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Clinical Evaluation of Plate Osteosynthesis for Repair of Long Bone Fracture in Dogs

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ABSTRACT

The present study was planned to deduce the effectiveness of the plate osteosynthesis for the repair of long bone fractures in dogs. The study was conducted on seven clinical cases in which bilateral fractures were present in three dogs whereas single was observed to be involved in rest of the cases. In the fractures involving radius and ulna, plates were used for the fracture stabilization. However, in two cases involving tibia and femur, firstly plate and intramedullary pin was used for surgical repair, respectively. The revised surgery was undertaken as the plate used to stabilize tibia fracture had implant failure (bending of plate). Fixation was done by using IMP and hydroxyapatite was also used to augment repair. Stabilization of femoral fracture by using IMP failed and was again attempted by using stack pinning and plate combination along with hydroxyapatite. The healing of the fractured fragments was evaluated by clinical and radiographic examination. Excellent results were observed in four cases, revised surgery was attempted due to implant failure in two cases and one case died 15 days after surgical procedure due to managemental related issue. It may be concluded that plate osteosynthesis yields excellent results when the plate size is evaluated based on bone size, bone involved and at least fixing of three screws on either side of fracture site.

HIGHLIGHTS

- 3.5 mm T- plate provided rigid fixation and fast recovery in the management of Colle's fracture.
- Plate rod combination may be suitable alternative for heavy animals with or without biomaterials.
- Biological fixation is important as wound dehiscence, necrosis, non-union may occur despite rigid fixation.

Keywords: Plate osteosynthesis, Fracture, Long bone fracture, Dog, Hydroxyapatite

Fracture of long bones are one of the most common orthopaedic problems encountered in canines. Among long bones, the incidence of femur fracture is found to be highest followed by tibia, radius-ulna and humerus (Dwivedi *et al.,* 2021). The most common method for management of these fractures is intramedullary pinning. But in case of radius-ulna fracture intramedullary pinning is technically not appropriate as the medullary cavity of radius-ulna is very narrow. So, in case of radius-ulna fracture plate application is the choice of treatment (Johnson, 2013). Though, the intramedullary pinning is common and technically less demanding surgical method for femur, tibia-fibula and humerus fracture management, most of the time it results into various complications like pin migration, seroma formation, relatively inferior technique with respect to mechanical stability, malunion, delayed union etc.

So, the fracture surgery is regularly challenged in animals as well as in human being by the presence of bone defects, reduced mechanical stability, various complications and

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a lack of bone healing. The concept of open reduction and stable internal fixation (ORIF), derived from the AO/ASIF principles that envisages restoration of anatomical alignment and allow functional mobilization. The intramedullary pinning unable to resist the torsional forces acting on bone and therefore most of the time it associated with various different types of complications. The biomechanical stability is a crucial factor during the process of fracture healing and surgical interventions, such as internal or external fixation are designed to improve stability and thereby enhance fracture healing. Bone plating is also an internal fixation device used since long back for long bone fracture repair in humans as well as in veterinary practice. The traditional plates again leads to the pressure osteopenia and thereby delayed healing because these plate causes compromise in periosteal blood supply. Stephan Perren was at the forefront of implant design, especially with respect to preserving the periosteal blood supply (Perren, 2015). This leads to a number of innovations applying these concepts were introduced which resulted into development of limited contact dynamic compression plates (LC-DCP), tubular plates, locking compression plates (LCP) etc. The application of these LCP plates in veterinary clinical practice recently introduced and resulted into improved healing and reduced implant related failure. In present study a review of seven cases of long bone fracture in dogs was done, which were stabilised by using new innovative bone plates. Recently, the utilization of bone biomaterials for faster and better healing of fractured bone is being promoted. Bone biomaterials of ceramic (hydroxyapatite), allogenic bone derivative (DBM) and composite (combination of two or more classes) type are used to augment bone healing. Farooq *et al.* (2019) opined that the group that received DBM showed faster and better radiographic healing as against the group without DBM application. Hydroxyapatite in various forms has been reported to be an enhancer for bone healing. Mohammed *et al*. (2023) concluded that using hydroxyapatite nano gel as filler for bone voids, accelerates the healing process and showed superior healing and callus formation in radiological analysis as compared to control group.

MATERIALS AND METHODS

Seven cases of long bone fracture presented to the Veterinary Clinical Complex of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu were included in this review. After recording of data related to the history and clinical examination, all the animals were subjected to radiographic examination in orthogonal views to confirm the type of fracture (Table 1). Based on the radiographic examination and clinical observations the treatment modality was decided. All the cases of the radius-ulna fracture were immobilised with 3.5 mm 7 holes locking compression plate except the bilateral colle's fracture case, where 3.5 mm 6 holes T-plate was used to immobilise the fracture fragments. The tibia fracture was stabilised by using 3.5mm LCP but after 1 week plate bending occurred that required revised surgery using intramedullary pin and hydroxyapatite application at fracture site. The case number 6 with femur fracture in this review was initially treated with intramedullary pinning but fixation failure occurred after 3 days of surgery. In this case also revised surgery was performed using plate rod combination along with hydroxyapatite application at fracture site. The last case i.e. case number 7 with femur fracture treated with 3.5 mm titanium LCP with 7 holes.

All cases were operated under general anaesthesia using atropine sulphate (@0.044 mg/kg body weight, intra muscular route), Xylazine hydrochloride (@2 mg/kg body weight, intra muscular route), ketamine hydrochloride (@10 mg/kg body weight, intra muscular route) and maintenance of anaesthesia was done using combination of ketamine and diazepam through intravenous route. The surgical approach for radius-ulna and tibia-fibula was through medial aspect and for femur fracture it was cranio-lateral aspect (Piermattei *et al.,* 2004).

Fig. 1: Aseptic preparation, exteriorization of fractured fragments and LCP application

In all the cases, the surgical site was prepared routinely for aseptic procedure. Then under general anaesthesia, the animals with radius-ulna and tibia-fibula fracture were restrained in lateral recumbency with the affected limb

Table 1: Summary of signalment, causative factor along with surgical procedure and outcome

Sl. No.	Breed	Age (Years)	Sex	Weight (Kg)	Cause of fracture	Type of fracture	Treatment	Outcome
1	Cross bred	3.5	M	24	Fall from height	Bilateral Colle's fracture	3.5 mm T-plate for both the limbs	Excellent recovery
2	ND	4.0	M	16.5	Road traffic accident (RTA)	Bilateral transverse fracture of mid shaft of radius-ulna	3.5 mm LCP	Excellent recovery
3	ND	2.5	M	19	RTA	Left radius-ulna mid shaft	3.5 mm LCP	Good
4	Siberian Husky	2.5	M	21	RTA	Left Radius ulna mid shaft	3.5 mm LCP	Poor
5	GSD	4.0	M	26	Fall from height	Bilateral Radius-ulna fracture and tibia-fibula fracture	3.5 mm LCP for left Radius-ulna, 3.5 mm LCP for tibia and right radius-ulna with external coaptation	Animal died after 15 days, Revised surgery performed for tibia fracture
6	GSD	3.5	M	42	Fall from height	Segmental fracture of left femur	Intramedullary pinning	Fixation failure occurs after 3 days, revised surgery performed with plate-rod
7	GSD	3.0	M	18	Fall from height	Diaphyseal fracture of femur	LCP along with wiring	Excellent

ND-Non-descript, GSD-German Shepherd, RTA-Road traffic accident, LCP-Locking compression plate.

Fig. 2: (**a** and **b**) Pre-operative radiograph of both forelimbs indicating bilateral radius-ulna fracture, (**c** and **d**) Post-operative radiographs after repair of right forelimb, (**e** to **g**) Subsequent post operative radiographs taken to assess healing and **(h)** radiograph showing disappearance of fracture line

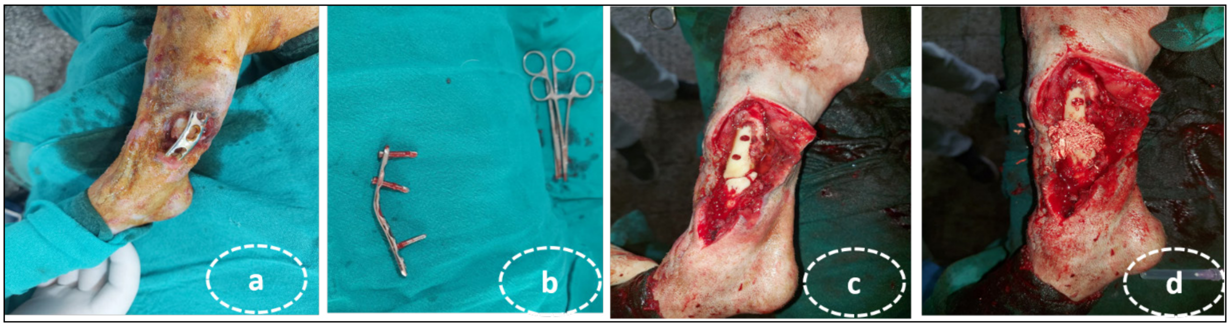

Fig. 3: (a) Complication of plate bending, **(b)** surgical removal of bent locking compression plate, **(c)** Reduction of fractured fragments and **(d)** application of biomaterial (hydroxyapatite) at fracture site during revised surgical procedure to enhance healing in case number 5th

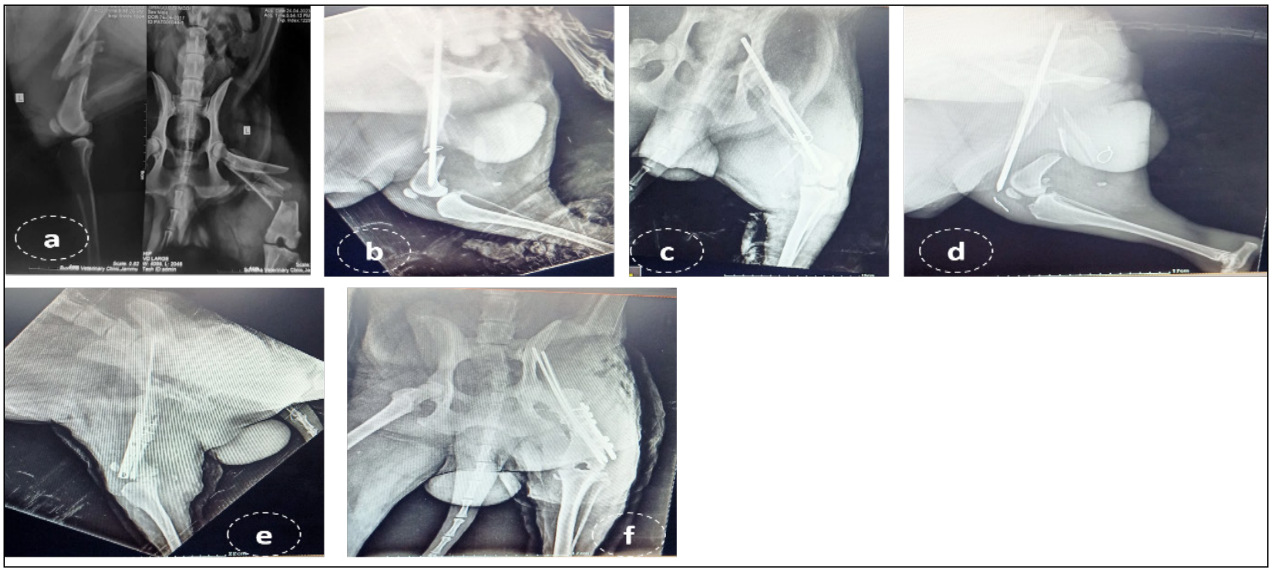

Fig. 4: (a) Pre-operative x-rays showing segmental fracture of femur, **(b)** fracture managed surgically with IMP, (**c** and **d**) failure of implant, (**e** and **f**) X-rays showing excellent fixation in both views with plate rod combination (case no. 6th)

towards lower side and for femur fracture the animal was restrained in lateral recumbency with the affected limb towards the upper side. The fractured fragments in all the cases were exteriorized following the standard surgical procedure advocated for these bones. General protocol for the aseptic preparation, exteriorization of the fracture fragments and plate application is given in Fig. 1. In colle's fracture, 3.5 mm, 6 holes T-plate was used in both the limbs at an interval of one week (Fig. 2). In case of mid shaft radius-ulna and tibia fracture 3.5 mm 7 holes LCP was used for immobilization. Revised surgery was required in case of tibia fracture as there was plate bending after 1 week of surgery (Fig. 3). Intramedullary pinning along with hydroxyapatite application at fracture site was done in revision surgery for tibia. In femur fracture encountered in case number 6, 5 mm intramedullary pin was initially used for immobilization but it required revise surgery after 3 days of initial surgery. In revised surgery, femur fracture was immobilised with two 2 mm intramedullary pins i.e. stack pinning, 3.5 mm dynamic compression plate fixation and hydroxyapatite application at fracture site (Fig. 4). The second case of femur fracture (case number 7), was immobilised with 3.5 mm LCP and cerclage wiring. In all the cases, during post-operative period antibiotics, analgesics, antacid and syrup consisting of minerals and vitamins were advised. Further, Robert

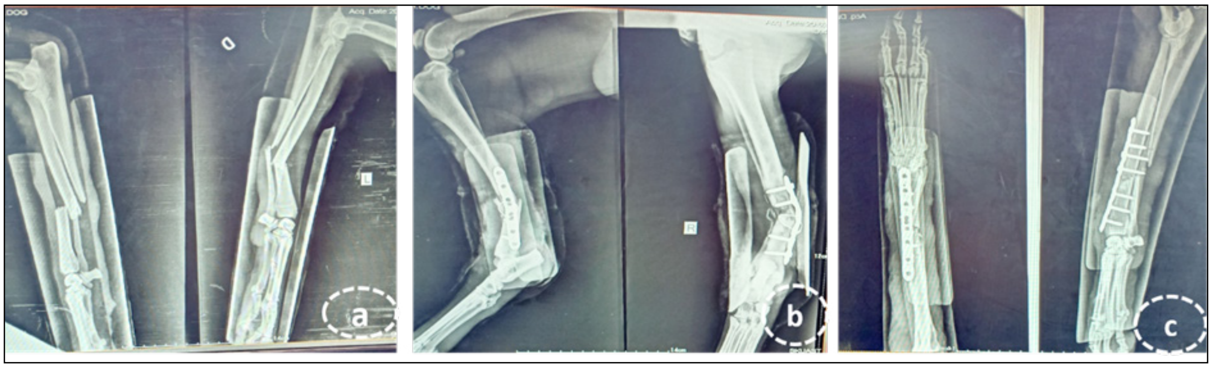

Fig. 5: (a) Pre-operative radiograph with bilateral radius-ulna fracture, **(b)** Post-operative radiograph of tibia fracture with implant failure (plate bending) and **(c)** Post-operative radiograph of radius-ulna showing successful repair with LCP (Case no. 5th)

Jones bandage along with strict rest were advised for 3 weeks. The efficacy of treatment was evaluated on the basis of biomechanical aspects of fixation, radiographic examination and functional outcome.

RESULTS AND DISCUSSION

In all the cases, 3.5 mm plates along with 3.5 mm screws and 6-8 combi holes provided better stability. In case number 1, the T-plate provided excellent stability except in the management of fracture of tibia in case number 5. The body weight of the animals under treatment varied between 16.5 kg to 42 kg, age between 2.5 to 4 years and all the animals were male. In two animals, bilateral fracture of radius-ulna (case number 1 and 2) was encountered while in another (case no. 5), bilateral fracture of radius-ulna and right tibia-fibula fracture was observed. In case number 1, bilateral radius-ulna fracture were managed with 3.5 mm T-plates along with 6 screws 3 in proximal segment and 3 in distal segment and provided excellent stability in both limbs. In case number 2, again bilateral radius-ulna fracture where only left limb was repaired using 3.5mm LCP with 3 screws in proximal and 3 screws in distal fragment provided excellent stability. Also, in case number 3, 3.5 mm LCP with 3 screws in proximal and 2 screws in distal fragment was used to stabilise right radius-ulna fracture resulted in excellent stability. Similarly in case number 4 and 5 the radius-ulna fracture was repaired with 3.5 mm LCP and 4 screws in proximal and 2 in distal fragment, again 4 in proximal and 3 in distal fragments, respectively provided excellent stability in both the cases. In case number 5 the tibia fracture was managed with 3.5 mm LCP with 2 screws in proximal and 2 screws in distal fragment and it resulted into fixation failure because of plate bending and loosening of screws (Fig. 3a and b). In this case, revised surgery was performed using 5mm IMP along with hydroxyapatite application at fracture site (Fig. 3c and d). In case number 6, femur fracture that was initially managed with IMP but after 3 days fixation failure occurred, underwent revised surgery and was managed with two 2 mm IMP, 3.5 mm plate with 3 screws in proximal and two screws in distal fragment along with application of hydroxyapatite at fracture site (Fig. 4). In this study, we observed that 3.5 mm plates along with minimum of 3 screws in proximal and 2 screws in distal fragment provided rigid immobilisation of fracture fragments in all the cases. In case number 7, the fracture was immobilised using 3.5 mm LCP with 3 screws in proximal and 3 in distal along with cerclage wiring provided stable fixation. In case of tibia fracture, the plate size was 3.5 mm but number of screws applied was 2 in proximal and 2 in distal fragment that resulted into plate bending i.e. fixation failure (Fig. 5). It may be because of biomechanically unstable fracture fixation which leads to loosening of screws and plate bending. Further, in this particular case the animal was also suffering from bilateral fracture of radius-ulna that may lead to excessive loading on the tibia which was repaired surgically with bone plate that resulted into implant failure. Kumar *et al.* (2018) in their study on management of femoral fractures using string of pearls locking compression plates, opined that the selection of size of plates and screws were mainly dependent upon the body weight and type of fracture. Pettitt (2013) also advocated regarding the selection of size of dynamic compression plates in canine, depends upon the patient size and bone size. He further reported that the length of the plate should be long enough to capture atleast 6 cortices in each segment of fractured bone. The screw density varied between 0.6 to 0.8 and in all cases as only locking head screws were used except in case of T-plates where the cancellous screws were used. In all the cases the screws were engaged in both the cortices i.e. in bicortical fashion. Hertel *et al.* (2001) proposed at least 6 cortices should be engaged i.e. 3 cortices on either side of fracture. Santos *et al.* (2016) in a biomechanical study of locking screws, reported that mono-cortical screws were more prone to bending than bi-cortical screws under axial compression. The radiological examination in immediate post-operative radiographs in all the animals revealed proper alignment of fractured fragments and plates and screws were properly placed. In case number 1 with bilateral radius-ulna fracture in distal third where the distal fragments in both limbs were very small the T-plates provided rigid fixation in both limbs without any significant compromise in range of motion of adjacent joints. The 60th day post-operative radiographs showed bridging of the fracture line in both limbs with minimum of periosteal callus formation (Fig. 1). Hamilton *et al.* (2005) used T-plates for the repair of distal third of radius-ulna fracture in 14 toy breed dogs and arrived on the conclusion that mini T-plates were suitable for management of radius fracture with smaller distal fragment. In case number 1, 2 and 3 fractured fragments healed without any serious complications but in case number 4 serious complications of wound dehiscence, sloughing of soft tissue over the plate and necrosis around the plate was noticed in post-operative period (Fig. 6).

Fig. 6: Showing surgical wound dehiscence and sloughing of skin due to vascular compromise in case no. 7.

This may be due to excessive manipulation of soft tissue intraoperatively i.e. lack biological fixation of fracture leading to compromise in blood supply to the affected bone and soft tissue surrounding the plate. Haffner-Luntzer *et al.* (2019) stated that conventional internal fixation with precise anatomic reduction usually requires an extensive surgical approach. This can contribute further to devascularisation and bone and surrounding soft tissue

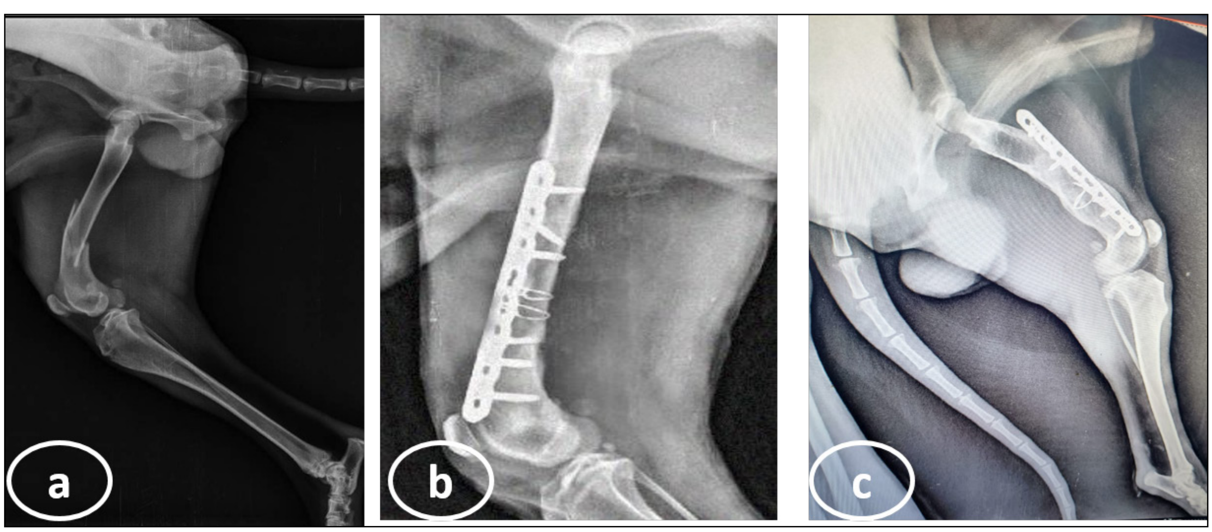

Fig. 7: (a) Pre-operative radiograph indicating femoral shaft fracture, **(b)** Post-operative radiograph, **(c)** post operative radiograph after a duration of 1.5 years

necrosis, above and beyond that initially resulting from the injury. Devascularisation also compromises the fracture healing process. The case number 5 did not turn up after 10th post-operative day. Case number 6 fixation remained stable up to 20 days thereafter on telephonic conversation with owner, it was noted that animal died due to acute gastric condition as the animal ingested the whole Robert Jones bandage and cotton. Haaland *et al.* (2009) reported that the bone plate and IM pins combination allows for mono-cortical screw placement without loss of holding power compared to bi- cortically placed cortex screws. An IM pin facilitates reduction of the fracture and restoration of normal bone length. Used together with a plate, the IM pin reduces the mechanical stress on the plate, thus increasing the strength of the construct. The case number 7 after 18 months reported about draining tract around the operated limb. This might be due to fracture related infection (Fig. 7). But as far as functional ability of the animal was concerned, the limb was stable. Slight hyperextension of limb was noticed due to stifle joint stiffness. So, we underwent for plate and wire removal as the tract infection was not being controlled by medicinal management.

CONCLUSION

It may be concluded that application of the LCP plate leads to excellent fracture management and provided very good stability to the affected limb. However, the body weight of the animal, bone involved and size of the bone must be taken into consideration while choosing the plate to be used for fracture stabilization. The plate should be fixed by involving atleast 6 screws of appropriate size meaning, three screws must be in on either side of the fractured fragments. Complications of plate osteosynthesis can vary from implant failure due to loosening of screws, bending of plate to surgical site infection, necrosis and suture dehiscence.

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