



Case Report

Management of Femur Fracture using Simple Intramedullary Steinmann Pin and Orthopedic Cerclage Wire in a Dog

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Abstract | A 14-month-old, non-descript and intact male dog was brought to the Veterinary Teaching Hospital with a history of being hit by a vehicle, followed by limping and holding of the right hind limb. The radiographic x-ray image of the affected limb revealed a closed, diaphyseal, overriding, oblique femur fracture. The dog underwent open reduction internal fixation (ORIF) using a simple intramedullary (IM) Steinmann pin and orthopedic cerclage wire. The dog was regularly examined postoperatively for evaluation of wound and fracture healing and return to functional mobility of the limb. The radiographic and physical examination on the 12th week showed cortical union, no signs of fracture lines, and absence of bridging callus on the alignment, with the dog being able to walk normally and bear proper weight on the affected limb, respectively. The IM Steinmann pin was removed from the affected limb in the 20th week following pin migration.

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Introduction

Motor vehicle accidents (MVAs) or road traffic accidents (RTAs) are one of the significant reasons for traumatic injury, hospitalization, and in some instances, even fatality leading to the death of domestic or wild animals. Among domestic animal companion animals particularly dogs are more frequently involved in MVAs or RTAs (Ben Ali, 2013; Canal *et al.*, 2018; Harris *et al.*, 2018; Keosengthong *et al.*, 2019) with breed predisposition to indigenous, non-descript, or mongrel dogs (Aithal *et al.*, 1999;

Keosengthong *et al.*, 2019; Kumar *et al.*, 2018). In animals, about 50 % of fracture injuries have been noted below 1 year of age and 80% below 3 years of age with the predominance of males in species of dogs and cats (Phillips, 1979).

In fracture injuries of the appendicular skeleton of dogs and cats pelvic limbs are more commonly involved with the femur bone being typically injured (Ali *et al.*, 2014; Keosengthong *et al.*, 2019). The major traumatic causes of femur fracture in dogs include automobile accidents, falling from a height, animal

bite, and human abuse while non-traumatic causes include bone pathology due to nutritional deficiency, neoplasia, and genetics (Aithal *et al.*, 1999; Keosengthong *et al.*, 2019; Kumar *et al.*, 2007; Zurita and Craig, 2022). The incidence of an open type is lower than a closed type of fracture in dogs and is most commonly associated with vehicular trauma (Millard and Weng, 2014). The fracture of the femur is a closed type most of the time due to the heavy overlying muscle of the limb (Beale, 2004). In mature dogs, metaphyseal and diaphyseal fracture is more apparent in contrast to puppies where proximal and distal physal fracture is more evident in fracture injury of the femur (Tercanlioglu and Sarierler, 2009).

The evolution and understanding in the field of fracture healing and bone regeneration have made a paradigm shift regarding the development and improvement of methods that are utilized to enhance fracture healing (Abed *et al.*, 2022). The successful outcome in musculoskeletal problems is determined by the appropriate treatment implemented. The choice of surgical treatment and implant requires knowledge and understanding of locomotive physiology and biomechanics, the magnitude and direction of forces acting on the joints and muscles, and the pathological condition of affected limbs (Shahar and Banks-Sills, 2002). The basic principle of biological fracture repair is focused on anatomic reduction and rigid fixation with minimal disturbance to the fracture site which could be achieved on simple transverse or oblique fracture of long bone with an open surgical technique (Harsen, 2002). There are different procedures for fracture management depending on the type of fracture so the choice and the use of implants also varies accordingly. The use of an external coaptation splint, cast padding, and sling is employed for uncomplicated and closed fractures while internal and external skeletal fixation is the commonly preferred method for the treatment of long bone fracture in small animals. It is crucial to consider the age and weight of an animal, characteristics, type of bone, type of fracture incurred, condition of fracture, associated soft tissue injuries, and fracture fixation techniques for the management of long bone fracture (Gadallah *et al.*, 2009). The return to functional mobility and early healing in long bone fracture depends on the application of proper surgical technique, preservation of regional soft tissue and blood supply, anatomic reduction, use of an appropriate implant, rigid fixation, and stabilization of the fracture site (Chandra Das *et al.*, 2020; Stiffler,

2004). Internal fixation procedure makes use of various implants such as intramedullary (IM) Steinmann pin, lag screws, interlocking nails, bone plates, screws, etc. (Aithal *et al.*, 1999). In young and rapidly growing dogs the anatomical confirmation of the hind limb makes it difficult for the application of external coaptation splint and cast for the treatment of diaphyseal fracture (Déjardin and Cabassu, 2008). ORIF is performed on, overriding and oblique fracture management of long bones in dogs (Bernarde *et al.*, 2001). IM Steinmann pin generally acts as an internal splint inside the medullary canal of a long bone that shares loading force with other bones, averts bending force applied to the bone, and retains the axial alignment of the fracture (Beale, 2004) while orthopedic wire provides the interfragmentary compression and maintains the apposition of bone fragments (Stiffler, 2004). Among the internal fracture fixation techniques retrograde IM pinning is an easy, effective, and economical procedure for the management of long bone fractures in dogs (Beale, 2004; Chandra Das *et al.*, 2020).

The present case report documents the surgical procedure involving ORIF in a specific orthopedic case of closed, diaphyseal, overriding, oblique femur fracture utilizing the combination of simple IM Steinmann pin and orthopedic cerclage wire and an evaluation of the outcome.

Case history and observation

A 14-month-old, non-descript and intact male dog weighing 25 kg was brought to the Veterinary Teaching Hospital (VTH), Faculty of Animal Science, Veterinary Science and Fisheries (FAVF), Agriculture and Forestry University (AFU) for treatment with a history of limping on the right hind limb for 7 days, which occurred immediately after being hit by a motor vehicle 1 week before presentation to VTH. On physical examination, the dog was bright, alert and responsive, with non-weight-bearing lameness of the right hind limb, swelling in the right lateral thigh region, and pain on palpation with crepitus, suggesting a high suspicion of femur fracture. The dog was given analgesics for pain management and sent for an X-ray radiograph of the femur of the right hind limb. Radiographic examination revealed the closed, diaphyseal, overriding, oblique femur fracture. Based on the above examination, assessment, and overall condition, the case was decided to be managed with the open reduction internal fixation technique utilizing a simple IM Steinmann pin and full cerclage orthopedic wire.



Figures 1 A and B: Preoperative aseptic preparation of the surgical site, including the positioning and sterile draping of the right hind limb.

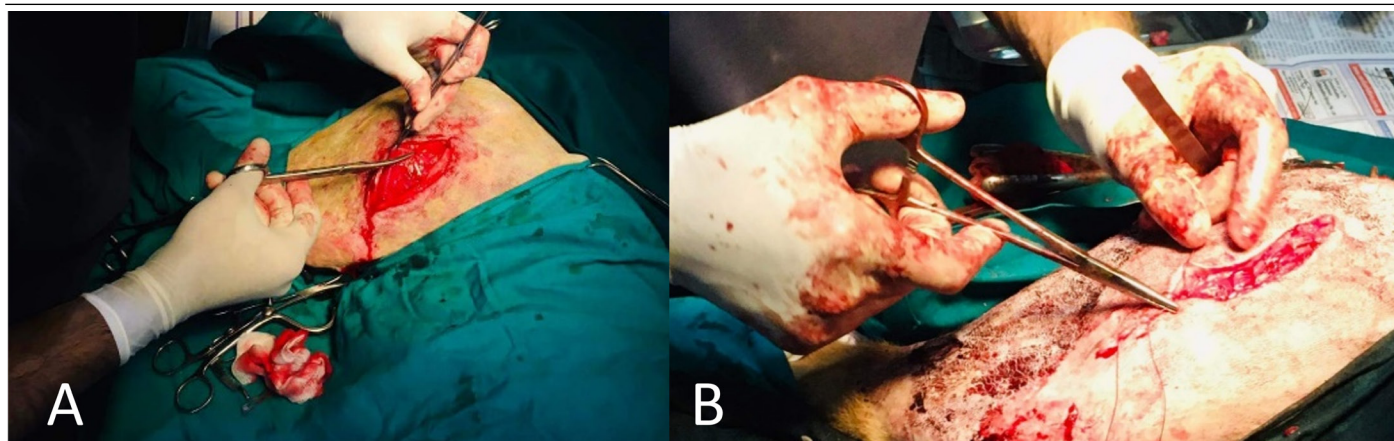
Preoperative preparation and anaesthetic procedure

Food and water were withheld for 12 hrs and 6 hr respectively before the procedure. The use of total intravenous anesthetic protocol (TIVA) was planned for perioperative anesthesia. Under physical restraint, the dog was premedicated with Xylazine HCL (20 mg/ml) and Ketamine HCL (50 mg/ml) combination in a ratio of 1:1 at the dose rate of 0.1 ml/kg bd. wt. (1 mg/kg bd. wt. Xylazine and 2.5 mg/kg bd. wt. Ketamine) IM. After sedation, an intravenous catheter (size 22 G) was fixed on the cephalic vein of the right forelimb, and induction was carried out with a 1:1 combination of general anesthetic Diazepam (5 mg/ml) and Ketamine (50 mg/ml) at a dose rate of 0.1 ml/kg bd. wt. (0.25 mg/kg bd. wt. Diazepam and 2.5 mg/kg bd. wt. Ketamine) IV. Lignocaine 2% at the dose rate of 1 mg/kg bd. wt. was given IV during induction preoperatively. Maintenance of anesthesia was done with a 1:2 combination of Diazepam (5 mg/ml) and Ketamine (50 mg/ml) at a dose rate of 0.1 ml/kg bd. wt. (0.17 mg/kg bd. wt. Diazepam and 3.33 mg/kg bd. wt. Ketamine) IV. For pain management during the perioperative period multimodal analgesia consisting of a combination of analgesic drugs Tramadol (50 mg/ml) at the dose rate of 4 mg/kg bd. wt., Meloxicam (5 mg/ml) at the dose rate of 0.2 mg/kg bd. wt. were given IV preoperatively during induction. Balanced anesthesia was achieved using total intravenous anesthesia throughout the perioperative procedure. Preoperative antibiotic prophylaxis was done with Ceftriaxone-Sulbactam (Ceftriaxone 1000 mg + Sulbactam 500 mg + 10 ml Sterile water) at a dose rate of 0.3 ml/kg bd. wt. (30 mg/kg bd. wt.

of Ceftriaxone) IV. During the perioperative period, IV fluid Lactated Ringers solution was administered at the rate of 10 ml/kg/ hr. through an IV catheter placed into the cephalic vein of the right forelimb to maintain physiological balance and compensate for loss during the surgical procedure. At the same time, the surgical site was clipped, shaved, and aseptically prepared using Savlon® (Chlorhexidine gluconate and Cetrimide), 70% alcohol, and Povidone-Iodine solution (Figure 1A).

Intraoperative procedure

The dog was positioned in left lateral recumbency and the affected right hind limb was positioned dorsally (Figures 1A and B). The incision site was marked as an imaginary line at the cranio-lateral aspect of the thigh region and the incision was given cranio-laterally extending from slight ventral to the greater trochanter and extending just proximal to the patella. Proper identification of the junction between fascia lata and biceps femoris muscle was made after retraction of superficial fascia (Figure 2A). The femoral shaft was then exposed after the separation of overlying muscles, i.e., the vastus lateralis and intermedius muscle were retracted cranially while the biceps femoris muscle retracted caudally. The fractured site which contained a bridging callus, bone fragments, and dead and necrotic tissue was scraped and removed. The site of the fracture and wound were made fresh and flushed with normal saline (0.9 % W/V). For fracture fixation, a 4 mm Steinmann pin was used in a standard retrograde IM pinning technique. The selection of the IM pin was made directly



Figures 2 A and B: Intraoperative procedure during open reduction internal fixation (ORIF), highlighting the separation of muscle layers and fascia following the skin incision and the closure of the skin incision (intradermal suture pattern) performed during the procedure.

by observing the IM canal of right femur intraoperatively. As a rule of thumb for the management of femur fracture an IM pin of size 60-70 % of canal width at the isthmus of the medullary cavity of the right femur was selected. The IM pin should also safely traverse the canal and seat in the metaphysis without affecting reduction. The limb was adducted with the maximal extension of the hip joint to prevent sciatic nerve injury. Subsequently, the IM pin was inserted from the end of the fractured femur at the proximal part and externalized out at the trochanteric foramen. The bone was realigned in linear symmetry with continuous traction and toggling of the proximal and distal fractured bone segments. The IM Steinmann pin out of the trochanteric foramen was then pushed carefully, slowly, and gradually in a rotating fashion and passed along the distal segment. The careful insertion of the IM pin in a normograde fashion is crucial to prevent unintentional penetration of the articular surface of the distal segment of the femur and to avoid entering into the stifle joint. After the IM pin was seated three full cerclage orthopedic wires were placed at the site of the oblique fracture. The IM Steinmann pin in the bone was measured in parallel along the length of the femur with another IM pin of the same length externally. After measurement, the excess length of the IM pin was cut to seat the exposed portion of the IM pin within the medullary cavity extending from the trochanteric foramen and metaphysis of the proximal fracture segment up to the metaphysis of the distal fracture segment respectively. The exposed IM pin was pushed further distal in the medullary cavity to seat the proximal end of the IM pin in the trochanteric foramen at level with or distal to the greater trochanter concurrently assessing the distal segment to prevent the IM pin

from inadvertently penetrating the articular surface or reaching the stifle joint.. After the completion of the procedure, the overlying muscle layers were closed using absorbable suture PGA (polyglycolic acid) U.S.P. size (2-0) in a simple continuous pattern, fascia and subcutaneous layer with PGA U.S.P. size (3-0) in a simple continuous pattern and skin with PGA U.S.P. size (3-0) intradermal in a simple continuous pattern (Figure 2B). The surgical site after skin closure was cleaned aseptically (Figure 3A), and finally covered with sterile gauze and padded with soft cotton bandages, gauze rolls, and adhesive tape.

Postoperative care and advice

Ceftriaxone-Sulbactam (Ceftriaxone 1000 mg + Sulbactam 500 mg + 10 ml Sterile water) was given at a dose rate of 0.3 ml/ kg bd. wt. (30 mg/ kg bd. wt. of Ceftriaxone) IV twice a day for 5 days. Meloxicam (5 mg/ ml) was given at a dose rate of 0.1 mg/ kg once a day for the next 3 days and Tramadol (50 mg/ ml) at a dose rate of 2 mg/ kg twice a day for the next 5 days subcutaneous (SC), looking at the overall status of the dog and taking into consideration the post-operative pain management. Similarly, wound examination and dressing were done daily for the next 3 days and every alternate day for the next 3 days till it was confirmed that the surgical wound (incision site) had healed without any complications. The owner kept the dog on a regular homemade diet of boiled chicken meat and rice, in addition, a calcium supplement (Cal-D-Pet®) 5 mL orally twice a day for 2 weeks was recommended. The owner was advised to keep the wound clean and dry, to restrict the movement of the pet as far as possible for 2-3 weeks, and to call the vet if in case any complication is noticed.



Figures 3 A and B: *Surgical site after wound closure and an X-ray image of the right femur taken 12 weeks postoperatively.*

Results and Discussion

Postoperative examination on 1st day revealed swelling on the surgical site. The dog was unable to bear weight postoperatively for 24 hrs lying in lateral recumbency. The dog was able to stand on all other limbs with non-weight bearing on the affected limb on the 2nd to 6th days postoperatively. The dog had started bearing slight weight with lameness and holding the limb while standing on the affected limb by the 7th day of the procedure. The dog was examined weekly from the next week of the procedure for pain assessment and functioning of the limb. After the 5th week, the dog had started bearing weight, and holding the limb while walking but showed no signs of pain or discomfort. The dog had started to bear weight and was walking while holding the right hind limb frequently after 7th week of the surgical procedure. On the 12th week of examination, the dog was bearing proper weight on the affected limb and walking properly. After the 20th week, the implant had migrated 3–4 cm proximally out of the skin from the affected limb, which was visualized externally. Radiographic examination in the 20th week showed cortical union, no signs of fracture lines, and an absence of bridging callus on the alignment, which revealed a union of fracture ends. The IM Steinmann Pin was extracted the next day under light sedation. Pain management with analgesics was done on the day of implant extraction and the next day. Though the pin had migrated superficially from the site there was no complication associated with the functional mobility and weight bearing on the affected limb. The fractured segments of the femur bone had healed completely as visualized on the x-ray

radiograph image 12th weeks postoperatively with a return on functional mobility of the limb which was assessed during physical examination.

Femoral fractures due to traumatic injury incurred in MVAs or RTAs are quite common and major causes of femur fractures both in adult and immature dogs (Tercanlioglu and Sarierler, 2009). Femur fractures were more commonly reported in males than females, which might be due to the aggressive nature and wandering behavior of male dogs, making them more susceptible to accidents and fractures (Abd El Raouf and Mekaw, 2017; Keosengthong *et al.*, 2019). A study done to evaluate the epidemiology of bone fracture in dogs showed that male dogs were more prone to fracture injury with non-descript breeds being mostly involved while the majority of bone fractures noticed were on the right hind limb with a higher incidence of femur fracture (Usadadiya *et al.*, 2020). A retrospective study over 10 years period in 310 cases of fracture in growing dogs showed that the incidence of femur fracture was higher in the osteopenic bone as compared to the normal bone with higher male predisposition equally in both the groups (Kumar *et al.*, 2007). It was reported that the majority of femoral fractures i.e., above 60 % in dogs occurred at or below two years old (Braden *et al.*, 1995; Kolata and Johnston, 1975). In mature dogs, metaphyseal and diaphyseal regions of the femur are the common sites for fracture injury (Beale, 2004; Kim *et al.*, 2012). A study done in 402 dogs with fracture injury showed that the middle and distal diaphyseal regions of the femur bone are commonly involved (Aithal *et al.*, 1999). In another study, the fracture site was observed at the middle

and distal ends of the normal long bone, characterized by an oblique type of fracture, in contrast to the findings in osteopenic bone (Kumar *et al.*, 2007). Due to the strong muscle groups covering the femoral diaphysis in the lateral and cranial planes, anatomical alignment of fracture segments utilizing the closed reduction technique is almost impossible. IM pinning is an effective procedure for fracture stabilization and management in most diaphyseal fractures of the tibia and femur (Bernarde *et al.*, 2001). IM Steinmann pin used for IM pinning should have a diameter to occupy at least 60%-70% diameter of the medullary canal at its narrowest place however the larger pins are selected for straight bones and will provide resistance to bending force (Chandra Das *et al.*, 2020). In general, for straight bones, the larger IM pin selected should occupy 70-80 % diameter of the medullary cavity. In a dog weighing more than 15 kg, the IM pin with a diameter of more than 4 mm was found to be appropriate (Peirone *et al.*, 2002). IM Steinmann pin used in fracture management of long bones is inserted either in retrograde or normograde fashion (Tobias and Johnston, 2013). In the retrograde pin insertion technique, a pin is advanced from the fractured end of one fragment of bone and driven out from the other end of the bone in the appropriate anatomic position. Once the fracture is reduced anatomically, the pin direction is reversed and then is driven into the opposite end of the bone i.e., towards the medullary cavity of another fractured fragment (Bojrab *et al.*, 2014; Fossum, 2019; Vasseur and Slatter, 2003). A study showed a lower success rate of end threaded IM pin as compared to simple Steinmann pin in close reduction internal fixation due to limited manipulation and poor reduction of fracture ends as well as the resistance developed due to entanglement of superficial and adjacent tissue structure while placing the end threaded IM pin in normograde fashion (Kaur *et al.*, 2015). Due to the adjacent proximity of the neutral axis, IM pins resist bending equally well in all directions; but, when utilized alone, their resistance to the disruptive forces of shearing, torsion, and compression is insufficient (Egger *et al.*, 1986; Lincoln, 1992). Thus, the combination of orthopedic wire along with the IM pin is indicated in cases of an oblique, spiral, as well as a comminuted fracture to provide interfragmentary compression and stabilization of fractured fragments. In this case, the dog started slight weight-bearing standing on the affected limb on the 10th day postoperatively, similar to the findings in a study (Rani *et al.*, 2012) where the dogs

started weight-bearing between the 5th and 14th days postoperatively. In a study of postoperative limb gait scoring involving 9 dogs with IM pinning, the dogs were unable to walk within 24 hrs, could stand while holding the limb but were not able to bear weight for 1st-3rd days and were able to bear weight at walking but holding the limb while speed walking at 11th-21st days postoperatively which was comparable to that of in this case (Abed *et al.*, 2022). Retrograde IM pinning for the management of femur fracture in a labrador showed gradual weight-bearing and secondary callus formation in the 2nd and 3rd week while functional weight-bearing of the limb was observed postoperatively in the 7th week (Chandra Das *et al.*, 2020). The reduction in time for bone healing with the use IM pin in fracture injury might be due to the increased bone resistance to the horizontal and bending forces applied to long bones (Inas *et al.*, 2012). Along with proper union and alignment of fractured fragments, bone healing was promoted by pluripotent stem cells derived from bone marrow due to the insertion of an IM pin (Fossum, 2019). The fractured segments of the femur bone had healed as demonstrated on the postoperative radiograph (Figure 3B) in the 12th week and there were no signs of complication associated with functional mobility of the limb in this case.

The complications associated with long bone fracture include fracture disease, implant failure, delayed union, non-union, malunion, hypertrophic callus formation, and osteomyelitis (Gadallah *et al.*, 2009). In internal fixation using an IM pin, complications are commonly encountered secondarily due to instability or inappropriate placement of the IM pin leading to delayed healing or non-union and pin migration causing soft tissue and sciatic nerve injury. The complications associated with orthopedic wire include wire migration, breakage, loosening, or overtightening leading to unstable fracture sites or restriction of blood supply which might cause delayed healing or non-union (Stiffler, 2004). In a study with 631 cases of long bone fracture in dogs, higher complications were observed in femur fracture while the poor outcome was noticed leading to severe lameness in long-standing old fractures, stiff joints with severe arthrosis, late-stage muscle atrophy, osteomyelitis, non-union and recurrent implant failure (Gadallah *et al.*, 2009). Gill *et al.* (2018) observed minor pin migration in the supracondylar femoral fractures of two animals, but the fracture healing and functional out-

come were not affected. [Abd El Raouf et al. \(2017\)](#) reported pin migration 10 weeks postoperatively after complete healing in one out of 17 cases which were managed successfully with pin removal. Bacterial biofilms surrounding the implant leading to chronic bone infection might be the cause of the unstable fracture and pin migration. In such cases, it is advised to remove the implant and restabilize the fracture along with appropriate treatment for the healing of the fracture ([Muir and Johnson, 1996](#)). [Schrader and Greenberg \(1987\)](#) suggested the removal of the IM pin in case of lameness which might be due to tissue irritation or migration of the IM pin. There were no further complications associated nor noticed with pin migration in this case even after a few weeks of pin removal till the 20th week of the procedure.

Traumatic fracture of bone involving the hind limb and pelvis causes moderate to severe pain ([Srithunyarat et al., 2017](#)). Acute pain is triggered during the management of fractures through surgical procedures like ORIF. Pain management is crucial for early recovery, stress management, and functional improvement of the affected limb which positively impacts the overall well-being and quality of life of the dog. Unmanaged acute pain due to fracture and surgical procedures during fracture management may lead to chronic pain, loss of functional ability, poor quality of life and welfare of animals ([Berry, 2015](#); [Dyson, 2008](#); [Vadivelu et al., 2010](#)). Pain management requires the use of multimodal analgesia in case of bone fracture. The use of Opioids and NSAIDs preoperatively and postoperatively alone or in combination is recommended widely for pain management in orthopedic cases. The use of NSAIDs in combination with opioids will reduce the dose and duration of both analgesic and anesthetic drugs along with reducing adverse effects ([Al Farii et al., 2021](#); [Gruet et al., 2011](#); [Laredo et al., 2004](#); [Mathews, 2000](#); [Taylor, 1999](#); [Walliser et al., 2015](#)). In this case, the use of balanced anesthesia was preferred leading to smooth and safe induction as well as uneventful recovery while the use of multimodal analgesia led to proper pain management, early healing, and return to functional mobility.

Conclusions and Recommendations

Management of traumatic orthopedic injuries involving bone fracture necessitates anatomical reduction and rigid fixation to promote primary healing of the

fractured segments of bone. It was found that open reduction internal fixation (ORIF) with a simple Intramedullary (IM) Steinmann pin and orthopedic cerclage wire for stabilization of closed, diaphyseal, overriding, oblique fracture allowed proper anatomic alignment and stable fractured bone segments in this case of oblique shaft fracture of right femur bone. This procedure provides appropriate fracture stabilization as well as early and primary healing of fractured bone and, with adequate pain management, will address the animal's welfare and quality of life.

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Novelty Statement

The present case report tries to depict the techniques frequently implied for the management of fracture in dogs as observed in this individual case in Nepal. Similarly it also provides details on the various aspects of fracture injury, its management, necessary precautions, complications, and addressing complications while prioritizing pain management and its importance in fracture injury.

Author's Contribution

KA - Performed the Procedure, Writing - Original Manuscript Draft, Writing - Reviewing and Editing the Manuscript Draft.

SP - Writing - Original Manuscript Draft.

MKS - Supervised the Procedure, Writing - Reviewing and Editing the Manuscript Draft.

Conflict of interest

The authors have declared no conflict of interest.

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