et al., 2018). This may be because fewer cats are kept as pets in our country than in other countries. Alternatively, cats may not receive the same level of veterinary care and therefore samples may not be sent to pathology laboratories, such as biopsy, necropsy, or cytology samples.

CONCLUSION

In this study, a significant increase in several tumor types was observed, including skin and mammary tumors, in cats from 2004 to 2022. We hypothesize that this was due to improvements in the care and feeding of the animals, the prolongation of their life span, the increase in the number of patients brought to the clinic, and the increased number of animal owners.

DECLARATIONS

Ethics Approval

Not applicable.

Conflict of Interest

The authors declared that there is no conflict of interest.

Consent for Publication

Not applicable.

Author contribution

Idea, concept and design: MTK, TG

Data collection and analysis: MYG,TG, MY, MS, YBK, EK,Sİ, NK, MTK, FBA

Drafting of the manuscript: MTK,TG

Critical review: TG

Data Availability

The author has provided the required data availability statement.

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