International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(10): 725-731
www.biochemjournal.com
Received: 25-07-2025
Accepted: 27-08-2025

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Prevalence and pathomorphological features of canine mast cell tumors

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i10j.6159

Abstract
Canine mast cell tumors are among the most common cutaneous neoplasms in dogs, with variable clinical behavior ranging from benign to highly aggressive forms. This study investigated the prevalence and pathomorphological features of mast cell tumors in 42 dogs diagnosed over a seven-month period. Tumor occurrence, clinical presentation, tumor location, cytological characteristics, and histopathological grading were analyzed. The age of occurrence of mast cell tumors ranged from 2 to 14 years, with the highest incidence in age group of 8 to 10 years and lowest incidence in age group of 12 to 14 years, with a mean age of 7.81 years, with a male predominance. Non-descript breeds were the most commonly affected, followed by Labrador and Golden Retrievers. The trunk was the most frequent tumor site. Cytological evaluation revealed characteristic round-to-oval mast cells with metachromatic granules and varying degrees of pleomorphism and anisokaryosis. Infiltration by eosinophils and neutrophils was frequently observed. Histopathological evaluation provided further characterization and grading of the tumors, using two widely accepted systems: Patnaik three-tier classification and the Kiupel two-tier system. Histopathology using Patnaik grading identified Grade II tumors as the most prevalent, while Kiupel grading showed an equal distribution of low-and high-grade tumors. These findings provide essential baseline data for improved diagnostic and therapeutic strategies in canine Mast cell tumors.

Keywords: Canine mast cell tumor, cytology, grading, histopathology, prevalence

Introduction
Cancer is a major health concern in veterinary medicine, accounting for approximately 23 percent of canine deaths (Gardner *et al.*, 2016) [6]. Among cutaneous tumors, canine mast cell tumors (MCTs) are particularly common, representing 16-21 percent of all skin neoplasms (Blackwood *et al.*, 2012) [1]. Their highly variable biological behavior poses challenges in prognostication and treatment planning (Welle *et al.*, 2008 and Tamlin *et al.*, 2020) [27, 22]. MCTs originate from neoplastic mast cells, which play roles in immune and allergic responses, and are influenced by genetic, molecular, and environmental factors (Misdorp, 2004; Warland and Dobson, 2013 and Shoop *et al.*, 2015) [13, 26, 18].

Mast cell tumors are most frequently observed in middle-aged to older dogs, with a mean age of around 8 years (Strefezzi *et al.*, 2003; Thompson *et al.*, 2011) [20, 23] and breed predispositions include Boxers, Labrador Retrievers, Golden Retrievers, Pugs, and Shar-Peis (Bostock, 1986; Villamil *et al.*, 2011) [2, 25]. No consistent sex predilection has been reported (White *et al.*, 2011) [28]. MCTs can occur anywhere on the body, most often on the trunk, limbs, and head and usually present as solitary cutaneous nodules of variable appearance (Welle *et al.*, 2008) [27].

Diagnosis is commonly achieved through fine-needle aspiration cytology, supported by histopathological grading using the Patnaik (1984) [15] or Kiupel (2011) [9] systems. However, prognostic variability persists even within similar histologic grades, emphasizing the need for further investigation into clinicopathological correlations and molecular markers (Scase *et al.*, 2006; Vascellari *et al.*, 2013) [17, 24].

The present study aimed to evaluate the prevalence, clinical presentation, and pathological features of canine MCTs in a defined population, with emphasis on their association with age, breed, sex, anatomical distribution, gross morphology, cytology, and histopathological grading in 42 confirmed cases.

Materials and Methods

The present study was conducted over seven months at the Department of Veterinary Pathology, Veterinary College, Hebbal, Bengaluru. A total of 105 cutaneous tumors were received from Veterinary College Hospital, Bengaluru and other hospitals in and around Bengaluru, of which 42 cases were confirmed as mast cell tumors through cytological and histopathological evaluation. Detailed information regarding breed, age, sex, clinical history, and tumor location was recorded for each case. Tumor size, consistency, color, ulceration, and adherence to surrounding tissues were documented during gross examination. Data on breed, age, sex, tumor location ang grading were tabulated, categorical variables were expressed as frequencies and percentages.

Cytology

Fine needle aspiration cytology (FNAC) was performed using 22-gauge needles, with smears stained using Field's stain. The cytological smears were initially assessed for staining quality and cellular adequacy. Evaluation of cellular morphology, along with nuclear and cytoplasmic characteristics, was carried out to confirm the presence of mast cell tumor neoplasia. Cytological evaluation focused on cell morphology, granularity, nuclear features, and the presence of inflammatory infiltrates, particularly eosinophils.

Histopathology and Classification

Representative tumor tissues were fixed in 10% neutral buffered formalin, processed, and processed using routine paraffin embedding techniques. Thin sections measuring 4 µm were prepared with a rotary microtome and stained using the Haematoxylin and Eosin (H & E) and Toluidine Blue. These stained sections were then microscopically examined to identify and classify the mast cell tumors. Histological grading was performed according to diagnostic criteria proposed by Patnaik *et al.* (1984) [15] and Kiupel *et al.* (2011) [9].

Ethical approval

The study protocol was reviewed and approved by Institutional Animal Ethics Committee (IAEC), Veterinary College, Hebbal, Bengaluru. All of the investigated samples were obtained for diagnostic purposes as part of routine and standard care. Procedures were designed to avoid or minimise discomfort, distress and pain. IAEC approval number: VCH/IAEC/2025/22.

Results

The study population included 42 dogs with histologically confirmed MCTs out of 105 cases. The prevalence and pathological features of MCTs in 42 dogs diagnosed over a seven-month period were evaluated in terms of tumor occurrence, clinical presentation, tumor location, cytological characteristics, and histopathological grading.

Age

In the current study, the age of dogs diagnosed with mast cell tumors ranged between 3 to 14 years, with a mean age of 7.81 years. The highest frequency of mast cell tumor cases was recorded in the 8 to 10 year age group which represented 33.3 percent (n = 14), followed by 19 percent (n = 8) in dogs aged 4 to 6 years. Tumor incidence in the 6 to 8 year group was 16.6 percent (n = 7), followed by 14.2 percent (n = 6) in 2 to 4 year group. 10 to 12 year group and 12 to 14 year group accounted for 9.5 percent (n = 4) and 7.1 percent (n = 3) respectively (Table-1).

Breed

Breed wise analysis revealed mast cell tumors were most prevalent in non-descript dogs, accounting for 35 percent (n = 15) followed by Labrador Retrievers which represented 21 percent (n = 9) and Golden Retrievers which represented 17 percent (n = 7). Pomeranians exhibited with a 7 percent (n = 3) incidence. Pug, German Shepherd and Bull dog accounted for two cases each (5%). The lowest incidence was noted in Rottweiler and Beagle breed which accounted for one case each (2%) (Table-2).

Sex

In the present study, mast cell tumors were more frequently identified in male dogs, accounting for 61.9 percent of cases (n = 26), whereas female dogs represented 38.1 percent of the tumor incidence (n = 16) (Table-3).

Location Wise Occurrence

Analysis of location wise occurrence revealed tumors were most commonly located on the trunk accounting for 64.28 percent (n = 27), followed by limbs which represented 21.42 percent (n = 9) and head and neck regions which represented 14.28 percent (n = 6) (Table-4).

Gross Pathology

In the current study of 42 spontaneous cases, 34 tumors presented as solitary nodules (80.95 %), while 8 cases (19.05 %) involved multiple nodules. Tumor size ranged from 1.0 to 13.0 cm in diameter. On gross examination, tumors were firm, well-circumscribed, solitary firm nodules or ulcerated nodules (Fig 1), erythematous inflammatory masses (Fig 2), and hairless raised masses adhered to underlying tissue. Cut surfaces displayed creamy white, yellow, or brown areas, often with multifocal hemorrhage and occasional ulceration (Fig 3).

Cytological Features

Out of 105 cases 42 samples were cytologically diagnosed as mast cell tumor. Microscopic examination revealed a dense population of round to oval cells characterized by pale cytoplasm containing coarse purple granules, often obscuring the nucleus (Fig 4). The cells demonstrated marked variability in size and shape, with nuclei ranging from round and oval to indented and eccentrically located. Nuclear chromatin appeared coarse, condensed, and vesicular, accompanied by one or more prominent nucleoli. A high nucleus-to-cytoplasm ratio and varying levels of cytoplasmic basophilia were evident, with occasional multinucleated cells noted (Fig 5). The presence of inflammatory cells, particularly eosinophils, neutrophils, and cellular debris, was also recorded. Cytologically, the tumors were classified into well-granulated types with indistinct nuclear features, intermediately granulated forms, and poorly granulated variants with distinct nuclear morphology and visible mitotic figures.

Histopathology and grading

Out of the 105 tumor tissues submitted for routine diagnosis to Department of Veterinary Pathology, Veterinary College, Bengaluru, 42 cases were confirmed as mast cell tumors

based on histopathological criteria. Neoplastic cells were round to polygonal, containing a central to slightly eccentric nucleus and pale cytoplasm with light grey to bluish granules. The tumor cells were arranged in rows or columns, with eosinophilic infiltration observed among the neoplastic mast cells. Toluidine blue staining revealed metachromatic granules typical of mast cells (Fig 6). According to Patnaik grading system, 8 cases (19.04 %) were classified as grade I (Well-differentiated), 23 cases (54.76 %) were classified as grade II (Intermediately differentiated) and 11 cases (26.19 %) were classified as grade III (Poorly differentiated) tumors (Table-5). In Kiupel grading system, 21 cases (50 %) were classified as Low-grade tumors and 21 cases (50 %) were classified as High-grade tumors (Table-6).

Grade I-Well-Differentiated Tumors: 8 tumors were classified as Grade I. Histologically, they exhibited rows or small clusters of monomorphic mast cells separated by mature collagen (Fig 7). Cells were round with abundant cytoplasm, distinct boundaries, and medium-sized intracytoplasmic granules. Nuclei were rounded with condensed chromatin. Mitotic figures were absent, and edema or necrosis was minimal.

Grade II-Intermediately Differentiated Tumors: 23 tumors were classified as Grade II. These were moderately to highly cellular, infiltrating the lower dermis and subcutis. Mast cells formed discrete clusters within a thin fibrovascular stroma (Fig 8). Cells ranged from round to ovoid, with occasional spindle and giant forms. Granules varied from fine to hyperchromatic; nuclei were round to indented with coarse to vesicular chromatin and prominent nucleoli. Binucleation and mitoses were infrequent, with diffuse edema and necrosis evident.

Grade III-Poorly Differentiated Tumors: 11 tumors were classified as Grade III. These showed marked cellularity and pleomorphism, extensively replacing subcutaneous and deep dermal tissues. Cells ranged from round to spindle-shaped and were arranged in sheets amid edema, hemorrhage, and necrosis (Fig 9). Cytoplasm was indistinct and sparsely granulated. Nuclei were vesicular with prominent nucleoli; binucleated and mitotic cells were frequent.

Low-Grade tumors: 21 cases were identified as low grade. Histologically, these tumors consisted of well-differentiated, monomorphic mast cells typically arranged in rows between collagen bundles, surrounded by edematous stroma. Numerous eosinophils were frequently present and tended to cluster around collagenolytic areas (Fig 10).

High-grade tumors: 21 cases were classified as high grade. These tumors displayed frequent mitotic figures within 10 high-power fields (Fig 11), with some fields showing five or more mitoses. Notable features included marked nuclear size variation, pronounced karyomegaly, and the presence of bizarre nuclei and several multinucleated neoplastic mast cells were observed (Fig 12).

Discussion

The present study provides a comprehensive analysis of 42 canine MCTs, emphasizing prevalence and pathological characteristics. The mean age of affected dogs (7.81 years) corroborates prior studies indicating that middle-aged to older dogs are at highest risk (Patnaik *et al.*, 1984; Welle *et al.*, 2008; Shoop *et al.*, 2015; Mochizuki *et al.*, 2017 and Darshan, 2025) [15, 27, 18, 5]. Breed predisposition reflected increased susceptibility in non-descript dogs followed by Labrador Retreivers and Golden Retrievers. The elevated occurrence of mast cell tumors in non-descript dogs in the current study could potentially be attributed to their larger population and their common preference as pets. This is consistent with findings of Pierini *et al.* (2019), Subapriya *et al.* (2024) and Darshan (2025) [16, 21, 5]. Martins *et al.* (2022) [12] emphasized that breed-specific occurrence of canine mast cell tumors (MCTs) varies significantly across geographical regions, influenced by differences in sample size and study duration.

Male dogs were more frequently affected in the current study. This finding is consistent with the results of London and Thamm (2013) and Darshan (2025) [11, 5] who also reported a higher tumor incidence in male dogs. However, several studies posit that there is no distinct gender predilection and that sex hormones do not significantly influence MCT development and survival period (White *et al.*, 2011, London and Thamm, 2013, Mochizuki *et al.*, 2017 and Smiech *et al.*, 2019) [28, 11, 14, 19]. The trunk was confirmed as the most common tumor site, aligning with previous reports (Welle *et al.*, 2008) [27]. Tumor morphology varied considerably; most were solitary nodules, but multiple lesions were noted in a subset, emphasizing the variable clinical presentation align with those previously reported by Goldschmidt and Hendrick (2002), Villamil *et al.* (2011), Subapriya *et al.* (2024) and Darshan (2025) [7, 25, 21, 5].

Cytological evaluation proved highly reliable, showed variation in size and shape, with nuclei that ranged from round to oval to indented forms with pale cytoplasm filled with metachromatic granules. Features such as moderate to evident pleomorphism and anisokaryosis were prominent. The nuclei typically contained coarse, condensed and vesicular chromatin and occasionally exhibited one or more distinct nucleoli and eosinophilic infiltration. These cytological observations are consistent with previous reports by Welle *et al.* (2008), Camus *et al.* (2016), Kiupel (2017), Kiupel and Camus (2019), Subapriya *et al.* (2024), and Darshan (2025) [27, 3, 10, 8, 21, 5].

Histopathology reinforced the heterogeneous nature of MCTs. Patnaik Grade II tumors were most prevalent, reflecting prior studies that suggest intermediate-grade tumors constitute the largest proportion of cases (Patnaik *et al.*, 1984 and Darshan, 2025) [15, 5]. Equal distribution of low-and high-grade tumors using Kiupel grading indicates a substantial proportion of clinically aggressive tumors, underscoring the need for careful monitoring and appropriate therapeutic intervention. Similar results were reported by Cruz *et al.* (2020) [4] who observed elevated incidence of high-grade tumors. Overall, the findings highlight the importance of integrated demographic, cytological, and histopathological assessment for accurate diagnosis, prognostication, and clinical management of canine MCTs.

Fig 1: Gross picture of mast cell tumor as single nodular, firm ulcerated mass affecting ventral thorax.

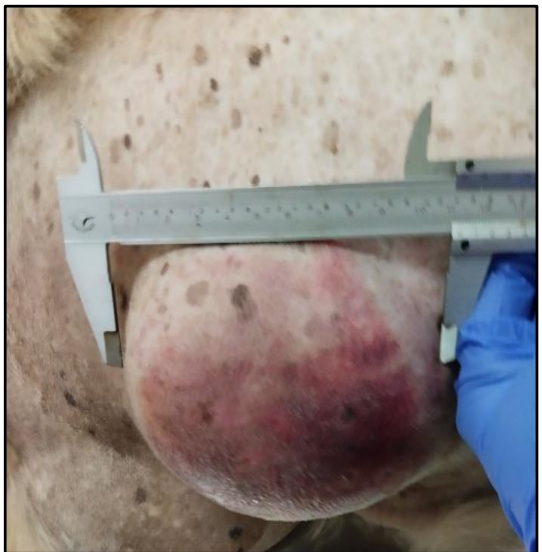

Fig 2: Gross picture of mast cell tumor as firm, erythematous tumor growth affecting right lateral abdomen.

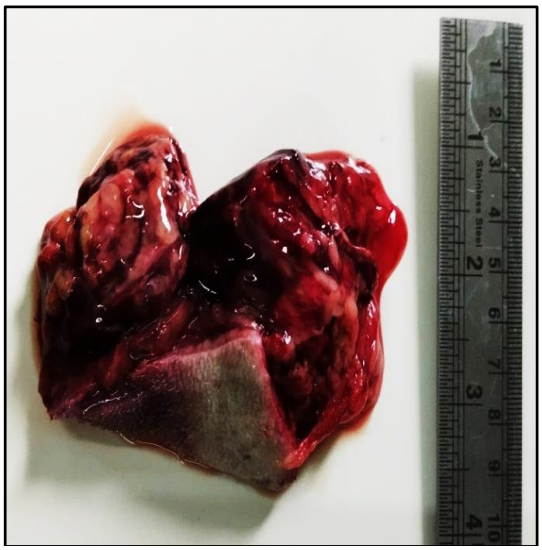

Fig 3: Cut surface of mast cell tumor with brown discoloration and multifocal hemorrhagic areas.

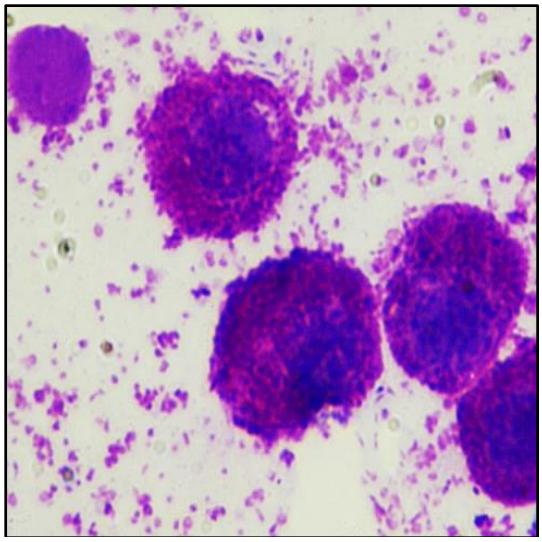

Fig 4: Cytology: Mast cells with round to oval nucleus, abundant pale cytoplasm with purple granules obscuring the nucleus. (Field's stain X1000)

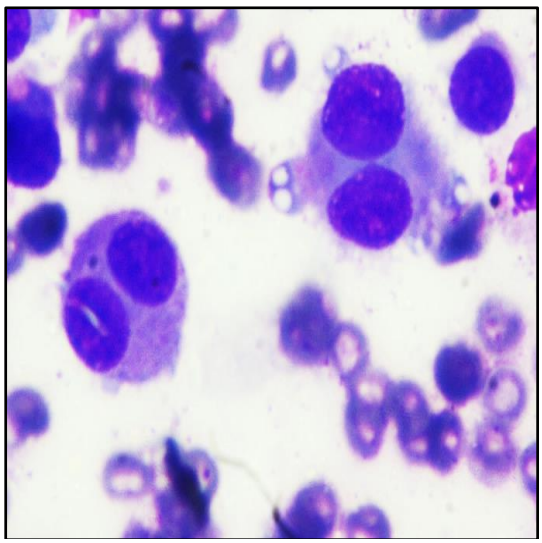

Fig 5: Cytology: Mast cells showing multiple nuclei. (Field's stain X400)

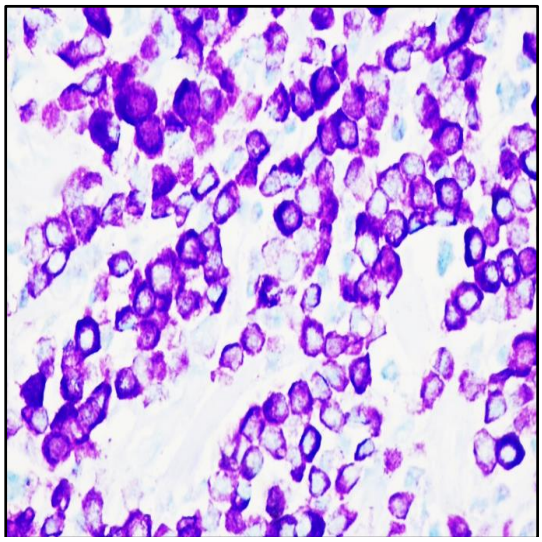

Fig 6: Histological section showing metachromatic granules in cytoplasm of mast cells. (Toluidine blue X400)

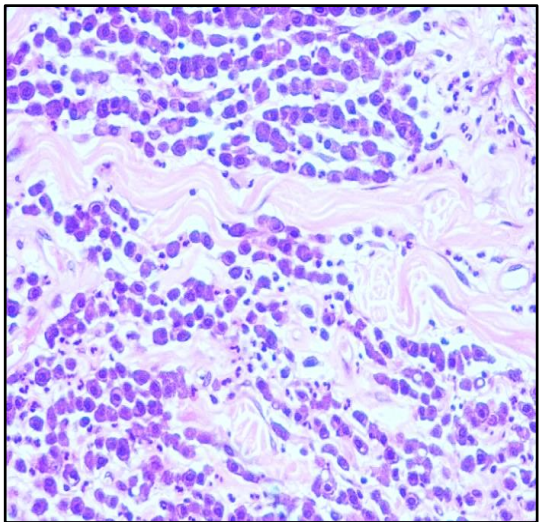

Fig 7: Histological section of well-differentiated MCT (Patnaik grading system): cells in rows, separated by collagen fibers. (H&E X200)

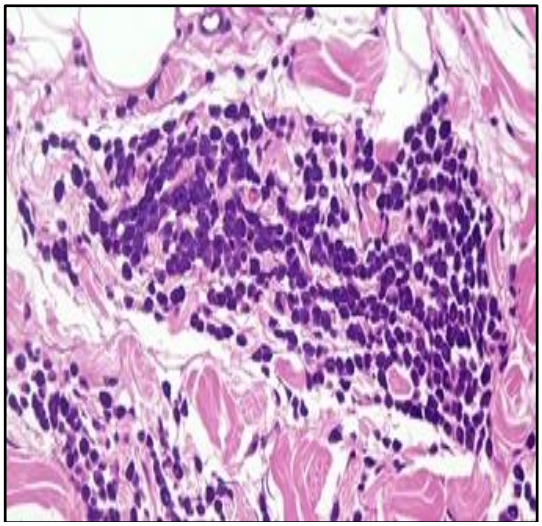

Fig 8: Histological section showing intermediately-differentiated MCT (Patnaik grading system): mast cells were arranged in discrete clusters supported by a thin fibrovascular stroma. (H&E X100)

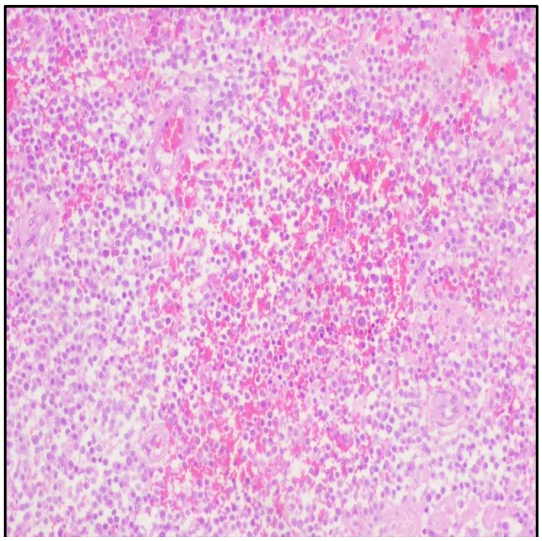

Fig 9: Histological section of poorly differentiated MCT (Patnaik grading system) showing cells ranging from round and ovoid to spindle-shaped were arranged in sheets with edema, hemorrhage and necrotic areas. (H&E X100)

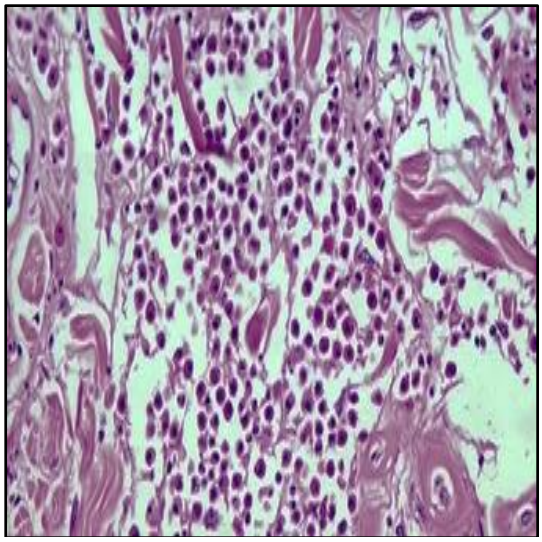

Fig 10: Histological section showing low-grade MCT (Kiupel grading system) showing numerous eosinophils were frequently present and tended to cluster around collagenolytic areas. (H&E X100)

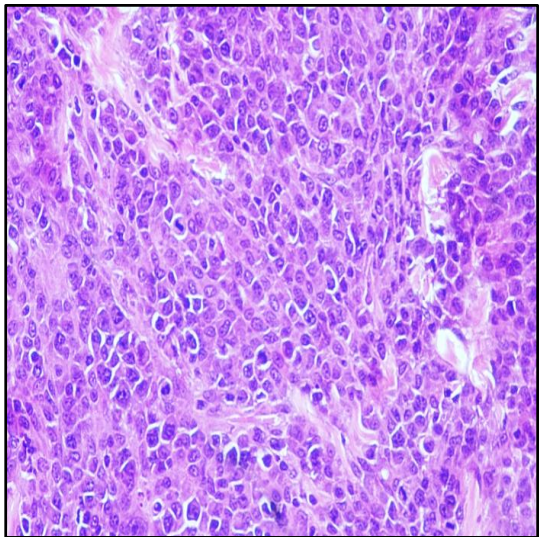

Fig 11: Histological section showing high-grade MCT (Kiupel grading system) showing mitotic figures in neoplastic mast cells. (H&E X200)

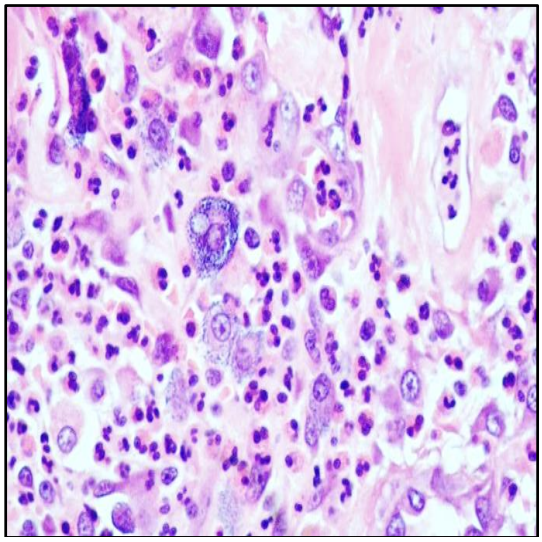

Fig. 12: Histological section showing high-grade MCT (Kiupel grading system) showing multi-nucleated neoplastic mast cells. (H&E X400)

Table 1: Age wise occurrence of canine mast cell tumors

Age Group (years)	Number of Cases	Percent Incidence (%)
2-4	6	14.2
4-6	8	19
6-8	7	16.6
8-10	14	33.3
10-12	4	9.5
12-14	3	7.1
TOTAL	42	100

Table 2: Breed wise occurrence of mast cell tumors

Breed	Number of Cases	Percentage (%)
Non-descript	15	35
Labrador Retriever	9	21
Golden Retriever	7	17
Pomeranian	3	7
Pug	2	5
Bull Dog	2	5
German Shepherd	2	5
Rottweiler	1	2
Beagle	1	2
TOTAL	42	100

Table 3: Sex wise occurrence of mast cell tumors

Sex	Number of Cases	Percent Incidence (%)
Male	26	61.9
Female	16	38.1
TOTAL	42	100

Table 4: Location wise distribution of canine mast cell tumors

Region	Number of Cases	Percent Incidence (%)
Trunk	27	64.28
Extremities	9	21.42
Head And neck	6	14.28
TOTAL	42	100

Table 5: Histopathological Patnaik (3 tier) grading of canine mast cell tumors (n = 42)

Patnaik grade	No. of cases	Percentage (%)
Grade I	8	19.04
Grade II	23	54.76
Grade III	11	26.19
TOTAL	42	100

Table 6: Histopathological Kiupel (2 tier) grading of canine mast cell tumors (n = 42)

Kiupel grade	No. of cases	Percentage (%)
High	21	50
Low	21	50
TOTAL	42	100

Conclusion

This study of 42 canine mast cell tumors in and around Bengaluru provides a detailed overview of prevalence, clinical presentation, and pathomorphological characteristics. Middle-aged dogs (mean 7.81 years) were most affected, with a male and non-descript breed predominance. The trunk was the most frequent tumor location, followed by limbs and head/neck regions. Tumors appeared as solitary, firm nodules and ulcerated nodules; FNAC consistently revealed metachromatic granules, pleomorphism, and eosinophilic infiltration. Patnaik Grade II tumors were most prevalent, while Kiupel grading showed an equal proportion of low and high-grade tumors, emphasizing the heterogeneity of disease severity. The results underscore the continued utility of combined cytological and histopathological evaluation for accurate diagnosis and prognostication in canine MCTs. These findings contribute valuable pathological data to guide clinical decision-making in veterinary practice.

Acknowledgment

We thank the Karnataka Veterinary Animal and fisheries sciences University, Bidar, Karnataka, India and Institute of Animal Health and Veterinary Biologicals, KVAFSU, Bengaluru, Karnataka, India for the support throughout the research. Further, we thank the masters and doctoral students and faculty of Department of Veterinary Pathology and Department of Veterinary Surgery and Radiology from Veterinary College, Bengaluru, Karnataka, India who helped us during our research.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Blackwood L, Murphy S, Buracco P, De Vos JP, De Fornel-Thibaud P, Hirschberger J, *et al.* European consensus document on mast cell tumours in dogs and cats. Vet Comp Oncol. 2012;10(3):e1-e29.
2. Bostock DE. Neoplasms of the skin and subcutaneous tissues in dogs and cats. Br Vet J. 1986;142(1):1-19.
3. Camus MS, Priest HL, Koehler JW, Driskell EA, Rakich PM, Ilha MR, *et al.* Cytologic criteria for mast cell tumor grading in dogs with evaluation of clinical outcome. Vet Pathol. 2016;53(6):1117-1123.
4. Cruz VS, Borges JCA, Nepomuceno LL, Goncalves PAM, Prado YCL, Bianchi C, *et al.* Histological classification and expression of markers of canine mast cell tumors. Vet World. 2020;13(8):1627-1634.
5. Darshan MB. Studies on Programmed Death Ligand-1 and C-Kit Marker Expression in Canine Mast Cell Tumors [M.V.Sc. thesis]. Bidar: Karnataka Veterinary, Animal and Fisheries Sciences University; 2025.
6. Gardner HL, Fenger JM, London CA. Dogs as a model for cancer. Annu Rev Anim Biosci. 2016;4:199-222.
7. Goldschmidt MH, Hendrick MJ. Tumors of the skin and soft tissues. In: Meuten DJ, editor. Tumors in Domestic Animals. 4th ed. Ames (IA): Iowa State University Press; 2002. p. 109-111.
8. Kiupel M, Camus M. Diagnosis and prognosis of canine cutaneous mast cell tumors. Vet Clin North Am Small Anim Pract. 2019;49(5):819-836.
9. Kiupel M, Webster JD, Bailey KL, Best S, DeLay J, Detrisac CJ, *et al.* Proposal of a 2-tier histologic grading system for canine cutaneous mast cell tumors to more accurately predict biological behavior. Vet Pathol. 2011;48(1):147-155.
10. Kiupel M. Mast cell tumors. In: Meuten DJ, editor. Tumors in Domestic Animals. 5th ed. Ames (IA): John Wiley and Sons Inc.; 2017. p. 176-202.
11. London CA, Thamm DH. Mast cell tumors. In: Withrow SJ, Vail DM, Page RL, editors. Small Animal Clinical Oncology. 5th ed. St. Louis (MO): Elsevier Saunders; 2013. p. 335-355.
12. Martins AL, Canadas-Sousa A, Mesquita JR, *et al.* Retrospective study of canine cutaneous tumors submitted to a diagnostic pathology laboratory in

Northern Portugal (2014-2020). Canine Med Genet. 2022;9(1):2-13.
13. Misdorp W. Mast cells and canine mast cell tumours: a review. Vet Q. 2004;26(4):156-169.
14. Mochizuki H, Motsinger-Reif A, Bettini C, Moroff S, Breen M. Association of breed and histopathological grade in canine mast cell tumours. Vet Comp Oncol. 2017;15(3):829-839.
15. Patnaik AK, Ehler WJ, MacEwen EG. Canine cutaneous mast cell tumor: morphologic grading and survival time in 83 dogs. Vet Pathol. 1984;21(5):469-474.
16. Pierini A, Lubas G, Gori E, Binanti D, Millanta F, Marchetti V. Epidemiology of breed-related mast cell tumour occurrence and prognostic significance of clinical features in a defined population of dogs in west-central Italy. Vet Sci. 2019;6(2):53-65.
17. Scase TJ, Edwards D, Miller J, Henley W, Smith K, Blunden A, *et al.* Canine mast cell tumors: correlation of apoptosis and proliferation markers with prognosis. J Vet Intern Med. 2006;20(1):151-158.
18. Shoop SJ, Marlow S, Church DB, English K, McGreevy PD, Stell AJ, *et al.* Prevalence and risk factors for mast cell tumours in dogs in England. Canine Genet Epidemiol. 2015;2:1-10.
19. Smiech A, Łopuszyński W, Ślaska B, Bulak K, Jasik A. Occurrence and distribution of canine cutaneous mast cell tumour characteristics among predisposed breeds. J Vet Res. 2019;63(1):141-148.
20. Strefezzi RDF, Xavier JG, Catão-Dias JL. Morphometry of canine cutaneous mast cell tumors. Vet Pathol. 2003;40(3):268-275.
21. Subapriya S, Ramesh S, Vairamuthu S, Ali MM, Shafiuzama M, Vijayarani K. Mast cell tumours (MCTs) in dogs: cytological, histopathological, immunohistochemical, immunocytochemical and molecular diagnosis. Int J Vet Sci Anim Husbandry. 2024;9(6):488-498.
22. Tamlin VS, Bottema CD, Peaston AE. Comparative aspects of mast cell neoplasia in animals and the role of KIT in prognosis and treatment. Vet Med Sci. 2020;6(1):3-18.
23. Thompson JJ, Pearl DL, Yager JA, Best SJ, Coomber BL, Foster RA, *et al.* Canine subcutaneous mast cell tumor: characterization and prognostic indices. Vet Pathol. 2011;48(1):156-168.
24. Vascellari M, Giantin M, Capello K, Carminato A, Morello EM, Vercelli A, *et al.* Expression of Ki67, BCL-2, and COX-2 in canine cutaneous mast cell tumors: association with grading and prognosis. Vet Pathol. 2013;50(1):110-121.
25. Villamil JA, Henry CJ, Bryan JN, Ellersieck M, Schultz L, Tyler JW, *et al.* Identification of the most common cutaneous neoplasms in dogs and evaluation of breed and age distributions. J Am Vet Med Assoc. 2011;239(7):960-965.
26. Warland J, Dobson J. Breed predispositions in canine mast cell tumour: a single centre experience in the United Kingdom. Vet J. 2013;197(2):496-498.
27. Welle MM, Bley CR, Howard J, Rufenacht S. Canine mast cell tumours: a review of the pathogenesis, clinical features, pathology and treatment. Vet Dermatol. 2008;19(6):321-339.
28. White CR, Hohenhaus AE, Kelsey J, Procter-Gray E. Cutaneous MCTs: associations with spay/neuter status, breed, body size, and phylogenetic cluster. J Am Anim Hosp Assoc. 2011;47(3):210-216.