Journal of Sustainable Veterinary & Allied Sciences
P-ISSN-2695-2661 e-ISSN: 2811-1346
JoSVAS 2026 September Vol. 8 Issue 3: 260-268

Original Research Article

SURVEY AND POST-OPERATIVE RADIOGRAPHIC EVALUATION OF LONG BONE FRACTURES IN DOGS: A RETROSPECTIVE STUDY

[*1]BAPPAH, M.N., [1]BADA, A.A., [1]MUHAMMAD, S., [2]MANA, H.P., [1]LAWAL, M., [1]MUHAMMAD, A.Y., [1]ADAMU, M., [1]SANI, A.S. & [3]JOSHUA, U.

[1]Department of Veterinary Surgery and Radiology, Ahmadu Bello University, Zaria, Nigeria [2]Department of Veterinary Surgery and Radiology, University of Maiduguri, Maiduguri, Nigeria [3]Department of Veterinary Surgery and Radiology, Michael Okpara University of Agriculture, Umudike, Nigeria

**Correspondence:* mnbappah@abu.edu.ng; +2348039232275

ABSTRACT

Radiography is a crucial diagnostic technique for musculoskeletal diseases. This study was aimed to radiographically determine the incidence of long bone fractures and their post-operative evaluations in dogs presented to Veterinary Teaching Hospital, Ahmadu Bello University, Zaria from 2019 to 2024. A total of 135 radiographs of long bone defects were evaluated, out of which 105 were long bone fractures. The common long bone fractures observed were 63 transverse (60.00%), 27 oblique (25.71%), 10 comminuted (9.52%) and 5 Salter Harris fractures(4.76%). These fractures occurred in femur 41 (39.05%), tibia and fibula 40 (38.10%), radius and ulna 16 (15.23%), and humerus 8(7.62%). The management techniques observed were 60 open reduction(57.14%), and 45 closed reduction (42.86%).In open reduction techniques, there were 20.00% with grade 0 (excellent alignment), 38.33% with grade I (good alignment), 23.33% with grade II (fair alignment), and 18.33% with grade III (poor alignment), while in closed reduction techniques, there were 24.44% with grade 0 (excellent alignment), 28.89% with grade I (good alignment), 22.22% with grade II (fair alignment), and 24.44% with grade III (poor alignment). In conclusion, from this study, transverse fracture was the most common long bone fracture with femur being the most common long bone affected. The intramedullary pin was observed to be the most common open reduction technique, while external skeletal fixation was the most common closed reduction technique. In addition, intramedullary pining with cerclage wire offered excellent alignment in open reduction, while external skeletal fixation offered excellent alignment in closed reduction.

Keywords: canine, fracture alignment, fracture reduction, post-operative radiographs, survey radiographs

INTRODUCTION

Radiography is a crucial diagnostic technique for musculoskeletal diseases, and additional musculoskeletal information can be obtained using other imaging modalities such as computed tomography, nuclear medicine, magnetic resonance imaging, and contrast radiography (Burk & Feeney, 2003). Radiography is considered an effective imaging modality to evaluate bone and its lesions, assess bone management techniques and monitor bone healing processes (Clement *et al*., 2003; Morgan & Wolvekamp, 2004; Marcellin-Little, 2020; Abako*et al*., 2021; Dakhane *et al*., 2021; Meomartino *et al*., 2021).

Survey radiography is usually undertaken to diagnose any underlying conditions which can be validated by x-ray (Kinns *et al.*, 2006; Swaroop *et al.*, 2023) and in suspected fracture, it provides the type, exact anatomic location and nature of the fracture (Sande, 1999; Burk & Feeney, 2003; Sadan *et al*., 2015). Post-operative radiography of fractures provide immediate vital information of the management techniques such as the reduction, alignment and implant integrity, and subsequently provide information on healing

http://doi.org/10.54328/covm.josvas.2026.375

progress and complications (Burk & Feeney, 2003; Fang *et al*., 2009; Bada *et al*., 2017; Roa *et al*., 2017; Henry & Cole, 2018; Lovric *et al*., 2020; Aliyu *et al*., 2022).

Fractures are usually caused by forces that exceed the bone's tensile strength, which leads to its discontinuity (Tobias & Johnston, 2012; DeCamp *et al.*, 2016), and radiographically revealed as a radiolucent gap at the site of the fracture (Fathy *et al*., 2018; Purnomo *et al*., 2022; Weniger *et al*., 2024). Fractures are classified as Salter Harris, transverse, oblique, spiral, communited, greenstick, and fissure or hairline (Unger *et al*., 1990; Keosengthong *et al*., 2019; Abo-Soliman *et al*., 2020; Mohan *et al*., 2024). Long bones include humerus, radius and ulna, femur, and tibia and fibula (Harasen, 2003a; Abd El Raouf *et al*., 2019), which each are divided into epiphysis, physis, metaphysis, and diaphysis (Markel *et al*., 1994; Zachary and McGavin, 2012). Survey radiographic examinations assist in ascertaining the specific fracture type and the anatomic location of the fracture, necessary in the selection of tools and implants for management (Mohan *et al*., 2024).

Post-operative radiography reveals early signs of imminent complications such as limb angulation, limb shortening, and bone infection (Rovesti *et al*., 2009). Postoperative radiography could reveal failed internal fixations which may lead to reoperation due to non-union or implant failure. These may result to undesirable consequences promoting high post-operative morbidity and cost implications (Tihonen *et al.*, 2019). Therefore, there is need to emphasize the clinical relevance of survey and post-operative radiographic evaluation in orthopaedic management. This study was aimed to radiographically determine the incidence of long bones fractures and their post-operative assessment in dogs presented to the Veterinary Teaching Hospital, Ahmadu Bello University Zaria, from 2019 to 2024.

MATERIALS AND METHODS

STUDY DESIGN

A total of one hundred and thirty five (135) radiographs of long bone defects of dogs presented to the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria were evaluated for the study, out of which one hundred and five (105) were survey and post-operative radiographs of long bone fractures. Radiographs were selected based on being diagnostic enough and free from artefacts. They were evaluated for types of fractures, reduction techniques, alignment, and the integrity of the implants.

METHOD

Radiographs were interpreted in a systematic manner and maximum information were extracted from the entire radiographs. Anatomical landmarks of the limbs helped in the identification of the views that served as guide in their placement.

PLACEMENT OF THE RADIOGRAPHS ON THE VIEWING BOX

For craniocaudal view radiographs, the proximal aspects of the long bone were placed uppermost. For mediolateral view radiographs, the proximal aspect of the long bones was placed uppermost, while the cranial aspect of the long bones was placed towards the viewer left hand side.

INTERPRETATION OF THE RADIOGRAPHS

Survey radiographs were evaluated for radiolucent gap of bone discontinuity, the nature of the lesion, and the anatomic location of the abnormality on the long bones.

Post-operative radiographs were evaluated based on the reduction techniques. The alignment for each technique was evaluated considering Rovesti *et al*. (2009) method on a scale of grade 0 – III. Grade 0 (excellent alignment) represented radiograph with an almost equal parallel fracture segments without any angle of deviation less than 5º formed by the fracture segments; grade I(good alignment) represented radiograph in which there was angle of deviation from 5º - 10º formed by the fracture segments; grade II (fair alignment) represented radiograph in which there was angle of deviation from 10º - 30º formed by the fracture segments; grade III (poor alignment) represented radiograph in which there was angle of deviation above 30º formed by the fracture segments.

STATISTICAL ANALYSIS

The data obtained from this study was presented in Tables and Figures. Chi-square test was used to evaluate the distribution probability of the different types of long bone fractures. The Kruskal-Wallis and Mann-Whitney tests were used to evaluate variations in alignment grades of open and closed reduction techniques respectively.

RESULTS

FRACTURES OF LONG BONES IN DOGS

The long bone fractures evaluated were 63 transverse (60.00%), 27 oblique (25.71%), 10 comminuted (9.52%) and 5Salter Harris (4.76%) fractures as shown in Table I. These fractures occurred in41 femur (39.05%), 40 tibio-fibula (38.10%), 16 radius and ulna (15.24%), and 8 humerus (7.62%) as shown in Table II.

TABLE I: TYPES OF LONG BONE FRACTURES OBSERVED IN THIS STUDY

Fracture type	Occurrence (n)	Percentage (%)	P-value, Chi-square, degree of freedom
Transverse	63	60.00	*P*< 0.0001
Oblique	27	25.71	Chi-square =151.7
Comminuted	10	9.52	Df = 3
Salter Harris	5	4.76	
Total	105	100	

TABLE II: LONG BONES AFFECTED WITH FRACTURES IN THIS STUDY

Long bones	Frequency (n)	Percentage (%)	P-value, Chi-square, degree of freedom
Femur	41	39.05	*P*< 0.0001
Tibia and fibula	40	38.10	Chi-square =49.2
Radius and Ulna	16	15.23	Df = 3
Humerus	8	7.62	
Total	105	100	

FRACTURE REDUCTION TECHNIQUES OF LONG BONES FRACTURE IN DOGS

The fracture reduction techniques observed were 60 open reductions (57.14%) and 45 closed reduction (42.86%) management techniques. The open reduction techniques included3 bone plating and screw (5.00%) (Figure I), 37 intramedullary pining (61.67%)(Figure II), 19 intramedullary pining with cerclage wire (31.67%) (Figure III), and 1 screws (1.67%). The closed reduction techniques included11 external coaptation (24.44%) (Figure IV), and 34 external skeletal fixation (ESF) (75.56%) (Figure V).

Figure I: Medio-lateral view of oblique femoral fracture of a dog managed with bone plate and screws showing grade III (poor) alignment.

Figure II: A-Medio-lateral view of transverse femoral fracture in a dog managed with IM pin showing grade I (good) alignment and B-Medio-lateral view of Salter Harris type I fracture of distal tibia in a dog managed with IM pin and external coaptation showing grade 0 (excellent) alignments

Figure III: Medio-lateral view of tibio-fibula fracture managed with IM pin and cerclage wire demonstrating grade 0 (excellent) alignment

Figure IV: A-Medio-lateral view of transverse tibio-fibula fracture in a dog, managed with cast (external coaptation) demonstrating grade III (poor) alignment. B-Medio-lateral view of oblique fracture of tibia in a dog, managed with external coaptation demonstrating grade II (fair) alignment

ALIGNMENT OF FRACTURE

The assessments of fracture alignment in this study were classified as excellent, good, fair, and poor. In open reduction techniques, there were 20.00% with grade 0 (excellent alignment), 38.33% with grade I (good alignment), 23.33% with grade II (fair alignment), and 18.33% with grade III (poor alignment).

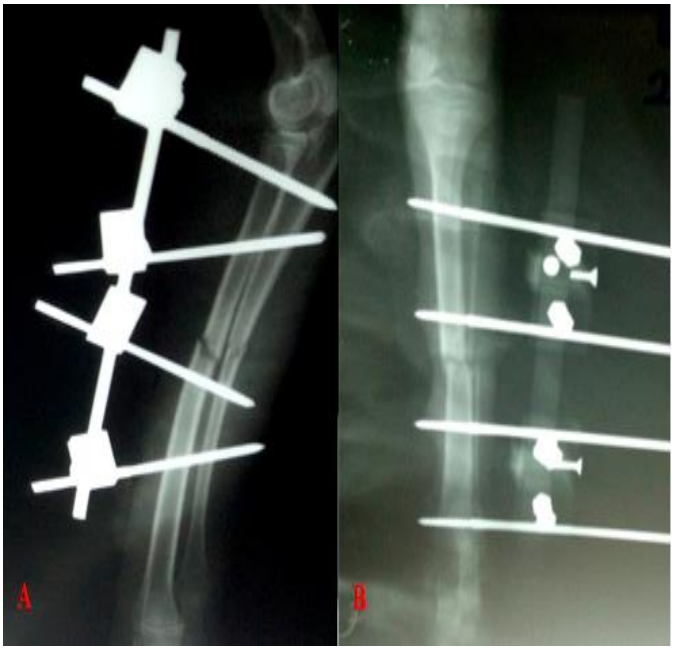

Fig V: A Medio-lateral view of radio-ulna transverse fracture in a dog, managed with ESF showing grade 0 (excellent) alignment and B-Cranio-caudal view of transverse fracture of tibio-fibula managed with ESF demonstrating grade II (fair) alignment

Intramedullary pining with cerclage wire (Figure III) had the highest excellent alignment in open reduction fracture management as summarized in Table III. While in closed reduction techniques, there were 24.44% with grade 0 (excellent alignment), 28.89% with grade I (good alignment), 22.22% with grade II (fair alignment), and 24.44% with grade III (poor alignment). External skeletal fixative (Figure V) had the highest excellent alignment in closed reduction fracture management as summarized in Table IV.

The Chi-square test revealed significant relationship between occurrence of fractures and types of fractures in Table I, and also significant relationship between frequency of fractures and long bones in Table II. The Kruskal-Wallis test revealed significant difference of alignment grades on open reduction techniques, $P = 0.0039$ in Table III. The Mann-Whitney test revealed non-significant difference of alignment grades on closed reduction techniques, $P > 0.05$ in Table IV.

TABLE III: EVALUATION OF ALIGNMENT IN VARIOUS OPEN REDUCTIONS FRACTURE MANAGEMEN

Grades	**Grade 0 (Excellent)**	**Grade I (Good)**	**Grade II (Fair)**	**Grade III (Poor)**	**Total**
Bone Plate And Screw	0	1	0	2	3
Intramedullary Pin	5	13	11	8	37
Intramedullary Pin & Cerclage wire	6	9	3	1	19
Screws	1	0	0	0	1
Total	12	23	14	11	60

TABLE IV: EVALUATION OF ALIGNMENT IN CLOSED REDUCTION FRACTURE MANAGEMENT

Grades	**Grade 0 (Excellent)**	Grade I (Good)	Grade II (Fair)	Grade III (Poor)	Total
External Coaptation	2	2	5	2	11
External Skeletal Fixative	9	11	5	9	34
Total	11	13	10	11	45

DISCUSSION

The most frequent fracture type observed in this study was transverse fracture. This finding agreed with Rani *et al.* (2004), Sran *et al.* (2016), Jain *et al.* (2018), Bidari *et al.* (2023), Kartik *et al.* (2023) and Sriharsha *et al.* (2024). This could be due to the preponderance of bending or compression forces as the cause of transverse fracture (Smith, 1985; Bidari *et al.*, 2023), which may be in form of falling or blunt hitting which is accustomed in free roaming dogs as majorly observed in Zaria. The most frequent long bone affected in this study was the femur. Similarly, Phillips (1979), Harasen (2003), Beale (2004), Elzomor *et al.* (2014), Eyarefe & Oyetayo (2016), Abo-Soliman *et al.* (2020), Kumar *et al.* (2020) and Gaddam (2024) reported femur to have the highest fracture occurrence in dogs. This could be due to the escape reflex in dogs during which they trust the forelimbs first, exposing the hindlimbs to the main impact of the trauma (Jain *et al.*, 2018), which could likely produce a less life-threatening injury (Harasen, 2003b).

The higher percentage of open reduction management techniques in this study could be attributed to the fact that it involves adequate apposition of fracture fragments and rigid bone implant fixations which produce early return to function of the fractured limb (Dudley *et al.*, 1997). In addition, anatomic site of the fracture with massive muscle swelling and nature of the fracture also suggest the higher preference in open reduction (Kumar *et al.*, 2018). However, closed reduction management techniques also have advantages such as minimal soft tissue trauma and reduced risk of infection at the site of the fracture (Rossello *et al.*, 2022). Intramedullary pinning was the most common open reduction technique in this study. A similar finding was reported by Tercanliogu & Sarierler (2009) and Budsberg (2010); this could be due to the fact that intramedullary pinning is an economical and efficient method that provides good stability with minimal complications as stated by Asma (2013). It supports the periosteal blood supply, reducing operating time by half (Daglar *et al.*, 2007). The ESF had the highest occurrence among closed reduction in this study. This was supported by Yoon *et al.* (2018), who reported that this provides lack of micro motion at the fracture site, and rigid fixation that favoured a more accelerated healing rate. However, ESF is not restricted to close reduction, as it can be employed in open reduction or minimal open reduction, especially in fractures involving the humerus or femur (Yardimci *et al.*, 2011; Yardimci *et al.*, 2018).

Combination of intramedullary pin and cerclage wire had the highest excellent alignment among the open reduction techniques. This finding was observed in Boudrieau & Sinibaldi (1992), Van der Zee (2014), Palmer (2020), and Adhikari *et al*. (2024).

This finding suggests that it is an affordable and simple fracture repair technique that is considered as the common fracture repair fixation method in oblique fracture (Palmer, 2020).While, external skeletal fixation had the highest excellent alignment among closed reduction techniques. This finding was reported by Piermattei *et al*. (2006), Roa *et al*. (2016) and Bada *et al*. (2018). The reason for this finding could be attributed to the main concept of closed reduction and external fixation, it is an easy biomechanical technique (Fossum, 2013; Radasch, 2014; Roa *et al*., 2016) that helps in stabilizing fracture segments and offering excellent alignment (Johnson *et al*., 1996; Dudley *et al*., 1997) with less soft tissue damage and enhance blood supply (Langley-Hobbs, 2014). In addition, it promotes early limb amputation (Ozsoy & Altunatmaz, 2003; Yardimci *et al*., 2018; Harshitha *et al*., 2023).

CONCLUSION

This study demonstrated that transverse fractures were the predominant long-bone fracture pattern in dogs, accounting for 60.0% of all cases, while the femur and tibia/fibula were the most frequently affected bones. Open reduction was the most commonly employed fracture management technique, with intramedullary pinning representing the principal method of stabilization. Among the open reduction procedures, intramedullary pinning combined with cerclage wire achieved the highest proportion of excellent fracture alignment and showed significantly better alignment outcomes compared with other open reduction techniques. In closed reduction management, external skeletal fixation produced the greatest number of excellent alignments and outperformed external coaptation in maintaining satisfactory fracture reduction. These findings indicate that the choice of fracture reduction and fixation technique substantially influence post-reduction alignment. Intramedullary pinning with cerclage wire appears to be a particularly effective option for open reduction of canine long-bone fractures, while external skeletal fixation remains a valuable minimally invasive alternative for closed reduction. These results provide important clinical evidence to guide treatment selection and optimize fracture management outcomes in dogs.

ACKNOWLEDGEMENT

Appreciation to the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria for the support.

CONFLICT OF INTEREST

There is no conflict of interest in regards to this manuscript

REFERENCES

Abako, J., Holak, P., Głodek, J. & Zhalniarovich, Y. (2021). Usefulness of imaging techniques in the diagnosis of selected injuries and lesions of the canine tarsus. A Review. *Animals*, 11(6), 1834.

Abd ElRaouf, M., Ezzeldein, S. A. & Eisa, E. F. M. (2019). Bone fractures in dogs: A retrospective study of 129 dogs. *Iraqi Journal of Veterinary Sciences*, 33(2), 401-405.

Abo-Soliman, A. A. M., Ahmed, A. E. & Farghali, H. A. M. A. (2020). Incidence of appendicular bone fracture in dogs and cats: retrospective study at Veterinary Hospital of Cairo University and some private clinics in Egypt. *World's Veterinary Journal*, 10(4), 638-652.

Adhikari, K., Poudel, S. & Shah, M.K. (2024). Management of femur fracture using simple intramedullary steinmann pin and orthopaedic cerclage wire in a dog. Veterinary Science: *Research and Reviews*, 10(2), 88-97.

Aliyu, B. S., Hassan, A. Z., Ochube, G. E., Umar, B. N., Lawal, M. & Ibrahim, A. S. (2022). Clinical and radiographic evaluations of healing femoral fractures managed with conventional and novel allo-cadaveric bone plates in dogs. *Sokoto Journal of Veterinary Sciences*, 20(5), 123-133.

Bada, A. A., Hassan, A. Z., Awasum, C. A., Emmanuel, E. G., Bappah, M. N., Lawal, M. & Ochube, G. E. (2017). Comparative evaluation of pin-in-fiberglass cast and Kirschner-Ehmer external fixative in the management of radius-ulna fractures in dogs. *Sokoto Journal of Veterinary Sciences*, 15(4), 36. https://doi.org/10.4314/sokjvs.v1

Bada, A. A., Ochube, G. E, Emmanuel, E. G., Oyenekan, I. O., Bappah, M. N., Muhammad, S. T., Lawal, M., Sani, M. A. & Hassan, A. Z. (2018). Management of a closed oblique humeral fracture using type I monopolar external skeletal fixator with limited open approach in a Nigerian indigenous puppy. *Veterinary Clinical Practice Journal*, 4(1), 1-7.

Beale, B. (2004). Techniques for the management of long bone fractures: Orthopaedic Clinical techniques femur fracture repair. *Clinical Techniques in Small Animal Practice*, 19(3), 134-150.

Bidari, K., Jahangirbasha, D., Dilipkumr, D. & Bhagavantappa, B. (2023). Incidence of long bone fractures in dogs a retrospective study (2016–2021). *The Pharma Innovation Journal*, 12(6), 531-534.

Boudrieau, R. J. & Sinibaldi, K. R. (1992, February). Principles of long bone fracture management. In *Seminars in Veterinary Medicine and Surgery (Small Animal)*, 7(1), 44-62.

Budsberg, S.C. (2010). Overview of methods of fracture fixation (Proceedings). *DVM360 Conference*. Retrieved. from https://www.dvm360.com/view/overview-methods-fracture-fixation-proceedings?utm_source=chatgpt.com

Clements, D. N., Gemmill, T., Corr, S. A., Bennett, D. & Carmichael, S. (2003). Fracture of the proximal tibial epiphysis and tuberosity in 10 dogs. *Journal of Small Animal Practice*, 44(8), 355-358.

Dakhane, P. S., Lokhande, D. U., Khandekar, G. S., Yadav, G. U., Tripathi, S. D., Ingole, S. D. & Kadam, D. P. (2021). Radiographic evaluation of long bone fractures by using antibiotic loaded bone cement (ALBC) and biosynthetic bone graft in dogs. *International Journal of Current Microbiology and Applied Sciences*, 10(5), 489-501.

DeCamp, C. E., Johnston, S. A., Déjardin, L. M. & Schaefer, S. L. (2016). *Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopaedics and Fracture Repair* (5th Ed.).Elsevier; St. Louis, Missouri.

Dudley, M., Johnson, A. L., Olmstead, M., Smith, C. W., Schaeffer, D. J. & Abbuehl, U. (1997). Open reduction and bone plate stabilization, compared with closed reduction and external fixation, for treatment of comminuted tibial fractures: 47 cases (1980–1995) in dogs. *Journal of the American Veterinary Medical Association*, 211(8), 1008-1012.

Elzomor, S. T., Sheta, E. M. E., Farghali, H. A. & Ashour, A. E. (2014). Prevalence of femoral fractures in dogs and cats. *Journal of the Egyptian Veterinary Medical Association*, 74(2), 269-278.

Eyarefe, O. D. & Oyetayo, S. N. (2016).Prevalence and pattern of small animal orthopaedic conditions at the Veterinary Teaching Hospital, University of Ibadan. *Sokoto Journal of Veterinary Sciences*, 14(2), 8-15.

Fang, D. M., Ritter, M. A. & Davis, K. E. (2009). Coronal alignment in total knee arthroplasty. *Journal of Arthroplasty*, 24(6), 39–43. doi:10.1016/j.arth.2009.04.034.

Fathy, M. Z., Ragab, G. H., Seif, M. M., Gadallah, S. M., Deeb, S. & Safwat, N. M. (2018). Clinico-radiographic and histopathologic evaluation of iliac shaft fracture in dogs (An experimental study). *Beni-Suef University Journal of Basic and Applied Sciences*, 7(2), 165-170.

Fossum, T.W. (2013). *Small Animal Surgery* (4th edn., pp. 930-931). Mosby Elsevier, Missouri USA.

Gaddam, V. (2024). The possible risk factors for bone fractures in animals and management of pre and postoperative pain. *Journal of Skeleton System*, 3(1). DOI: 10.58489/2836-2284/009.

Harasen, G. (2003a). Common long bone fracture in small animal practice—Part 2. *The Canadian Veterinary Journal*, 44(6), 503.

Harasen, G. (2003b). Common long bone fractures in small animal practice—part 1. *The Canadian Veterinary Journal*, 44(4), 333-334.

Harshitha, G., Nagaraja, B.N., Suresh, L., Nagaraju, N. & Ansar Kamran, C. (2023). Management of radius-ulna fractures with modified type II external skeletal fixation in dogs. *The Pharma Innovation Journal*, 12(2), 1052-1056.

Henry, G.A. & Cole, R. (2018).Fracture healing and complications in dogs. In: Thrall, D.E. (Ed.) *Textbook of Veterinary Diagnostic Radiology* (7thEdn. pp. 366-387). Elsevier; USA.

Jain, R., Shukla, B.P., Nema, S., Shukla, S., Chabra, D. & Karmore, S.K. (2018). Incidence of fracture in dog: a retrospective study. *Veterinary Practitioner*, 19(1), 63-65.

Johnson, A. L., Seitz, S. E., Smith, C. W., Johnson, J. M. & Schaeffer, D. J. (1996). Closed reduction and type-II external fixation of comminuted fractures of the radius and tibia in dogs: 23 cases (1990–1994). *Journal of the American Veterinary Medical Association*, 209(8), 1445-1448.

Keosengthong, A., Kampa, N., Jitpean, S., Seesupa, S., Kunkitti, P. & Hoisang, S. (2019). Incidence and classification of bone fracture in dogs and cats: a retrospective study at veterinary teaching hospital, Khon Kaen University, Thailand (2013-2016). *Veterinary Integrative Sciences*, 17(2), 127-139.

Kinns, J., Mai, W., Seiler, G., Zwingenberger, A., Johnson, V., Caceres, A., Valdes-Martinez, A. & Schwarz, T. (2006).Radiographic sensitivity and negative predictive value for acute canine spinal trauma. *Veterinary Radiology and Ultrasound*, 47(6), 563–570.

Kumar, V., Lalzawmliana, V., Mukherjee, P. & Nandi, S. K. (2018). Surgical management of distal diaphyseal fracture in radius and ulna using t-plate in whippet dog. *Indian Journal of Animal Health*, 57(1), 121-124.

Kumar, B. B., Sharma, A. K., Reetu, P. K., Kumar, C. & Kumar, R. (2020). Study on incidence of fractures with respect to breed, age, sex, type and location of fractures and bone involved. *Journal of Entomology and Zoology Studies*, 8(2), 21-24.

Langley-Hobbs, S. (2003).Biology and Radiological Assessment of Fracture Healing. *In Practice*, 25, 26-35.

Lovrić, L., Kreszinger, M. & Pećin, M. (2020).Surgical Treatment of Canine Femoral Fractures–A Review. *World's Veterinary Journal*, 10(2), 137-145.

Marcellin-Little, D. (2020). The orthopedic examination in dogs: a fast and effective tool. In: *138th Annual Convention of the Illinois State Veterinary Medical Association (ISVMA). https://www.isvma.org/wpcontent/uploads/2020/10/TheOthropedicExaminationinDogsAFastandEffectiveTool.pdf*.Retrieved on 10/01/2025.

Markel, M. D., Sielman, E., Rapoff, A. J. & Kohles, S. S. (1994). Mechanical properties of long bones in dogs. *American Journal of Veterinary Research*, 55(8), 1178-1183.

Meomartino, L., Greco, A., Di Giancamillo, M., Brunetti, A. & Gnudi, G. (2021).Imaging techniques in veterinary medicine. Part I: radiography and ultrasonography. *European Journal of Radiology Open*, 8, 100382.

Mohan, A., Mahesh, V., Manjunatha, K., Murthy, M. S. K. & Nagaraja, B. N. (2024). Studies on management of radius fractures in dogs using point contact fixator plate system (PC-FIX). *International Journal of Veterinary Sciences and Animal Husbandry*, 9(5), 256-262.

Morgan, J. P. & Wolvekamp, P. (2004). *Atlas of Radiology of Traumatized Dog and Cat*, (2nd edn.) Schluterche, Hannover.

Özsoy, S. & Altunatmaz, K. (2003). Treatment of extremity fractures in dogs using external fixators with closed reduction and limited open approach. *Veterinárí Medicína*, 48(5), 133.

Palmer, R. H. (2020). How to fix a femur fracture with IM pin and cerclage wire: step by step. *Small Animal: Orthopedics*. Retrieved from https://www.cabidigitallibrary.org/doi/pdf/10.5555/20210293711

Phillips, I. R. (1979). A survey of bone fractures in the dog and cat. *Journal of Small Animal Practice*, 20(11), 661–674.

Piermattei, D., Flo, G. & DeCamp, C. (2006). *Handbook of Small Animal Orthopedics and Fracture Repair* (4th edn., pp. 49-94). Elsevier Inc., Missouri USA.

Purnomo, A., Budhi, S., Adji, D., Anggraeni, D., Anggoro, D., Widyarini, S., Chhetri, S. & Purnama, M. T. E. (2022).Radiographic and Histological Evaluation in Canine Femur after Implantation of 304 Stainless-steel-based Plate. *Pharmacognosy Journal*, 14(4), 388-392.

Radasch, R. M., Lewis, D. F., McDonald, D. E., Calfee, E. F. & Barstad, R. D. (2008). Pesvarus correction in dachshunds using a hybrid external fixation. *Veterinary Surgery*, 37(1), 71-81.

Rani, U. R., Vairavaswamy, T. & Kathiresan, D. (2004). A retrospective study on bone fractures in canines. *Indian Veterinary Journal*, 81, 1048-1050.

Rao, J. R., Kumar, V. G., Rao, T. M., Kumar, D. P., Reddy, K. C. S. & Raghavender, K. B. P. (2016). Use of hybrid external fixation technique in the repair of long bone fractures in dogs. *International Journal of Current Microbiology and Applied Sciences*, 5(11), 579-586.

Rao, J. R., Kumar, V. G., Rao, T. M., Kumar, D. P., Reddy, K. C. & Raghavender, K. B. P. (2017). Use of tie-in configuration technique in the repair of femoral and humeral diaphyseal fractures in dogs. *International Journal of Advance Research*, 5(7), 436-442.

Rosselló, G. C., Carmel, J., Pead, M., Lacosta, V. V. & Lafuente, P. (2022).Comparison of post-operative outcomes after open or closed surgical techniques to stabilize metacarpal and metatarsal fractures in dogs and cats. *BMC Veterinary Research*, 18(1), 300.

Rovesti, G. L., Schwarz, G. & Bogoni, P. (2009). Treatment of 30 angular limb deformities of the antebrachium and the crus in the dog using circular external fixators. *The Open Veterinary Science Journal*, *3*(1), 41-54.

Sadan, M. A., Amort, K. & Kramer, M. (2015). Imaging of acetabular fractures in 14 dogs: a comparison of plain radiography and CT scan. *Indian Journal of Veterinary Surgery*, 36(1), 37-40.

Sande, R. (1999). Radiography of orthopedic trauma and fracture repair. *Veterinary Clinics of North America: Small Animal Practice*, 29(5), 1247–1260. doi:10.1016/s0195-5616(99)50112-5.

Sran, T.K., Singh, S.S., Mohindroo, J. & Saini, N.S. (2016). Frequency of long bone fractures in dogs: A retrospective study. *Indian Journal of Veterinary Surgery*, 37(1), 1-5.

Sriharsha, G. V., Kumaresan, A., Kokila, S., Arulmozhi, A., Kathirvel, S. & Dharmaceelan, S. (2024). A retrospective study on the incidence of long bone fractures in dogs. *International Journal of Veterinary Science and Animal Husbandary*, 9(5), 800-803.

Swaroop, G. L., Dilipkumar, D., Bhagavantappa, B., Venkatgiri, M. P. & Bijurkar, R. J. (2023). Incidence of long bone fractures in dogs: a retrospective study. *Pharma Innovation Journal*, 12(10), 743-745.

Tercanliogu, H. & Sarierler, M. (2009).Femur fractures and treatment options in dogs which brought our clinics. *Lucrari Stiiniiifice Medicina Veterinaria*, 42(2), 98-101.

Tiihonen, R., Alaranta, R., Helkamaa, T., Nurmi-Lüthje, I., Kaukonen, J. P. & Lüthje, P. (2019). A 10-Year retrospective study of 490 hip fracture patients: Reoperations, direct medical costs, and survival. *Scandvian Journal of Surgery*, 108, 178–184.

Tobias, K. M. & Johnston, S. A. (2012). *Veterinary Surgery*: *Small Animal* (pp. 568-1182). Elsevier: St. Louis, Mo.

Unger, M., Montavon, P. M. & Heim, U. F. A. (1990). Classification of fractures of long bones in the dog and cat: introduction and clinical application. *Veterinary and Comparative Orthopaedics and Traumatology*, 3(02), 41–50. doi:10.1055/s-0038-1633228.

Van der Zee, J. (2014). In vitro biomechanical comparison of the effects of cerclage wires, an intramedullary pin and the combination there of on an oblique osteotomy of the canine tibia. *Veterinary and Comparative Orthopaedics and Traumatology*, 27(2), 91-96.

Weniger, M. B. H., Feichtenschlager, C., Linde, N. & Peppler, C. (2024). Long-term outcome of a canine longitudinal patellar fracture treated with lag screw and pin. *Veterinary Record Case Reports*, e1028.

Yardımcı, C., Önyay, T., İnal, K., Ozbakir, B. & Özak, A. (2018). Management of humeral fractures in dogs by using semicircular external fixator and intramedullary pin tie-in combination. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, 24(2), 295-300. DOI: 10.9775/kvfd.2017.18870.

Yardimci, C., Ozak, A. & Nisbet, H. O. (2011).Management of femoral fractures in dogs with unilateral semicircular external skeletal fixators. *Veterinary Surgery*, 40(3), 379-387.

Zachary, J. F. & McGavin, M. D. (2012). *Pathologic Basis of Veterinary Disease*, (5th edn.). Elsevier, St. Louis, Mo.