International Journal of Veterinary Sciences and Animal Husbandry 2025; 10(8): 380-385

ISSN: 2456-2912
NAAS Rating (2025): 4.61
VET 2025; 10(8): 380-385

www.veterinarypaper.com
Received: 14-06-2025
Accepted: 17-07-2025

Raval VS
Department of Zoology, St. Xavier's College (Autonomous), Ahmedabad, Gujarat, India

Koshti AJ
Department of Zoology, St. Xavier's College (Autonomous), Ahmedabad, Gujarat, India

Corresponding Author:
Raval VS
Department of Zoology, St. Xavier's College (Autonomous), Ahmedabad, Gujarat, India

Bone cancer incidents among canines that must not be overlooked

Raval VS and Koshti AJ

DOI: https://www.doi.org/10.22271/veterinary.2025.v10.i8f.2515

Abstract
Cancer is a multifactorial disease influenced by a combination of genetic, environmental, and lifestyle factors. In recent years, the incidence of cancer has risen sharply, not only in humans but also in animals, with contributing factors including exposure to pesticides, industrial pollution, and widespread chemical contaminants. While human oncology receives significant attention in terms of research and treatment infrastructure, veterinary oncology particularly concerning companion animals remains critically under-addressed. Among the various malignancies affecting canines, osteosarcoma (OS) stands out as one of the most aggressive and commonly occurring primary bone tumors. Despite its severity, specialized veterinary facilities capable of diagnosing and treating such cancers are limited, especially in under-resourced regions. Many affected dogs are misdiagnosed or inadequately treated with symptomatic supplements such as calcium and multivitamins, which offer no therapeutic benefit for malignancies. The primary aim of this research is to highlight the growing prevalence of canine in urban areas bone cancer and underscore the urgent need for continued research into early diagnostic tools, standardized treatment protocols, and increased public and clinical awareness. Addressing this gap is essential to improving survival rates and quality of life for affected animals, while also advancing the field of comparative oncology.

Keywords: Canines, bone cancer, aggressive, treatment

1. Introduction
Osteosarcoma (OS) is the most common primary bone tumor in dogs, accounting for approximately 80-85% of all malignant skeletal neoplasms (Withrow *et al*., 2013) [20]. It is an aggressive, malignant, mesenchymal tumor characterized by osteoid production and rapid local invasion, coupled with a high propensity for early metastasis, particularly to the lungs (Selmic and Liptak, 2016) [18]. Although relatively uncommon compared to soft tissue neoplasms, OS carries disproportionate clinical and epidemiological significance due to its lethality, high recurrence rate, and impact on both canine welfare and veterinary oncology practice. In large and giant breed dogs, osteosarcoma has been consistently recognized as a leading cause of morbidity and mortality, and the disease serves as a powerful model for human osteosarcoma, underscoring its importance in comparative oncology (Khanna *et al*., 2006) [7].
Epidemiologically, canine OS predominantly affects older, large-breed dogs, with Rottweilers, Great Danes, Saint Bernards, Irish Wolfhounds, and Scottish Deerhounds showing particularly high incidence rates (Mueller *et al*., 2007) [14]. Most cases occur in middle-aged to older dogs (7-9 years), although younger dogs are not exempt, particularly in giant breeds where earlier onset has been reported. The appendicular skeleton, especially the metaphyseal regions of long bones such as the distal radius, proximal humerus, distal femur, and proximal tibia, are the most common anatomical sites of tumor development (Thrall, 2017) [19]. The axial skeleton, including the mandible, spine, ribs, and pelvis, may also be affected, though less frequently. Importantly, the distribution pattern appears to parallel regions of high mechanical stress and active bone remodeling, supporting the hypothesis that biomechanical and microenvironmental factors contribute to oncogenesis (Dernell *et al*., 2007) [5].

Clinically, the disease typically presents with progressive lameness, localized swelling, and varying degrees of pain, which are often misattributed to orthopedic disorders such as arthritis or trauma in the early stages. By the time a definitive diagnosis is established, many dogs already harbor micrometastatic disease, particularly in the lungs, even when undetectable radiographically. Radiographic hallmarks include aggressive osteolysis, cortical thinning, periosteal proliferation with a characteristic "sunburst" pattern, and irregular new bone formation (Thrall, 2017) [19]. Definitive diagnosis requires histopathological confirmation, usually achieved through core biopsy. While fine needle aspiration (FNA) may provide preliminary cytological information, it lacks sufficient accuracy compared to histopathology (Dernell *et al*., 2007) [5].

The prognosis of canine OS is guarded, with survival outcomes depending largely on treatment modality and metastatic status at diagnosis. Without treatment, median survival time rarely exceeds 2-3 months, largely due to uncontrolled pain and rapid progression. Limb amputation alone provides effective local control but does not address metastatic spread, yielding median survival times of approximately 4-6 months (Withrow *et al*., 2013) [20]. Amputation combined with adjuvant chemotherapy remains the current gold standard, extending median survival to 10-12 months (Selmic *et al*., 2014) [17]. Platinum-based agents such as carboplatin and cisplatin, along with doxorubicin, remain the mainstay of chemotherapy protocols. For dogs in which amputation is not feasible due to comorbidities or owner preference, limb-sparing procedures utilizing allografts, endoprostheses, or cortical autografts have been attempted, particularly for distal radius tumors. However, these procedures carry significant risks of infection, implant failure, and local recurrence (Lascelles *et al*., 2005) [9]. More recently, non-invasive alternatives such as stereotactic body radiation therapy (SBRT) have been investigated, providing promising outcomes in terms of pain relief and local disease control while preserving limb function (LaRue *et al*., 2014) [8].

Palliative treatment remains a cornerstone of management for cases in which curative intent is not feasible. Pain management strategies include nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, adjunctive analgesics such as gabapentin, and bisphosphonates such as pamidronate and zoledronate, which inhibit osteoclastic bone resorption and strengthen bone integrity (Fan *et al*., 2007) [6]. Palliative radiation therapy has been shown to provide substantial analgesia, though it does not significantly extend survival. While these approaches improve quality of life, the fundamental challenge of systemic micrometastasis remains unsolved (Wypij, 2013) [21].

In recent years, significant research efforts have been directed toward novel therapeutic strategies, reflecting both the need to overcome chemoresistance and the comparative relevance of canine OS to human oncology. Immunotherapy has emerged as a particularly promising avenue. Vaccine-based therapies, such as the HER2-targeted Listeria monocytogenes construct (ADXS31-164), have demonstrated potential in delaying metastasis and prolonging survival in canine clinical trials (Bergman *et al*., 2014) [2].

One of the most striking is the near-total exclusion of free-roaming and stray dog populations from the osteosarcoma literature. Most epidemiological data are derived from referral hospitals and insured pets, which represent a fraction of the canine population worldwide. Stray dogs, which constitute a substantial demographic in many countries, face chronic stressors such as malnutrition, repeated trauma, infections, and hormonal imbalances that could influence tumorigenesis (Roth and Thompson, 2020) [16]. Chronic inflammation, in particular, has been implicated as a driver of cancer initiation and progression across species (Mantovani *et al*., 2008) [12]. However, the absence of surveillance systems or dedicated studies in this group perpetuates a critical blind spot in veterinary oncology. Understanding osteosarcoma in stray populations may provide novel insights into environmental and genetic risk factors, as well as the natural history of the disease in unmanaged settings.

Incorporating stray dogs into osteosarcoma in the present research could be facilitated by leveraging existing infrastructures such as Capture, Neuter, Vaccinate, and Release (CNVR) programs. These programs provide opportunities for screening and basic diagnostic evaluation during sterilization procedures, thereby generating epidemiological data that currently do not exist. Community education campaigns could further enhance early detection by training caregivers, feeders, and municipal workers to recognize early warning signs such as persistent lameness or localized swelling. Beyond the immediate welfare benefits to stray dogs, integrating these populations into OS research may enrich comparative oncology by broadening the genetic and environmental variability under study.

Collectively, canine osteosarcoma represents a complex and multifaceted challenge in veterinary oncology. Its aggressive biology, diagnostic delays, and limited treatment outcomes highlight the urgent need for more effective diagnostic and therapeutic strategies. Advances in immunotherapy, molecular diagnostics, and targeted therapy offer promising avenues, but the full potential of research will only be realized through inclusive approaches that extend beyond the owned pet population. Given its strong parallels with the human disease, canine OS continues to serve as both a clinical priority and a translational model. A comprehensive introduction to this disease must therefore acknowledge not only the established knowledge regarding epidemiology, clinical features, diagnosis, and treatment, but also the emerging opportunities and unaddressed gaps in research—particularly the neglect of stray and underserved canine population.

2. Materials and Methods

A mixed-methods research design was adopted for this study to ensure a comprehensive understanding of canine osteosarcoma from both clinical and experiential perspectives. Data were collected using a structured survey that included both quantitative (closed-ended) and qualitative (open-ended) questions. The survey was developed to gather detailed information from practicing veterinarians regarding their firsthand experiences, diagnostic practices, and treatment strategies in managing canine bone cancer. A total of seven veterinarians were selected and contacted through a combination of phone and in-person interviews. This dual approach allowed for a deeper contextual understanding and enabled the researchers to capture both statistical trends and nuanced insights related to osteosarcoma diagnosis and treatment in clinical settings. In addition, relevant pictures and visual documentation of clinical cases were collected and captured directly by the author to supplement the data and provide stronger contextual support for the findings.

Fig 1: Shows tumor in forepaw

Fig 2: Shows x-ray of pelvic region of canine

3. Observation and Results

Veterinarians interviewed for this study offered critical qualitative insights that significantly deepened the understanding of osteosarcoma (OS) beyond numerical findings. These observations, derived from their clinical experience and patient interactions, illuminated the complex interplay of genetic, environmental, dietary, and healthcare accessibility factors that influence the incidence and management of OS in dogs. Several recurring themes emerged, each contributing to a broader perspective on the disease's real-world implications.

3.1 Increasing Prevalence and Breed Predisposition

A recurring concern among participants was the noticeable rise in osteosarcoma cases in recent years. Although national registries and large-scale surveillance data remain limited in veterinary oncology, these clinical experiences suggest a potential upward trend that warrants further epidemiological investigation.

3.2 Environmental and Nutritional Risk Factors

Another prominent theme that emerged from the interviews was the possible role of environmental and dietary influences in the etiology of osteosarcoma. Many veterinarians expressed concern over the increasing reliance on highly processed commercial pet foods, which often contain preservatives, artificial flavors, and other additives whose long-term biological impact remains inadequately studied.

3.3 Clinical Challenges and Treatment Limitations

All participating veterinarians emphasized the clinical gravity of osteosarcoma, particularly its aggressive nature and poor prognosis without timely and comprehensive intervention. Unlike other orthopedic disorders such as panosteitis, osteomyelitis, or osteochondritis dissecans which typically respond well to medical or surgical treatment, OS demands a multimodal therapeutic approach. Standard management generally includes amputation or limb-sparing surgery, followed by systemic chemotherapy to address potential micrometastases. However, access to such advanced interventions remains limited in many regions due to financial constraints, scarcity of veterinary oncology specialists, and delayed presentation by pet owners unfamiliar with early warning signs.

The clinical data obtained from participating veterinarians further corroborated the trends highlighted through observational insights. Quantitative findings revealed several noteworthy patterns in the epidemiology and anatomical distribution of osteosarcoma in dogs.

Each veterinarian reported an average of seven to eight new osteosarcoma cases per year, reflecting the persistent presence of this malignancy in everyday practice. Although OS represents a smaller fraction of total bone-related conditions, it remains one of the most lethal due to its aggressive behavior and high rate of metastasis.

3.4 Age and Demographic Distribution

The study found that 80% of osteosarcoma cases occurred in dogs over 7 years old, with over half affecting dogs aged 9 years and above.

3.5 Anatomical Predilection

Consistent with existing literature, osteosarcoma was most frequently found in the appendicular skeleton, particularly in long, weight-bearing bones. The most commonly affected sites included:

- Radius/ulna-26.8%
- Femur-24.8%
- Tibia-20.3%
- Humerus-16.1%
- Other bones (e.g., pelvis, mandible)-12%

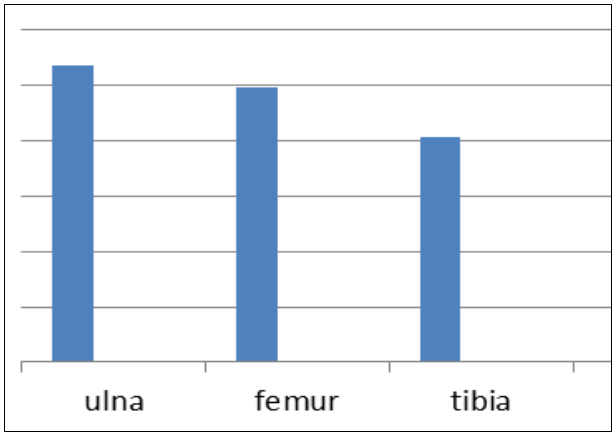

Fig 3: Shows ratio of OS in different bones

3.5.1 Relative frequency among bone disorders

Among a total of 30 bone-related clinical cases reviewed across participants, osteosarcoma accounted for approximately 10% (3 out of 30 cases). Other more prevalent conditions included fractures, osteomyelitis, and inflammatory bone diseases. However, despite its lower relative frequency, osteosarcoma was universally regarded as the most clinically significant due to its lethality, complexity, and impact on quality of life.

In contrast to other orthopedic diseases, which often respond to conservative treatment, OS requires aggressive and invasive therapy. Unfortunately, survival rates remain modest, particularly when metastasis is present at diagnosis or when access to treatment is delayed or unavailable. REF supportive finding in discussion.

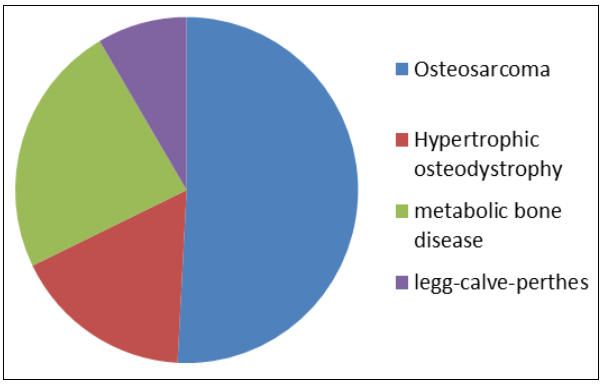

Fig 4: Shows different bone disease in comparison to osteosarcoma

4. Discussion

The findings of this study highlight the multifactorial complexity of canine osteosarcoma (OS), emphasizing that its clinical presentation, biological behavior, and therapeutic response cannot be understood in isolation. Rather, OS represents the culmination of intersecting genetic, environmental, and socioeconomic influences that collectively shape disease onset and progression. By drawing from veterinary clinician observations and published research, the discussion underscores critical challenges while identifying promising avenues for translational and clinical advancement.

One of the most consistent clinical insights from veterinarians involved in this study was the advanced stage at which most dogs were presented. Owners frequently sought medical attention only after persistent lameness and visible swelling, by which point metastatic dissemination had likely already occurred. Notably, clinicians reported instances where pulmonary metastasis was suspected despite negative thoracic radiographs, supporting earlier evidence that micrometastasis often precedes clinical detectability (Selmic and Liptak, 2016) [18]. This underscores a pressing gap in current diagnostic tools. While conventional radiography and histopathology remain essential, they fail to provide the sensitivity required for detecting subclinical disease. As a result, survival outcomes remain guarded even when aggressive therapies such as amputation and chemotherapy are pursued.

An important dimension to emerge is the role of breed-specific genetic predisposition. The overrepresentation of large and giant breed dogs such as Rottweilers, Irish Wolfhounds, and Great Danes was consistent with global literature (Mueller *et al*., 2007) [14]. The selective breeding practices that maintain closed gene pools in these breeds appear to inadvertently perpetuate deleterious mutations, including those affecting tumor suppressor genes like TP53 and RB1 (Perry *et al*., 2014) [15]. These mutations, combined with the biomechanical stressors of supporting larger body masses, create a biological environment favorable to neoplastic transformation. The findings of this study echo calls from previous research advocating for genetic screening programs within high-risk breeds (Modiano *et al*., 2018) [13]. Such programs could serve not only as predictive markers but also as a foundation for designing preventive strategies, including selective outcrossing to restore genetic diversity.

Another key factor that surfaced in this investigation is the impact of environmental and lifestyle determinants. Several veterinarians anecdotally linked poor dietary quality and sedentary lifestyles in companion dogs to broader patterns of chronic disease, including neoplasia (Lauten, 2006) [10]. While causality between nutrition and OS remains unproven, chronic low-grade inflammation and metabolic dysregulation are plausible mediators that warrant investigation. Likewise, reduced physical activity in urbanized, indoor-kept dogs may diminish immune surveillance, thereby lowering the host's ability to detect and eliminate malignant cells before they establish metastatic niches. These associations highlight the need for longitudinal epidemiological studies incorporating diet, exercise, and environmental exposures into OS risk assessment.

In addition to owned dogs, the neglect of stray and underserved canine populations represents a serious blind spot in osteosarcoma research. Current epidemiological data are overwhelmingly skewed toward insured, hospital-presenting animals, while free-roaming populations arguably at higher risk due to cumulative stress, trauma, and malnutrition remain virtually invisible in cancer surveillance systems. This exclusion not only underrepresents disease prevalence but also narrows the scope of genetic and environmental variables that may influence tumorigenesis. Chronic inflammation from untreated injuries or infections, for instance, has been implicated as a driver of carcinogenesis in other species (Mantovani *et al*., 2008) [12]. Addressing this gap requires expanding OS detection into community-based programs, such as incorporating tumor screening into CNVR (Capture, Neuter, Vaccinate and Release) initiatives. Doing so would serve both a welfare function by reducing untreated suffering and a research function, by enriching datasets with previously neglected populations.

Therapeutically, while limb amputation with adjuvant chemotherapy remains the gold standard, veterinarians expressed concern over its limitations, particularly in cases with pre-existing metastasis. Standard chemotherapeutics, including carboplatin and doxorubicin, continue to extend survival modestly, but the plateau in outcomes underscores the need for innovative interventions (Boston *et al*., 2006; Selmic *et al*., 2014) [3, 17]. This aligns with growing enthusiasm around novel therapeutics, including immuno-oncology, targeted small-molecule inhibitors, and oncolytic virotherapy. Early-phase studies with Listeria monocytogenes-based vaccines and dendritic cell therapies have demonstrated delayed metastatic spread and improved immune recognition of tumor cells (Bergman *et al*., 2014; Modiano *et al*., 2018) [2, 13]. Similarly, tyrosine kinase inhibitors like toceranib phosphate show potential in controlling angiogenesis and proliferation in advanced cases (London *et al*., 2012) [11]. Although these therapies remain largely confined to research or referral centers, their translational relevance is significant, given that canine OS is a well-recognized model for human pediatric osteosarcoma (Khanna *et al*., 2006) [7].

Pain management was identified as another area requiring both clinical and research innovation. While NSAIDs, gabapentin, and bisphosphonates remain staples for symptom relief (Fan *et al*., 2007) [6], their benefits are largely palliative, not disease-modifying. This reality forces veterinarians and owners into difficult ethical decisions, balancing aggressive treatment against quality of life considerations. Palliative radiation therapy offers temporary relief but similarly does not halt disease progression (Wypij, 2013) [21]. These findings reinforce the argument that quality-of-life metrics should be integrated into OS management frameworks, both to guide clinical decision-making and to structure outcome reporting in veterinary oncology studies.

Another notable insight from this study was the socioeconomic dimension of OS care. Several practitioners emphasized that treatment decisions were heavily influenced by financial considerations, often leading owners to decline advanced interventions such as limb-sparing surgery, SBRT, or novel immunotherapies. This aligns with broader concerns in veterinary medicine that economic limitations shape not only individual outcomes but also research data, as cost barriers reduce enrollment in advanced therapeutic trials (LaRue *et al*., 2014) [8]. Thus, improving access to innovative treatments through subsidies, clinical trials, or lower-cost alternatives remains an essential step in advancing the field.

Finally, the study highlights an overarching need for research and innovation to focus on early detection. Investigations into circulating tumor DNA (ctDNA), microRNA signatures, and immunophenotyping are promising in their ability to detect OS earlier and to stratify risk in predisposed breeds (Chibuk *et al*., 2021) [4]. Early intervention could transform the prognosis of this disease, shifting the clinical paradigm from late-stage palliation toward meaningful long-term control. Coupling these innovations with broader surveillance systems, particularly inclusive of stray and underserved populations, would generate more representative data and ultimately foster more effective translational applications.

Taken together, the findings of this study underscore that osteosarcoma in dogs is not simply a localized skeletal malignancy but rather a complex, systemic condition influenced by genetic, environmental, and socioeconomic factors. The path forward requires a dual approach: advancing cutting-edge therapies while also addressing gaps in access, surveillance, and inclusivity. By broadening the scope of research and integrating precision medicine with community outreach, veterinary oncology can move closer to mitigating the burden of OS on both canine patients and the families who care for them.

5. Conclusion

Canine osteosarcoma (OS) remains a highly aggressive malignancy with profound clinical, welfare, and translational significance. This study reinforces its strong breed predisposition, frequent appendicular localization, and poor prognosis despite current gold-standard therapies of amputation and chemotherapy. Insights from practicing veterinarians highlighted the role of genetics, environment, diet, and socioeconomic constraints in shaping outcomes, while also exposing critical blind spots such as the neglect of stray and underserved populations. Future progress will depend on advancing early diagnostic biomarkers, integrating immunotherapy and targeted agents, and expanding surveillance to include community-based programs. By combining precision medicine with inclusive research strategies, veterinary oncology can improve outcomes while enriching comparative models for human osteosarcoma.

Financial Support
Not available

Conflict of Interest
Not available

Reference

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How to Cite This Article
Raval VS, Koshti AJ. Bone cancer incidents among canines that must not be overlooked. International Journal of Veterinary Sciences and Animal Husbandry. 2025;10(8):380-385.