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A clinical study of configuration of long bone fractures in dogs: A review of 154 cases

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Abstract

The present study was conducted on 154 long bone fractures in dogs presented to the Veterinary Clinical Complex, NTR College of Veterinary Science, Gannavaram, from January 2025 to December 2025. Detailed history and signalment were recorded. Fractures were evaluated by clinical and radiographic examination and classified according to the Association for Osteosynthesis (AO) /Association for the Study of Internal Fixation (ASIF) classification system. The diaphyseal fractures were further classified using Winquist-Hansen classification. This study highlights the usefulness of standardized classification systems in evaluating canine long bone fractures.

Keywords: Long bone fractures, dogs, AO/ASIF classification, diaphyseal, Winquist-Hansen classification.

Introduction

Fractures of long bones represent a common and significant concern in small animal practice, particularly in dogs. The increasing occurrence of high-energy trauma, in which there is considerable dissipation of kinetic energy, has led to fractures that are increasingly severe and difficult to treat (Bishnoi *et al.*, 2013) ^[1]. A standardized description of a fracture is important, as it directs the orthopedic surgeon towards careful classification, thereby facilitating the selection of appropriate methods of reduction, fixation and immobilization (Abo-Soliman *et al.*, 2020) ^[2]. Fracture classification forms the basis for selection and prognosis of the most appropriate treatment regimen and also aids in comparative orthopaedic and retrospective studies of fracture treatment (Unger *et al.*, 1990) ^[3]. Establishing appropriate treatment for complex fractures requires adequate pre-operative planning and accurate interpretation of fracture classification. The classification system should be simple, reproducible, provide prognostic information and guide treatment selection (Bishnoi *et al.*, 2013) ^[1]. The AO/ASIF classification system for long bone fractures in humans has been adapted for use in small animals with minor modifications (Messmer and Montavon, 2004) ^[4].

AO/ASIF classification is a comprehensive, alpha-numeric system used in orthopedics to categorize fractures based on their anatomical location, morphology and severity. This system allows grading of fractures based on increasing severity and complexity across different anatomical locations and provides valuable prognostic and therapeutic information, being simple to apply and capable of generating reliable clinical data (Unger *et al.*, 1990) ^[3]. The Winquist and Hansen (WH) classification is widely used to categorize diaphyseal fractures based on the extent of comminution (Winquist and Hansen, 1980) ^[5].

The present study highlights the importance of standardized classification systems in the systematic evaluation of long bone fractures in dogs and aid in better understanding of fracture patterns and their characteristics.

Materials and Methods

The present study included 154 cases of long bone fractures in dogs presented to the Veterinary Clinical Complex and Department of Veterinary Surgery and Radiology, NTR College of Veterinary Science, Gannavaram, during the period from January 2025 to

December 2025. Detailed history and signalment of all cases were recorded. The affected limbs were radiographed in standard orthogonal views i.e, craniocaudal and mediolateral projections, to determine the fracture location and configuration. These radiographic findings aided in confirming the type of fracture and helped in pre-operative planning, including selection of appropriate implants. All the fractures were classified using the AO/ASIF classification system based on anatomical location and fracture morphology. Among these, 131 diaphyseal fractures were further classified according to the Winkquist-Hansen classification system based on the degree of comminution.

According to the AO/ASIF classification system, fractures were described using an alphanumeric code indicating the bone involved, fracture location, morphology and severity. In this system, the first digit represented the bone (1-humerus, 2-radius-ulna, 3-femur and 4-tibia-fibula), while the second digit indicated the location of the fracture within the bone (1-proximal, 2-diaphyseal and 3-distal). Diaphyseal fractures of the humerus, femur, and tibia-fibula were grouped as Type A (simple: A1 spiral, A2 oblique, A3 transverse), Type B (wedge: B1 spiral wedge, B2 bending wedge, B3 fragmented wedge), and Type C (complex: C1 spiral, C2 segmental, C3 irregular). Diaphyseal fractures of the radius-ulna were classified based on bone involvement, with Type A including (Simple fracture of: ulna A1, radius A2, or both bones A3), Type B including (wedge fractures of : ulna B1, radius B2, wedge fracture of one bone and simple or wedge of other B3) and Type C including (complex fractures : ulna C1, radius C2, both radius and ulna C3). The same classification principles were extended to fractures of the proximal and distal segments, with specific modifications for certain anatomical regions. Fractures of segments 13, 33, 21, 41, 23 and 43 were classified based on their relation to the joint surface as Type A (extra-articular), Type B (partial articular) and Type C (complete articular). In certain anatomical regions, additional distinctions were made. For the proximal humerus (11), fractures were grouped as extra-articular unifocal (Type A), extra-articular bifocal (Type B) and articular (Type C). In the proximal femur (31), Type A included trochanteric fractures, Type B neck fractures and Type C head fractures.

Diaphyseal fractures were further classified according to the Winkquist-Hansen classification system based on the degree of comminution. In this classification, fractures were graded from Grade 0 to Grade V, where Grade 0 indicated no comminution with a two-piece fracture, Grade I represented the presence of a small unimportant bone fragment, Grade II indicated greater than 50% contact between the major proximal and distal fracture fragments, Grade III showed less than 50% contact between the fragments, Grade IV denoted absence of contact between the major fracture fragments, and Grade V represented segmental fractures with no contact between the proximal and distal fragments.

Results and Discussion

The common symptoms observed in the patients of the current study included non-weight bearing lameness on affected limb, abnormal angulation at the fracture site, oedema, crepitation at the site of fracture and pain on palpation.

In the present study, fractures were systematically categorized using the AO/ASIF classification system described by Muller *et al.* (1990) [6], with alphanumeric coding to denote their anatomical location and morphological characteristics, as

adopted in previous studies by Unger *et al.* (1990) [3], Raghunath *et al.* (2007) [7] and Gaddam *et al.* (2022) [8].

Among the 154 long bone fractures, the highest incidence was observed in the femur (n=72, 46.75%), followed by tibia and fibula (n=33, 21.43%), radius and ulna (n=31, 20.13%), and humerus (n=18, 11.69%).

According to the AO/ASIF classification, among the 154 long bone fractures recorded in the present study, the highest number of fractures were diaphyseal simple fractures of radius and ulna (22A3) recorded in 16.23% (n=25), followed by diaphyseal simple oblique fractures of femur (32A2) in 15.58% of cases (n=24) and diaphyseal simple transverse fractures of femur (32A3) in 12.99% of cases (n=20). Although femur was the most frequently affected bone overall, the highest frequency of a specific fracture type was observed in radius and ulna (22A3). This may be attributed to the relatively uniform fracture configuration occurring in radius-ulna, whereas fractures in the femur exhibited greater variation in type and pattern. Similar findings were reported by Kallianpur *et al.* (2018) [9], who, using Unger's classification system, observed that distal zone diaphyseal radius-ulna fractures (22A2) were most frequently encountered, despite higher involvement of femur. However, Raghunath *et al.* (2007) [7], using the AO/ASIF classification system, reported diaphyseal transverse fractures (32A3) as the most prevalent type, followed by diaphyseal oblique fractures (32A2), indicating variation in fracture patterns among different studies. These differences may be attributed to variation in sample size, study population and the nature of traumatic forces involved.

Among 72 femoral fractures, simple diaphyseal fractures (32A) were recorded highest in (n=45), 62.49% of cases, followed by distal extra-articular fractures (33A) in 16.67% of cases. Diaphyseal complex (32C) and wedge fractures (32B) were recorded in 8.34% and 6.95% of cases, respectively, while proximal fractures (31B and 31C) were least common. Out of 33 tibia and fibula, simple diaphyseal fractures (42A) were recorded highest in (n=24) 72.72% of cases, followed by diaphyseal complex (42C) and wedge fractures (42B) in 15.16% and 6.06% of cases, respectively, whereas proximal (41A) and distal (43A) extra-articular fractures were least common, each accounting for 3.03% of cases. Among 31 radius and ulna fractures, simple diaphyseal fractures (22A) were recorded highest in (n=27) 87.09% of cases, followed by diaphyseal wedge (22B) and diaphyseal complex fractures (22C) in 6.45% and 3.23% of cases, respectively, while proximal extra-articular fractures (21A) accounted for 3.23% of cases. Among 18 humeral fractures, simple diaphyseal fractures (12A) were recorded highest in (n=14), 77.77% of cases, followed by distal extra-articular fractures (13A) in (n=2), 16.67% and proximal extra-articular fractures (11A) in 5.56% of cases.

The predominance of simple diaphyseal fracture types (12A, 22A, 32A and 42A) in the present study corresponds with the findings of Raghunath *et al.* (2007) [7], Kallianpur *et al.* (2018) [9], Gaddam *et al.* (2022) [8] and Surya Lakshmi *et al.* (2026) [10]. This indicates that bending and compressive forces are the major etiological factors responsible for canine long bone fractures, as reported by Surya Lakshmi *et al.* (2026) [10]. The distribution of different fracture types according to AO/ASIF classification is presented in Table 1. Representative radiographs showing various fracture types were illustrated in Figures I - XII.

Table 1: AO/ASIF Classification of long bone fractures in dogs (n=154)

S.No	AO/ASIF Code	No	% of total cases	Bonewise%	Type of fracture
I HUMERUS					
1	11 A1	1	0.65	5.56	Proximal extraarticular simple fracture
2	12 A2	6	3.9	33.33	Diaphyseal simple oblique fracture
3	12 A3	8	5.2	44.44	Diaphyseal simple transverse fracture
4	13 A2	2	1.3	11.11	Distal extraarticular, metaphyseal multifragmentary fracture
5	13 C1	1	0.65	5.56	Distal complex articular fracture
	Total	18	11.69%	100%	
II RADIUS & ULNA					
1	21 A1	1	0.65	3.23	Proximal extra-articular ulnar fracture, radius intact
2	22 A2	2	1.3	6.45	Diaphyseal simple fracture of radius, ulna intact
3	22 A3	25	16.23	80.64	Diaphyseal simple fracture of both radius and ulna
4	22 B3	2	1.3	6.45	Diaphyseal wedge fracture of radius, simple ulnar fracture
5	22 C3	1	0.65	3.23	Diaphyseal complex fracture of both radius and ulna
	Total	31	20.11%	100%	
III FEMUR					
1	31B1	1	0.65	1.38	Proximal extra articular basicervical fracture
2	31B2	1	0.65	1.38	Proximal extra articular transcervical neck fracture
3	31C1	2	1.3	2.78	Proximal articular simple head fracture
4	32A1	1	0.65	1.38	Diaphyseal simple incomplete fracture
5	32A2	24	15.58	33.33	Diaphyseal simple oblique fracture
6	32A3	20	12.99	27.78	Diaphyseal simple transverse fracture
7	32B1	2	1.33	2.78	Diaphyseal spiral wedge fracture
8	32B2	3	1.95	4.17	Diaphyseal multiple wedge fracture
9	32C2	3	1.95	4.17	Diaphyseal complex segmental fracture
10	32C3	3	1.95	4.17	Diaphyseal complex fracture with non-reducible wedges
11	33A1	9	5.84	12.5	Distal extra articular simple fracture
12	33A2	3	1.95	4.17	Distal extra-articular wedge fracture
	Total	72	46.78%	99.99%	
IV TIBIA & FIBULA					
1	41A1	1	0.65	3.03	Proximal extra articular avulsion fracture
1	42A2	14	9.09	42.42	Diaphyseal simple oblique fracture
2	42A3	10	6.49	30.30	Diaphyseal simple transverse fracture
3	42B1	2	1.3	6.06	Diaphyseal fracture with one reducible wedge
4	42C1	1	0.65	3.03	Diaphyseal complex fracture with reducible wedges
5	42C2	1	0.65	3.03	Diaphyseal complex segmental fracture
6	42C3	3	1.95	9.1	Diaphyseal complex irregular fracture
7	43A1	1	0.65	3.03	Distal extra articular metaphyseal simple fracture
	Total	33	21.42%	100%	
	Total	154	100%	100%	

Fig. (I-XII): Representative radiographs showing different fracture types based on AO/ASIF classification.**Fig I:** 12A2**Fig II:** 12A3**Fig III:** 21A1**Fig IV:** 22A3

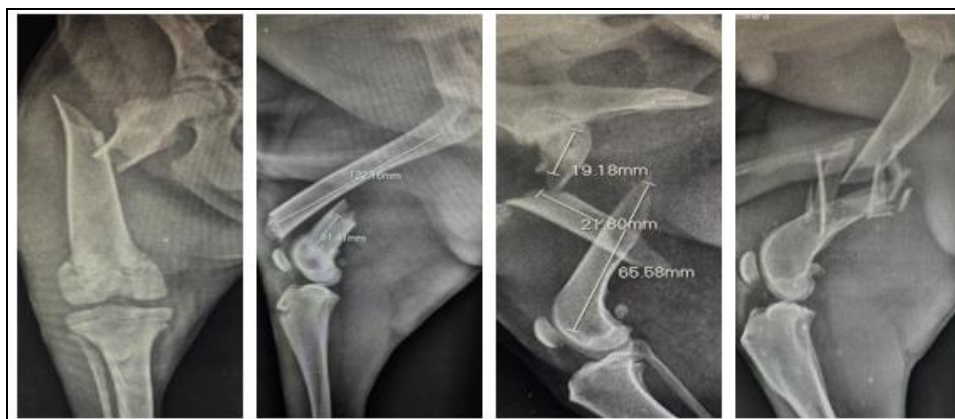


Fig V: 32A2

Fig VI: 32A3

Fig VII: 32C3

Fig VIII: 32C3

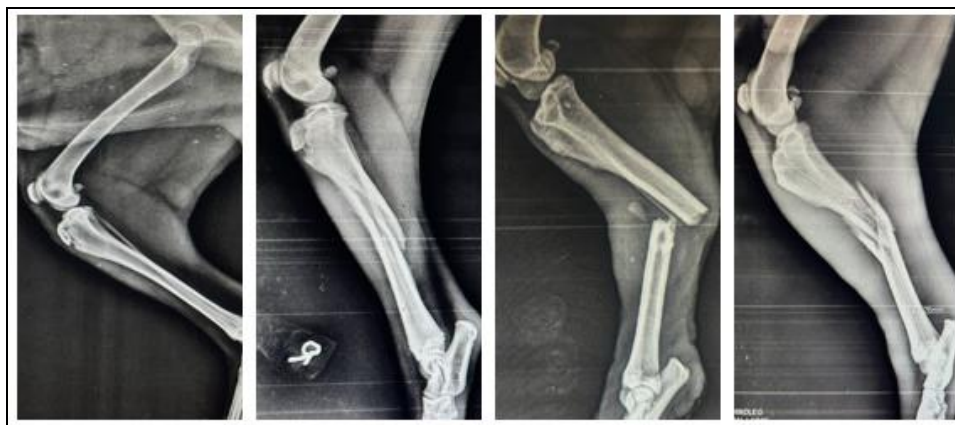


Fig IX: 41A1

Fig X: 42A2

Fig XI: 42A3

Fig XII: 42C1

Among the 154 long bone fractures recorded in the present study, 131 were diaphyseal in location and were further graded according to the Winquist-Hansen classification system. Of these, the majority were categorized under Grade I accounting for 40.46% of cases (n=53), followed by Grade 0 in 31.30% of cases (n=41) and Grade II in 12.21% of cases (n=16). Grade IV fractures were observed in 7.63% of cases

(n=10), while Grade III fractures were recorded in 5.34% of cases (n=7) and Grade V fractures in 3.05% of cases (n=4). This observation was comparable with the findings of Gaddam *et al.* (2022) [8], who also reported a higher occurrence of Grade I fractures. The Winquist-Hansen classification of long bone diaphyseal fractures was shown in Table. 2.

Table 2: Winquist-Hansen Classification of diaphyseal fractures in dogs (n=131).

S.No	Grading of Fracture	Number of cases	Percentage (%)
1.	Grade 0	41	31.30
2	Grade I	53	40.46
3	Grade II	16	12.21
4	Grade III	7	5.34
5	Grade IV	10	7.63
6	Grade V	4	3.05
	Total	131	99.99

Conclusion

This study highlights the usefulness of the AO/ASIF and Winquist-Hansen classification systems in the systematic evaluation of long bone fractures in dogs. The application of these standardized classification systems facilitated clear identification of fracture patterns and assessment of the degree of comminution. The findings also demonstrate variation in fracture configuration among different bones, emphasizing the importance of precise classification for better understanding and clinical assessment of fractures.

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