Radiographic Evaluation of Pelvic Limb Musculoskeletal Lesions in Animals Presented for Clinical Diagnosis

Abdulhakeem Binhambali [1,2,4*], Maruf Lawal[1, 2], Nasiru Asipita Salau[1, 2], Abdulwaheed Abodunrin[1,2], Muazu Nuhu Bappah[1], Echiobi Gaba Emmanuel[3], Mohammed Abdurrahman1 Rashidah Abimbola Mustapha[5]

[1]Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria
[2]Diagnostic Imaging Center, Ahmadu Bello University Veterinary Teaching Hospital, Zaria, Nigeria
[3]Ahmadu Bello University Veterinary Teaching Hospital, Zaria, Nigeria
[4]Department of Clinical Science, College of Veterinary Medicine, Tuskegee University, Tuskegee, USA
[5]Department of Theriogenology and Production, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria.
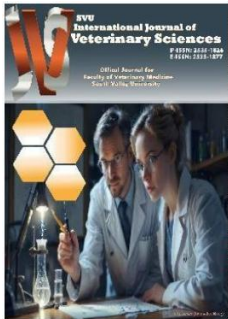
ABSTRACT

This study, conducted at the Veterinary Teaching Hospital of Ahmadu Bello University, Zaria, analysed the prevalence of musculoskeletal conditions affec7ting the pelvic limb using radiographic data from 1989 to 2019. A total of 646 radiographs of canine, feline, equine, ovine, avian and bovine) were reviewed, revealing bone and joint diseases in 203 cases (31.4%), fractures in 236 cases (36.5%) and no pathological findings in 207 cases (32.1%). Among bone and joint diseases, hip dysplasia (101 cases, 49.8%) and osteoarthritis (72 cases, 35.5%) were most common, while bone tumors (10 cases, 3.7%), tenosynovitis (18 cases, 6.7%), and panosteitis (2 cases, 0.7%) were less frequent. Pelvic fractures were predominantly ilio-ischiatic (42 cases, 57.5%), followed by pubic bone (15 cases, 20.5%), iliac wing (10 cases, 13.7%), and ilium (6 cases, 8.2%) fractures. Among long bone fractures, femoral body fractures were most prevalent (74 cases, 47.4%), followed by tibial (40 cases, 25.6%), femoral head (25 cases, 16.0%), femoral head luxation (12 cases, 7.7%), and fibular fractures (5 cases, 3.2%). The high incidence of hind limb fractures highlights the vulnerability of animals to trauma, likely due to accidents or collisions common in this region. Further research is essential to enhance diagnostic accuracy and refine management strategies for bone and joint diseases across species.

Keywords: *Bone and Joint disease, Canine, Fracture, Hip Dysplasia, Osteoarthritis*

INTRODUCTION

The locomotor system, also known as the musculoskeletal system, comprises the skeleton, skeletal muscles, cartilages, tendons, ligaments, joints, and connective tissues (Shukunami, 2017). It is one of the critical systems in the body that offers other systems reliance for locomotion (Netter, 2019; Sylvester et al., 2021; Chytas et al., 2024). Changes in the physiology of this system can significantly reduce the quality of life and might prevent the animal from performing optimally (Jarecki et al., 2023; Garant et al., 2023), whether as a companion pet or a productive animal. Conditions affecting the musculoskeletal system, such as fractures, osteoarthritis, panosteitis, osteosarcoma, osteoporosis, and osteochondritis, reduce the functionality of this system (Jarecki et al., 2023; Azzolino et al., 2021). These conditions can either partially inhibit movement due to muscle or joint pain (Clank and Cameford, 2023) or completely inhibit movement due to dysplasia or fractures. It is important to note that animal joints are commonly affected by both fractures and non-fracture conditions (Johnson et al., 1994).

Radiography is usually employed to evaluate lameness and pain caused by developmental bone diseases (Fox 2021; Sengox et al., 2020). Most cases of musculoskeletal conditions seen in many clinics involve fractures (Piermattei and Flo, 2015), especially in this study region, with very little reported on non-fracture cases.

Radiography is also employed in large animal patients (Sengox et al., 2020; Turek et al., 2024), which is used primarily to confirm the presence and severity of conditions affecting the ungulate's musculoskeletal system. However, over half of the reported cases from diagnostic examinations in dogs involve bones and joint luxation (Morgan 1981). Radiographic examination of a horse's limbs is also crucial for diagnosing various lameness conditions, including laminitis and navicular diseases (Davis et al., 2017; Hanlon, 1982). Fractures of the navicular bone and the third phalanx are among the most frequent fractures observed in horses (Loughride et al., 2017; Adams and Stashak, 2011).

Historically, fracture cases were the most common indication for limb radiography and orthopedic surgery in animals (Corr 2012; Jimenez-Heras et al., 2014). Most injured animals are mostly examined for suspected fractures on presentation, and older animals that are increasingly unwilling to use their limbs seldom screened for degenerative joint diseases (DJD) or secondary joint diseases like gout (Jarecki et al., 2023; Johnson et al., 1994; Kealy, 2011). Radiography of the musculoskeletal system is used to determine the nature of fractures and the extent of damage to surrounding tissues and joints to decide the best management options for fractures, DJD, and other musculoskeletal issues (Davis et al., 2017; Hanlon 1982; Hinterwimmer et al., 2024).

The dominant symptom of musculoskeletal diseases and conditions in animals is pain (Lascelles et al., 2022). These pathologies can result in either non-weight-bearing due to fractures or chronic pain from tissue damage that can persist for long periods (Zhao et al., 2022). Weight-bearing can also be affected when the pathology is not severe (Pickering et al., 2024). Like humans, animals can also suffer from chronic conditions such as cancer, osteoarthritis, osteosarcoma, and intervertebral disc degeneration (IVDD) (Zhao et al., 2022), which impact their musculoskeletal systems (Zhao et al., 2022; Thompson et al., 2018). Evaluating function and pain in chronic musculoskeletal disorders, especially the non-fracture conditions is often challenging, as these conditions typically progress slowly, making them difficult to identify during routine clinical examinations and increasing the likelihood of misdiagnosis (Hercock et al., 2009). Moreover, pain affects multiple dimensions in both animals and humans, including physiological, emotional, sensory, socio-cultural, cognitive, and behavioral aspects (McGuire et al., 1992; Saxer et al., 2024). Chronic pain is particularly prevalent among companion animals such as dogs and cats, often arising from conditions similar to those affecting humans. The aforementioned ailments are just a few examples of the health challenges these animals face(Loughridge et al., 2017).

The aim of this study is to determine the incidence rate of musculoskeletal diseases and conditions presented and diagnosed at the Diagnostic Imaging Centre (DIC) of the Veterinary Teaching Hospital of Ahmadu Bello University, Zaria, from 1989 to 2019. The study also seeks to provide reliable information regarding the prevalence of musculoskeletal conditions within the study area.

MATERIALS AND METHODS

Study location

The study was carried out at the DIC of Ahmadu Bello University, Veterinary Teaching Hospital, Zaria, Kaduna state. Zaria is a major city in Kaduna State in Northern Nigeria, and also a Local Government Area which is located on the geographic co-ordinates Latitude: 11° 4' 44N and 7° 42' 37E, with an elevation foot of 2509 and Zip Code of 810222. Zaria's 2024 population is now estimated at 786,197. In 1950, the population of Zaria was 50,006 and had grown steadily by 20,190 in the last year, which represents a 2.64% annual change. These population estimates and projections come from the latest revision of the UN World Urbanization Prospects and represent the urban agglomeration of Zaria, which typically includes Zaria's population in addition to adjacent suburban areas. It is the second largest city after Kaduna, the state's capital (Ayo-Opemipo *et al.*, 2025).

Data collection and management

A total of 646 archived radiography of pelvic limbs from various animal species presented to

the Diagnostic Imaging Centre (DIC) at Ahmadu Bello University Veterinary Teaching Hospital (ABUVTH), Zaria, spanning the years 1989 to 2019, were included in this study. Data collection occurred over a five-month period, from February 11th to July 30th, 2019. To ensure an unbiased analysis, all reviewers were blinded to the medical records associated with the archived radiography except when necessary. The radiography was analyzed by three trained and experienced radiographers, utilizing a 3-screen X-ray film viewer (291D X-Ray Film Illuminator, S&S X-Ray Products Inc.). Data was recorded and organized in an Excel spreadsheet on a Dell Latitude laptop (Latitude 3540, 13th Gen Intel® Core™ i3-1315U). For analysis, the radiography was categorized based on several criteria, including species, age, sex, anatomical location, radiograph orientation, and the distribution of fractures to provide detailed clarity and adequate result. The distribution of pelvic and long bone fractures, as well as various radiographic conditions, was recorded. The conditions were classified into fracture and non-fracture categories. Non-fracture conditions were grouped together for further analysis. Additionally, age categories were divided into "adult" and "young," while sex was classified as either "male" or "female." The anatomical location of each fracture was also determined for each record.

Consideration

The radiography (non-digital film) was sorted based on anatomical locations and only the radiography of the pelvic limbs was used. Spoiled and damaged radiography (i.e. that radiography spoiled by water) was not included and they were dropped. The exercise was performed in strict adherence to the rules of radiographic viewing, which assisted us in having a positive and correct interpretation and diagnosis.

Statistical Analysis

All recorded data were entered and calculated using Microsoft Excel 2019. Statistical analyses were conducted using SPSS 25.0 software for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics were employed to summarize the data where applicable. For statistical interpretation, standard mean was used when appropriate. Additionally, comparisons between recorded factors, such as age and sex, were carried out using the chi-square ($\chi2$) test.

RESULTS

From the six hundred and forty-six radiographs reviewed, detailed in (Figure 1a), fracture cases 236 (36.5%) were the most prevalent, while bone and joint diseases (non-fracture conditions) constituted 203 (31.4%) and non-pathological cases constituted 207 (32.1%). The distribution of radiographs across various species, as depicted in (Figure 1b), revealed a predominant representation of canine radiographs at 586 cases (90.7%), followed by equine radiographs at 34

cases (5.3%) and feline 11 cases (1.7%), with minor contributions from other species such as avian, bovine, and ovine. As highlighted in (Figure 1c), adult animals constituted the majority, comprising 441 (68.3%) of the evaluated radiographs, while the remaining 205 (31.7%) consisted of young animals. Also, Figure 1d provides insights into the gender distribution, with female animals accounting for 324 cases (51.2%) and male animals comprising 321 cases (49.8%). Moreover, analysis of fracture types, as illustrated in Figure 1e, revealed that fractures of the long bones of the pelvic limb were the most prevalent, representing 156 cases (66.1%), followed by fractures of the pelvic bone and lower hind limb at 73 cases (30.9%) and 7 cases (3.0%), respectively. The comparison of different radiographic views, as outlined in Figure 1f), showcased the predominance of medio-lateral views, accounting for 324 cases (50.2%), ventro-dorsal views at 217 cases (33.6%), cranio-caudal views at 61 cases (9.4%), and dorso-ventral views at 44 cases (6.8%). In Figure 1g) result for pelvic bone fractures, ilio-ischiatic fractures accounted for the highest proportion at 42 cases (57.5%), followed by pubic bone fractures at 15 cases (20.5%). Fractures of the iliac wing and ilium were reported in 10 cases (13.7%) and 6 cases (8.2%), respectively.
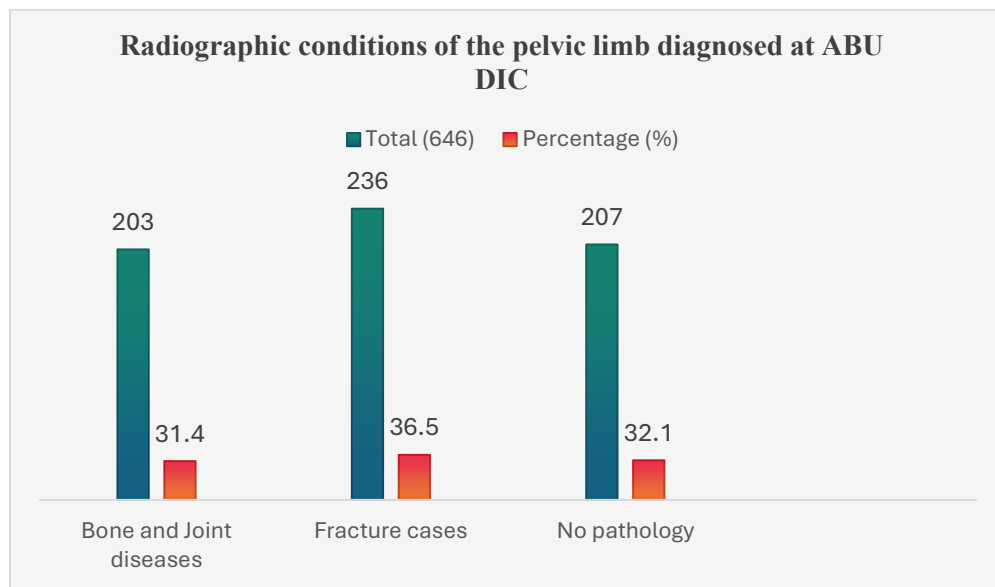

Figure 1a: Shows the radiographic conditions of the pelvic limb diagnosed at Diagnostic Imaging Center of ABUVTH, Zaria.
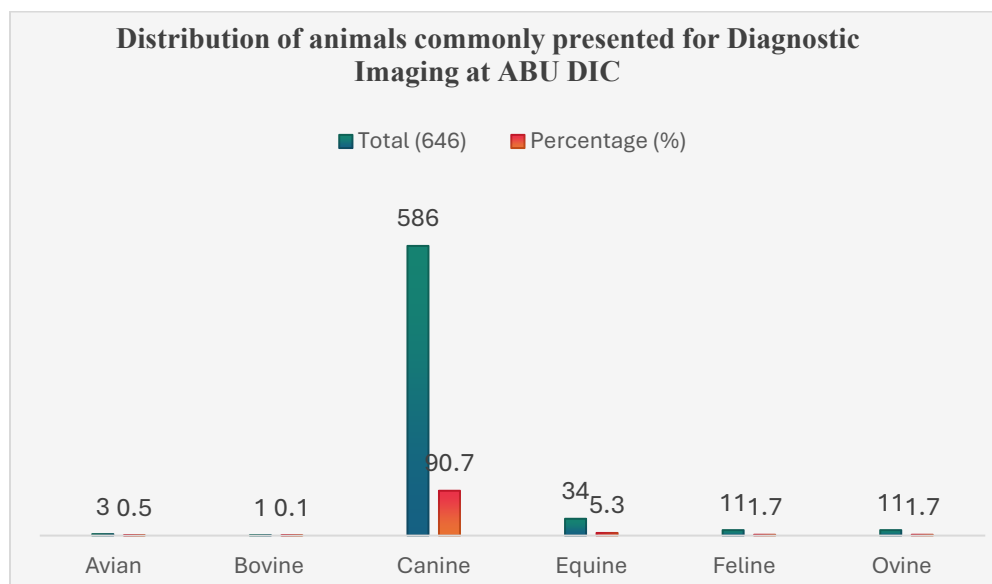
Figure 1b: Shows the distribution of animals commonly presented for X-ray at the Diagnostic Imaging Center of ABUVTH, Zaria
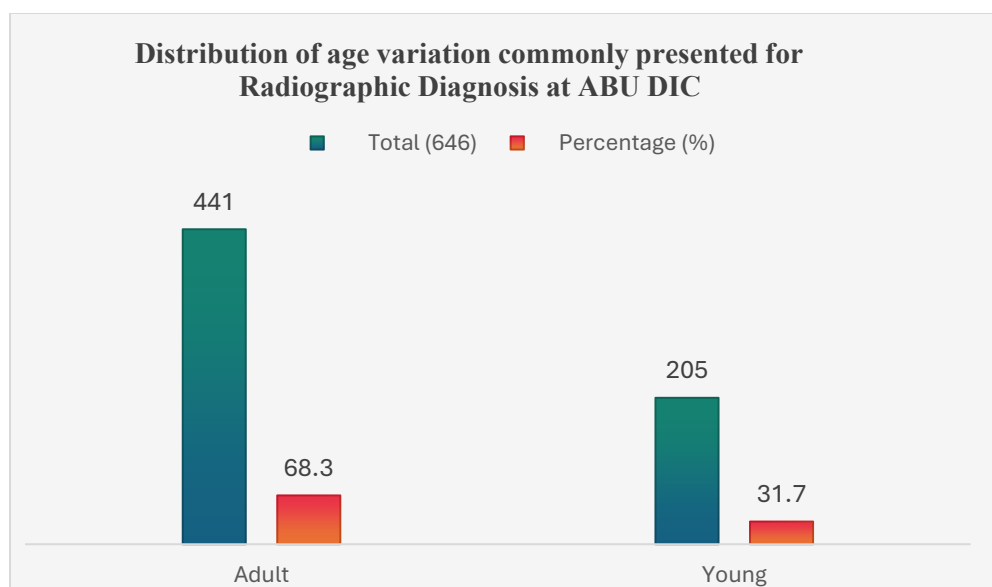

Figure 1c: Shows distribution of age variation commonly presented for Radiographic Diagnosis at Diagnostic Imaging Center of ABUVTH, Zaria.
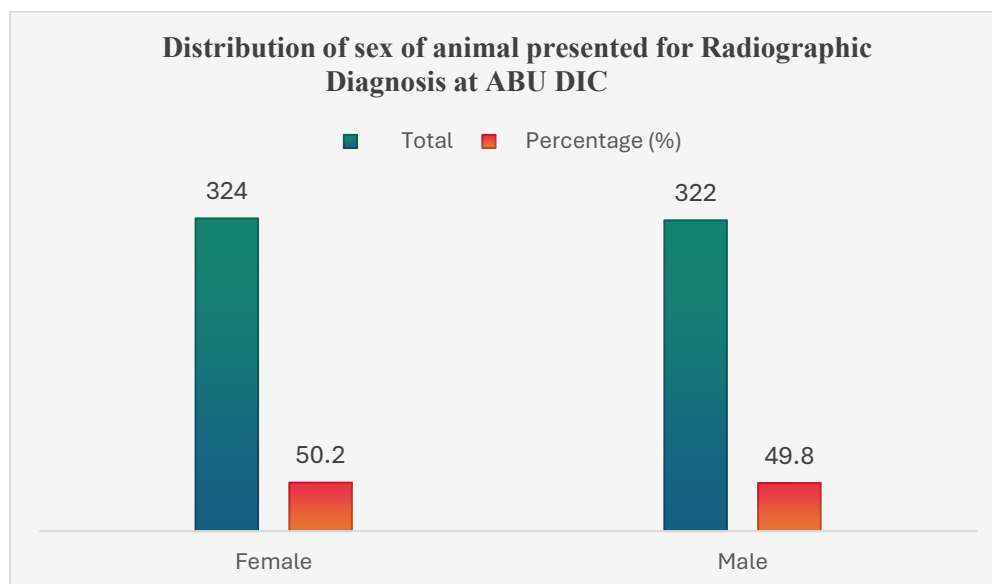
Figure 1d: Shows distribution of sex of animals presented for Radiographic Diagnosis at Diagnostic Imaging Center of ABUVTH, Zaria.

Figure 1e: Shows distribution of fractures of long bones presented for Radiographic Diagnosis at Diagnostic Imaging Center of ABUVTH, Zaria.

Figure 1f: Shows distribution of radiographic positions of cases presented for Radiographic Diagnosis at Diagnostic Imaging Center of ABUVTH, Zaria.
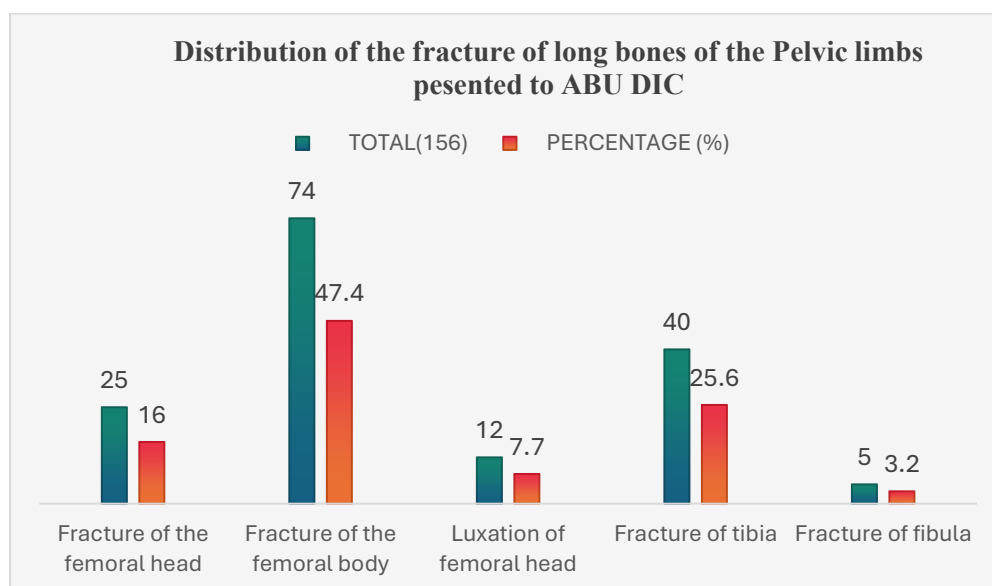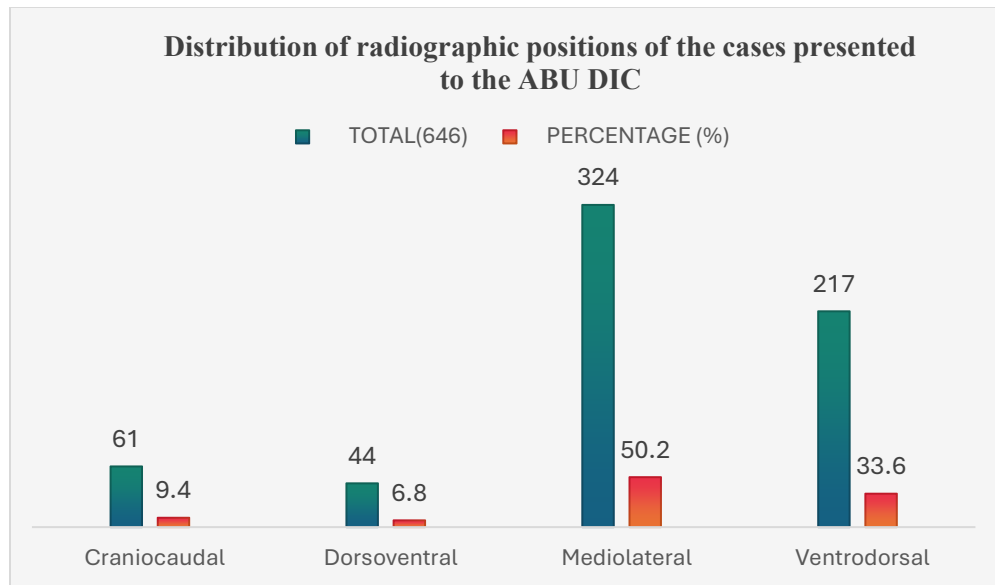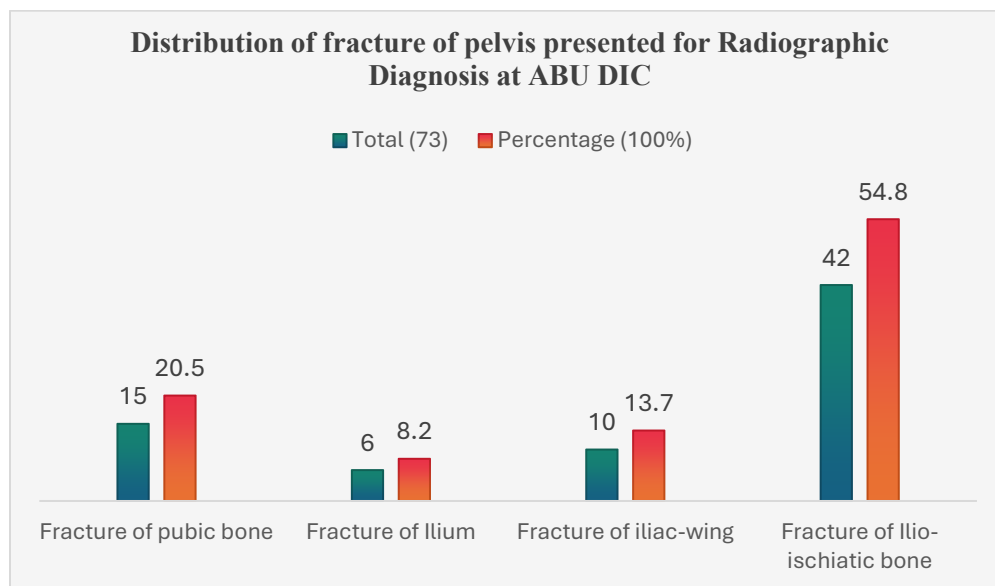

Figure 1g: Shows distribution of fracture of pelvis presented for Radiographic Diagnosis at Diagnostic Imaging Center of ABUVTH, Zaria.
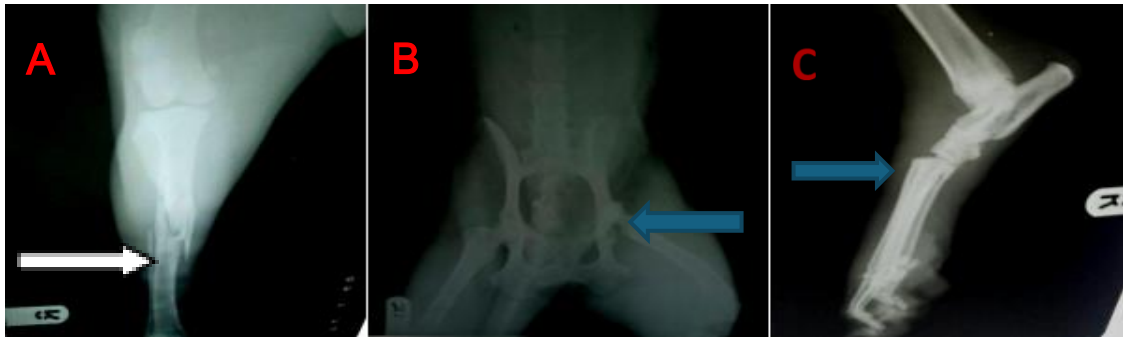
Figure 2: A. Radiograph (adult dog) showing fracture of the tibia and fibula (white arrow), B. A radiograph (female dog) showing fracture of the pelvic bone with concurrent dysplasia of the left hip (blue arrow), C. Fracture (adult dog) of the metatarsal bone at the proximal region (blue arrow)
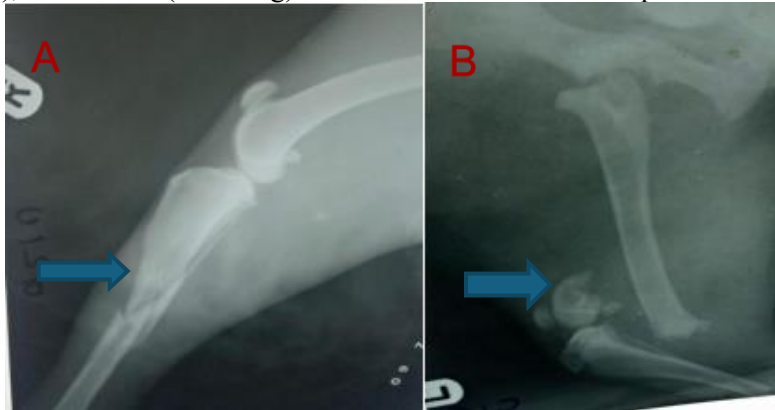

Figure 3: a. Radiograph (adult dog) showing mediolateral view of the fracture of tibia and fibula (blue arrow) with contact between the edges of the femur and tibia which could also lead to osteoarthritis b. Complete fracture of the epiphyseal of the femur (blue arrow) of a dog.

The species-age-related analysis in Table 1 revealed 520 adults and 126 young animals. Among the adult population, canines represented the majority, with 470 cases, then equines (30), felines (7), ovines (10), and avians (3) and bovines were recorded in the adult category while in young, result shows canine (116), equine (4), feline (4), ovine (1) and bovine (1) respectively. The species-sex-related breakdown of cases in Table 2 also comprises 396 canines, 10 equines, 10 felines, 8 ovine, 3 avian, and 1 bovine for female animals, while the male population totaled 126, with canines at 190, then 24 equine cases, with fewer instances in other species. The analysis of fracture conditions in Table 3 indicates that long bone fractures were the most common, with canines representing 154 of these cases. Pelvic fractures accounted for 73 cases, and lower hind limb fractures totaled 7. In our evaluation of Species-bone and joint conditions/pathologies analysis in (Table 4), we documented a total of 203 cases of pathology, with hip dysplasia (HD) being the most prevalent (101 cases, including 97 canines and 4 felines), followed by osteoarthritis (OA) (72 cases with 53 canine species, 7 cases each for feline and equine and 5 ovine cases) and bone tumors with 10 cases.

Table 1: Standard mean of species-age related

Species \ Age	Canine	Equine	Feline	Ovine	Avian	Bovine	Total	SD
Adult	470	30	7	10	3	0	520	188.09
Young	116	4	4	1	0	1	126	46.57
Total	586	34	11	11	3	1	646	234.63

Table 2: Standard mean of species-sex related

Species \ Sex	Canine	Equine	Feline	Ovine	Avian	Bovine	Total	SD
Female	396	10	10	8	3	1	520	159.10
Male	190	24	1	3	0	0	126	75.85
Total	586	34	11	11	3	1	646	234.63

Table 3: Standard mean of species-fracture conditions related

Species \ Fracture	Canine	Equine	Feline	Ovine	Avian	Bovine	Total	SD
Long bone	154	-	-	-	2	-	156	62.71
Pelvic bone	73	-	-	-	-	-	73	29.80
Lower hind limb	3	3	-	-	-	1	7	1.47
Total	230	3	0	0	2	1	236	93.41

Table 4: Standard mean of species-Bone and joint conditions/pathologies related

Species \ Condition/Pathologies	Canine	Equine	Feline	Ovine	Avian	Bovine	Total	SD
Bone tumor	8	2	-	-	-	-	10	3.20
Hip Dysplasia	97	-	4	-	-	-	101	39.31
Osteoarthritis	53	7	7	5	-	-	72	20.34
Paneostitis	17	1	-	-	-	-	18	6.87
Tenosynovitis	-	2	-	-	-	-	2	0.82
Total	175	12	11	5	0	0	203	69.35

DISCUSSION

Bone and joint disease conditions are becoming one of the leading causes of immobility in animals (Guadagni, 2023). In this study, we conducted a comprehensive analysis of musculoskeletal conditions affecting various species. The predominant issues affecting the pelvic limb that were presented to the DIC were fracture (Figure 2a) and non-fracture conditions (Figure 2b). These musculoskeletal conditions occurred within various regions of the pelvic limb, including a fracture along the metatarsal region of the hind limb (Figure 2c). According to the study by Meghini *et al.*(2023), they stated that fracture cases accounted for 23% in their study in a retrospective study from 2013-2018. Kokila *et al.* (2023) also reported in their study in goat that out of 893 cases, 344 (38.5%) involved fractures, with metacarpal (28.4%) and metatarsal (22.9%) bones being the most commonly affected, this is also similar with the findings of Sindhu *et al. (*2023) which also reported cases of fracture on long bone with 64.04% occurrence on pelvic limbs, and tibiotarsal fractures being most common (43.82%) in birds. A study by Sriharsha *et al.* (2024) reported in their study that 1,950 dogs presented with long bone fractures, with femoral fractures being the most frequent, and Bhargav *et al.* (2024) also reported cases of canine fracture in about 362 cases which 81.49% were long bone fractures, with femoral fractures accounting for 40.34%. However, in this study,

we observed that out of the 646 radiographs reviewed, fracture cases accounted for the highest proportion, with 236 cases representing 36.5% of all presentations. These findings prove the significant burden fractures place on animal health and the clinical workload in veterinary practice.

The predominance of fracture cases aligns with earlier reports in both companion and farm animal studies, where traumatic injuries, often from road traffic accidents, falls, and animal interactions, have been cited as leading contributors to orthopedic conditions. However, in this study, the high prevalence of fractures may also reflect increased awareness and accessibility to diagnostic imaging, allowing for more timely and accurate identification of skeletal injuries. It is also notable that fracture cases outnumbered other common musculoskeletal conditions, such as joint dislocations, developmental bone disorders, or degenerative joint diseases. This may suggest a relatively acute pattern of presentation, with fractures prompting more urgent diagnostic intervention compared to chronic or progressive orthopedic diseases, which are sometimes underreported or overlooked during routine care. Joint diseases are one of the most common causes of significant clinical disability in dogs, leading to altered activity patterns, as proven by Brown *et al.*(2010). In this study, we noticed that among the various bone and joint diseases evaluated, hip dysplasia emerged as the most

prevalent condition, accounting for 49.8% (101 cases) of the total cases. This was closely followed by OA, which represented 35.5% (72 cases), highlighting their significant contribution to musculoskeletal morbidity in the studied population. In contrast, other conditions such as tenosynovitis (6.7%, 18 cases), bone tumors (3.7%, 10 cases), and panosteitis (0.7%, 2 cases) were relatively uncommon.

As noted earlier HD has the most prevalent cases in this study and this is correlated to the findings made by Loder and Todhunter (2017), which also noted similar trend with result that shows, that the HD scores in dogs were 1 in 74,931 dogs; 2 in 601,893; 3 in 95,154; 4 in 6,772; 5 in 86,321; 6 in 47,971; and 7 in 8,004 respectively, resulting in an overall canine HD prevalence of 15.56% in their study which is a bit high. Tenosynovitis also presented, although this is lower than the similar report made by Casper *et. al.* (2023) that reported 48% of 84 cases in their study, while paneostitis was just a small portion of the cases presented in this study and this seems insignificant compared with the overall number of data reviewed. On osteoarthritis (OA), Johnston *et al.* (1997) highlighted that osteoarthritis (OA), one of the primary causes of immobility among bone and joint diseases, affects approximately 20% of dogs over the age of one year in North America. In a study by Anderson *et al.* (2018), found that an annual prevalence of appendicular OA was 2.5%, with higher rates in older and larger breeds. In

contrast, O'Neil *et al.* (2014) also reported 6.6% in dogs of all ages and breeds in their studies, which also proofs significant by Roitner *et al.* (2024) in their study showing prevelance of OA in dogs as follows; elbow (57.4%), shoulder (39.2%), stifle (36.4%), and hip (35.9%) respectively and, in young dog study by Alves *at al.* (2024) reported that among dogs aged 8 months to 4 years, 39.8% exhibited radiographic signs of OA, and 23.6% showed clinical signs, indicating early onset in younger populations. In other species like cats and rabbits, OA prevalence was reported to be 94% and 19.6% respectively. However, in a study by Ramos *et al.* (2020) in horses, they reported a low prevalence of OA. These findings suggest that developmental and degenerative joint disorders, particularly HD and OA, are the primary causes of clinical presentations involving the musculoskeletal system involving DJD, while inflammatory and neoplastic conditions occur less frequently.

Furthermore, in this study, the cases presented to the DIC also exhibited a predominant representation of the Canine species, constituting a substantial amount of the total cases evaluated. This dominance was followed by the Equine species, then Feline and Ovine, and minor contributions from Avian species. Notably, the Bovine species accounted for the smallest proportion of the cases reviewed. The occurrence of Canine cases in the DIC can be related to profound bond and emotional

attachment that pet owners, both within the study area and globally, share with their canine companions. This deep connection often motivates pet owners to prioritize the well-being and healthcare needs of their canine companions, particularly concerning matters related to mobility and musculoskeletal health. Moreover, owners may exhibit a heightened vigilance and proactive approach towards seeking medical attention and diagnostic evaluations for their canine pets, thus contributing to the substantial representation of canine cases observed in the DIC in this part of the world. The prevailing cultural and societal norms of the community regarding the role of dogs as valued companions and integral members of the family unit further accentuate the significance placed on their health and welfare. Likewise, horses hold significant value, particularly due to the crucial role their limbs play in activities such as racing, polo matches, and traditional durbar events, which are especially common in Northern Nigeria, particularly in Zaria. These activities depend heavily on the optimal functioning of a horse's limbs for peak performance and overall success. Hence, any deviation from normal limb function or the presence of an injury is promptly evaluated and treated as such. At the DIC of ABUVTH, Zaria, where this study was conducted, X-ray imaging serves as the primary modality for assessing and diagnosing conditions affecting equine limbs. The relatively

low frequency of cats presented as companion animals for radiographic evaluation in the study area may be attributed to several factors, including the unique behavioral characteristics of cats. Cats are known for their ability to conceal signs of pain and discomfort more effectively than many other species, a trait that can pose challenges for owners in recognizing and interpreting indicators of underlying health issues and this was also reported by Roughan *et al.* in their study. Indeed, the subtlety of feline pain expression may contribute to a delay in seeking veterinary care for conditions necessitating radiographic imaging. Study by Merola *et al.* indicates that the recognition of behavioral cues associated with pain in cats may be influenced by the observer's familiarity with and understanding of feline behavior. They further revealed that only a limited number of signs are reliably linked to acute pain in cats, including panting, pupil dilation, and blepharospasm. However, no specific behavioral cues have been identified as indicative of chronic pain conditions in felines. The interplay between cats' natural tendency to mask pain and owners' ability to detect subtle changes in behavior proves the importance of education and awareness regarding feline health and well-being. Enhancing owner knowledge of potential signs of discomfort in cats, as well as promoting regular veterinary check-ups, may help facilitate earlier detection and intervention for underlying health issues. Other domestic animals, including

cattle, sheep, goats, and pigs, are occasionally presented to the ABUVTH, Zaria, for evaluation of hind limb conditions. However, it's noteworthy that such cases are relatively rare for radiographic examination. This scarcity of presentations can be attributed to various factors, one of which is the reluctance of owners to incur the costs associated with diagnostic examinations, especially in this part of the world. Often, owners of these animals may prioritize economic considerations over treatment expenses, opting instead to sell or salvage the animal rather than investing in diagnostic procedures and subsequent treatment like other animals (Abdulrahman *et al.*, 2011).

The distribution of cases based on age reveals a predominance of adult animals, accounting for approximately of the presentations, compared to young animals. This trend may stem from several underlying factors specific to the local context. For instance, in the case of dogs, older animals are mainly employed for hunting (Loder and Todhunter, 2017) and security purposes in this region of the world, thereby experiencing a higher frequency of injuries and musculoskeletal conditions. Whereas, younger animals may exhibit greater resilience than older animals and may recover more readily from minor fractures than older animals (Piermattei and Flo, 2015). Furthermore, fractures involving growth plates in young animals often resolve without permanent physical deformities (Robert, 1999), which also depend on the degree of bony

structure involvement and the nature of displacement. In other domestic animals, adult animal cases presentation can be attributed to their utilization for breeding purposes by farmers. Adult animals are typically retained for their reproductive potential, especially in ruminants and other food animals, which contribute to the overall economic value and productivity of livestock operations in the study area. This emphasis on breeding stock explains the significance of maintaining the health and mobility of adult animals, thereby ensuring sustained productivity and profitability within the agricultural sector. The proportion of female animals slightly exceeded that of male animals. Female animals are primarily retained for breeding, and owners capitalize on their reproductive potential to sustain and expand livestock populations. In contrast, male animals are often valued for their perceived prestige or security roles due to their potentially aggressive nature. This is highlighted in a study by Marshall *et al.* (2016), which revealed that pastoralists carefully select male breeding animals based on productivity, adaptability, and market value to optimize herd profitability. Similarly, female animals are typically culled due to poor performance, with broader family livelihood considerations playing a role in the decision-making process.

In addition, fractures predominantly affect the long bones of the pelvic limbs, making their assessment and anatomical localization critical

for accurate diagnosis, effective treatment planning, and reliable prognostic estimation, as emphasized by Uhl *et al.* in 2011. The prevalence of fractures can be partly attributed to husbandry practices and environmental factors that influence animal welfare (Temple and Manteca, 2020). In regions with weak regulatory oversight, animals are often managed under extensive systems, allowing them to roam freely. However, this increased mobility exposes them to significant risks, particularly traumatic injuries, with automobile accidents being a common cause of fractures in the study area, as reported by Kadima *et al.* in 2008. This finding also aligns with the earlier report by Abdulrahman's study in 2011, which highlighted the impact of environmental factors on musculoskeletal health and demonstrated that free-roaming animals are more susceptible to traffic-related injuries than those kept indoors (Abdulrahman *et al.*, 2011).

Radiographic analysis revealed distinct patterns in the positioning of animals during imaging procedures. Medio-lateral (Figure 3a) and ventro-dorsal views were the most commonly utilized positions at the study center. These positions likely provide optimal visualization of the pelvic limb anatomy and also an avoidance of superimposed positions on intended bony structures (Kenneth and Jihn, 2014), and to avoid minimal stress on both the animal and the handler, and this also largely depends on the anatomical consideration of the diagnosing

condition. In contrast, dorso-ventral views accounted for a great number of cases presented, potentially limiting the visibility of pelvic bone structures due to superimposition. Cranio-caudal views were also notably utilized for standing horses, which reflect their reliability in capturing accurate diagnostic images (Nowack and Schlickewei, 2013).

Fracture distribution patterns highlighted the vulnerability of specific pelvic regions to traumatic forces. Ilio-ischiatic and pubic fractures were the most presented. these regions are particularly susceptible to impact or collision, given their exposure during locomotion (Purra and Tripathi, 2011). Additionally, fractures involving the iliac wing and ilium emphasized the interconnection of adjacent pelvic structures, with injuries in one region often affecting adjacent anatomical sites (Johnston, 1997). Anatomical variations, such as differences in elasticity and maturation stages, contribute to the diverse mechanisms of fracture observed (Meghini *et al.*, 2023) on the long bones. Fractures of the femoral body (Figure 3b) and tibia are likely due to the prominent positioning of these bones within the pelvic limb. Whereas fractures involving the femoral head and luxation may result from dislodgment during collisions, which might be due to the vulnerability of these structures. At the same time, fractures of the fibula were the least common, possibly reflecting its relatively protected anatomical location.

The incidence rate of both fractures and bone and joint diseases at the study center accentuates the substantial burden of musculoskeletal conditions within the study population. Notably, bone and joint diseases are estimated to affect approximately 20% of the adult dog population, often resulting in significant clinical disability (13). While numerous studies have focused on fracture cases, our findings emphasize the need for more comprehensive research on non-fracture musculoskeletal conditions. Expanding epidemiological investigations into the incidence and prevalence of these diseases is crucial for developing effective therapeutic strategies to address the challenges posed by non-fracture cases in animals.

CONCLUSION

In conclusion, musculoskeletal conditions, particularly fractures, and joint diseases like hip dysplasia (HD) and osteoarthritis (OA), represent a significant challenge to animal health in the study area. Fractures, especially in the pelvic limb, were common, and joint diseases reinforced the importance of addressing these conditions. The high number of canine cases reflects the close bond between humans and dogs, while the low number of feline cases suggests a need for better owner education on cat health. Radiographic imaging remains crucial for accurate diagnosis and management, as over 32% of radiographies showed no pathology, demonstrating the limitations of clinical diagnoses alone. This study lays the groundwork for future research and provides valuable insights for veterinarians in both practice and academic settings. Further research is needed to explore non-fracture conditions and develop effective treatments for musculoskeletal diseases in animals.

AUTHOR'S CONTRIBUTIONS

ABH (email2hambali@gmail.com) assumes formal accountability for the integrity of the entire project. SAN and AA share equal responsibility for the conception, design, drafting, and revision of the manuscript. ML, MNB, EEG, MA, and RA provide overarching supervision, guidance, and corrections throughout the development of the main components of this work.

Technicians at the Department, whose dedication greatly contributed to the success of the study.

ETHICAL STATEMENT

This study was conducted at the Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine of Ahmadu Bello University, Zaria. Approval for the project was granted by the Ahmadu Bello University Ethical Committee on Animal Use and Care with the approval number ABUCAUC/2019/36. All ethical protocols related to medical records handling and confidentiality were observed throughout the study.

DATA AVAILABILITY

The datasets generated and analyzed are available and were submitted along with this manuscript.

REFERENCES

Abdulrahman M (2011). Retrospective studies of road traffic accidents in domestic animals reported at the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria. *Vet Clin Pract Bull*, 1(3): 13–17.

Adams OR, Stashak TS (2011). Adams and Stashak's lameness in horses. 6th ed. Wiley-Blackwell.

Alves J (2024, April 22). The prevalence and treatment of osteoarthritis in companion animals. Companion Animal Health. https://publications.companionanimalhealth.com/the-prevalence-and-treatment-of-osteoarthritis-in-companion-animals

Anderson KL, O'Neill DG, Brodbelt DC, Church DB, Meeson RL, Sargan D, Summers JF, Zulch H, Collins LM (2018). Prevalence, duration and risk factors for appendicular osteoarthritis in a UK dog population under primary veterinary care. *Sci Rep*, 8: 5641. https://doi.org/10.1038/s41598-018-23940-z

Azzolino D, Spolidoro GCI, Saporiti E, Luchetti C, Agostoni C, Cesari M (2021). Musculoskeletal changes across the lifespan: Nutrition and the life-course approach to prevention. *Front Med*, 8: 697954. https://doi.org/10.3389/fmed.2021.697954

Bhargav GN, Mahesh R, Mallikarjuna Rao CH, Suresh K, Devi Prasad V (2024). Incidence of femoral fractures in dogs. *Int J Vet Sci Anim Husb*, 9(6): 731–733. https://www.veterinarypaper.com/archives/2024/9/6/K/9-6-110

Brown DC, Boston RC, Farrar JT (2010). Use of an activity monitor to detect response to treatment in dogs with osteoarthritis. *J Am Vet Med Assoc*, 237(1): 66–70.

Caspers MK, Gier CJ, Reesink HL (2023). Equine non-septic tenosynovitis: A systematic literature review of site-specific pathological lesions, outcomes and surgical complications. *Equine Vet J. Advance online publication.* https://doi.org/10.1111/evj.14000

Chytas D, Piagkou M, Tsakotos G, Protogerou V, Demesticha T, Natsis K (2024). Methods and outcomes of teaching functional anatomy of the musculoskeletal system: A scoping review. *Morphologie*, 108(360): 100729. https://doi.org/10.1016/j.morpho.2023.100729

Clark N, Comerford E (2023). An update on mobility assessment of dogs with musculoskeletal disease. *J Small Anim Pract*, 64(10): 599–610. https://doi.org/10.1111/jsap.13650

Corr S (2012). Complex and open fractures: A straightforward approach to management in the cat. *J Feline Med Surg*, 14(1): 55–64. https://doi.org/10.1177/1098612X11432827

Davis AM, Fan X, Shen L, Robinson P, Riggs CM (2017). Improved radiological diagnosis of palmar osteochondral disease in Thoroughbred racehorses. *Equine Vet J*, 49(4): 454–460. https://doi.org/10.1111/evj.12636

Fox DB (2021). Physeal injuries and angular limb deformities. *Vet Clin North Am Small Anim Pract*, 51(2): 305–322. https://doi.org/10.1016/j.cvsm.2020.11.003

Garant RC, Tobalske BW, Ben Sassi N, van Staaveren N, Tulpan D, Widowski T, Powers DR, Harlander-Matauschek A (2023). Does wing use and disuse cause behavioural and musculoskeletal changes in domestic fowl (Gallus gallus domesticus)? *R Soc Open Sci*, 10(1): 220809. https://doi.org/10.1098/rsos.220809

Guadagni F (2023, September 30). Osteoarthritis in animals. Veterinary Rehabilitation Services of Virginia. https://www.rehab.vet/blog/osteoarthritis-in-animals

Hanlon GF (1982). A radiographic approach to bone neoplasm. *Vet Clin North Am Small Anim Pract*, 12(2): 239–248.

Hercock CA, Pinchbeck G, Giehda A, Clegg PD, Innes JF (2009). Validation of a client-based clinical metrology instrument for the evaluation of canine elbow osteoarthritis. *J Small Anim Pract*, 50: 266–271.

Hinterwimmer F, Serena RS, Wilhelm N, Breden S, Consalvo S, Seidl F, Juestel D, Burgkart RHH, Woertler K, von Eisenhart-Rothe R, Neumann J, Rueckert D (2024). Recommender-based bone tumour classification with radiographs: A link to the past. *Eur Radiol.* Advance online publication. https://doi.org/10.1007/s00330-024-10672-0

Jarecki J, Polkowska I, Kazimierczak W, Wójciak-Kosior M, Sowa I, Dresler S, Blicharski T (2023). Assessment of the impact of physical activity on the musculoskeletal system in early degenerative knee joint lesions in an animal

model. *Int J Mol Sci*, 24(4): 3540. https://doi.org/10.3390/ijms24043540

Jiménez-Heras M, Rovesti GL, Nocco G, Barilli M, Bogoni P, Salas-Herreros E, Armato M, Collivignarelli F, Vegni F, Rodríguez-Quiros J (2014). Evaluation of 68 cases of fracture stabilisation by external hybrid fixation and a hybrid construct classification proposal. *BMC Vet Res*, 10: 189. https://doi.org/10.1186/s12917-014-0189-4

Johnson JA, Austin C, Breur GJ (1994). Incidence of canine appendicular musculoskeletal disorders in 16 veterinary teaching hospitals from 1980 through 1989. *Vet Comp Orthop Traumatol*, 7: 56–69. https://doi.org/10.1055/s-0038-1633097

Johnston SA (1997). Osteoarthritis: Joint anatomy, physiology, and pathobiology. *Vet Clin North Am Small Anim Pract*, 27: 699–723.

Kadima KB, Kwanashie G, Bala U, Sambo K (2008). Pattern of traumatic injuries on domestic animals reported at the Veterinary Teaching Hospital from 1980 to 1989. *Vet Clin Pract Bull*, 1(1): 51–56.

Kenneth LB, John PL (2014). Radiographic positioning & related anatomy (8th ed., pp. 175–358). Mosby.

Kokila S, Dharmaceelan S, Kathirvel S, Balachandran P, Arivuchelvan A (2023). Incidence of metacarpal and metatarsal fractures in goats (2020–2023). *Indian J Vet Anim Sci Res*, 52(5): 119–122.

https://epubs.icar.org.in/index.php/IJVASR/article/view/146473

Lascelles BDX, Brown DC, Conzemius MG, Gill M, Oshinsky ML, Sharkey M (2022). The beneficial role of companion animals in translational pain research. *Front Pain Res*, 3: 1002204. https://doi.org/10.3389/fpain.2022.1002204

Kealy JK, McAllister H, Graham JP. (2011). Diagnostic radiology and ultrasonography of the dog and cat. DOI: 10.1016/C2009-0-46814-4.

Loder RT, Todhunter RJ (2017). The demographics of canine hip dysplasia in the United States and Canada. *J Vet Med,* 2017: 5723476.

https://doi.org/10.1155/2017/5723476

Loughridge AB, Hess AM, Parkin TD, Kawcak CE (2017). Qualitative assessment of bone density at the distal articulating surface of the third metacarpal in Thoroughbred racehorses. *Equine Vet J*, 49(2): 172–177. https://doi.org/10.1111/evj.12556

Marshall K, Mtimet N, Wanyoike F, Ndiwa N, Ghebremariam H, Mugunieri L, Costagli R (2016). Traditional livestock breeding practices of men and women Somali pastoralists: Trait preferences and selection of breeding animals. *J Anim Breed Genet*, 133: 534–547. https://doi.org/10.1111/jbg.12223

McGuire DB (1992). Comprehensive and multidimensional assessment and

measurement of pain. *J Pain Symptom Manage*, 7(5): 312–319. https://doi.org/10.1016/0885-3924(92)90064-O

Menghini TL, Shriwise G, Muir P (2023). Fracture healing in 37 dogs and cats with implant failure after surgery (2013–2018). *Animals* (Basel), 13(9): 1549. https://doi.org/10.3390/ani13091549

Merola I, Mills DS (2016). Behavioural signs of pain in cats: An expert consensus. *PLoS ONE*, 11(2): e0150040. https://doi.org/10.1371/journal.pone.01500 40

Morgan JP (1981). Techniques of veterinary radiographs. Veterinary Radiology Associates: 10–34.

Moses AO, Binhambali A, Victor OS, Babashani M, Felix US, Joseph OA (2025). Effects of age and circadian rhythm on vital parameters and erythrocyte osmotic fragility of donkeys during seasonal changes. *PLOS One*. doi:10.1371/journal.pone.0313780.

Netter F (2019). Atlas of human anatomy, 7th ed. Saunders.

Nowack K, Schlickewei W (2013). Beckenring: Injuries of the pelvis and apophysis in childhood and adolescence. *Unfallchirurg*, 116(12): 1069–1075. https://doi.org/10.1007/s00113-013-2461-7

O'Neill DG, Church DB, McGreevy PD, Thomson PC, Brodbelt DC (2014). Prevalence of disorders recorded in dogs attending primary-care veterinary practices in England. *PLOS ONE*, 9(3): e90501. https://doi.org/10.1371/journal.pone.00905 01

Pickering ME, Delay M, Morel V (2024). Chronic pain and bone-related pathologies: A narrative review. *J Pain Res*, 17: 2937–2947. https://doi.org/10.2147/JPR.S469229

Piermattei D, Flo GL (2015). Fractures of the femur and patella. In: Handbook of small animal orthopedics and fracture repair. 3rd ed. W.B. Saunders: 469–515.

Pura J, Tripathi A (2011). Incidence of fracture and its management in animals. *Sci Tech J*, pp. 54–56.

Ramos S, Pinto A, Cardoso M, Alexandre N, Bettencourt E, Monteiro S, Gama LT (2020). Prevalence of radiographic signs of osteoarthritis in Lusitano purebred horses. *J Equine Vet Sci*, 94: 103196. https://doi.org/10.1016/j.jevs.2020.103196

Robert B (1999). Disorders and injuries of the musculoskeletal system (3rd ed., pp. 505–508). Lippincott Williams & Wilkins.

Roitner M, Klever J, Reese S, Meyer-Lindenberg A (2024). Prevalence of osteoarthritis in the shoulder, elbow, hip and stifle joints of dogs older than 8 years. *Vet J*, 305: 106132. https://doi.org/10.1016/j.tvjl.2024.106132

Roughan JV, Flecknell PA (2003). Evaluation of a short duration behaviour-based postoperative pain scoring system in rats.

Eur J Pain, 7(5): 397–406. https://doi.org/10.1016/S1090-3801(03)00032-X

Saxer F, Hollinger A, Bjurström MF, Conaghan PG, Neogi T, Schieker M, Berenbaum F (2024). Pain-phenotyping in osteoarthritis: Current concepts, evidence, and considerations towards a comprehensive framework for assessment and treatment. *Osteoarthritis Cartilage Open,* 6(1): 100433. https://doi.org/10.1016/j.ocarto.2023.100433

Şengöz Şirin Ö, Şen Y, Özgermen B, Bumin A, Alkan Z (2020). Clinical and radiographic diagnosis of developmental orthopedic disease and bone lesions in Thoroughbred Arabian foals. *Dicle Univ J Fac Vet Med*, 13(2): 114–118. https://dergipark.org.tr/en/pub/duvetfd/issue/59112/794092

Shukunami C (2017). Integration of the musculoskeletal components by tendons and ligaments (in Japanese). *Clin Calcium*, 27(3): 367–373. PMID: 28232651.

Sindhu R, Velavan A, Pushkin Raj H, Mohamed Shafiuzama, Saran S (2023). Incidence of long bone fractures in birds: A retrospective study. I*nt J Vet Sci Anim Husb*, 8(6): 223–227. https://doi.org/10.22271/veterinary.2023.v8.i6d.841

Sriharsha GV, Kumaresan A, Kokila S, Arulmozhi A, Kathirvel S, Dharmaceelan S (2024). A retrospective study on the incidence of long bone fractures in dogs. I*nt J Vet Sci Anim Husb*, 9(5): 800–803. https://www.veterinarypaper.com/archives/2024/9/5/L/9-5-96

Sylvester AD, Lautzenheiser SG, Kramer PA (2021). A review of musculoskeletal modelling of human locomotion. *Interface Focus*, 11(4): 20200060. https://doi.org/10.1098/rsfs.2020.0060

Temple D, Manteca X (2020). Animal welfare in extensive production systems is still an area of concern. *Front Sustain Food Syst,* 4: 545902. https://doi.org/10.3389/fsufs.2020.545902

Thompson K, Moore S, Tang S, Wiet M, Purmessur D (2018). The chondrodystrophic dog: A clinically relevant intermediate-sized animal model for the study of intervertebral disc-associated spinal pain. *JOR Spine*, 1: e1011. https://doi.org/10.1002/jsp2.1011

Turek B, Borowska M, Jankowski K, Skierbiszewska K, Pawlikowski M, Jasiński T, Domino M (2024). A preliminary protocol of radiographic image processing for quantifying equine osteoarthritis in the field: A model of bone spavin. *Appl Sci*, 14(13): 5498. https://doi.org/10.3390/app14135498

Uhl M, Geiger J, Strohm PC (2011). Skeletal trauma during the growing period. *Radiology Diagnosis*, 51(8): 719–734.

Zhao Y, Zhang H, Li N, Li J, Zhang L (2022). Chronic pain after bone fracture: Molecular mechanisms and therapeutic strategies. *Brain Sci,* 12(8): 1056. https://doi.org/10.3390/brainsci12081056.