RESEARCH ARTICLE

Evaluation of Locking Compression Plate as Bone Plating and Plate Rod Construct for Tibial Fracture Repair in Dogs

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Abstract

The study was conducted on 12 clinical cases of dogs with tibial fractures, which were randomly divided into two groups consisting of six dogs in each group. In group I, fractures were repaired by bone plating using 2.7 mm or 3.5 mm locking compression plate (LCP) and in Group II, fractures were repaired by plate rod construct (PRC) using 3.5 mm locking compression plate with 1.8 mm or 2 mm K-wire. Based on clinical and radiological evaluation, the healing of the fracture was studied at different post-operative intervals (0, 15th, 30th, 45th and 60th days). Both groups underwent clinical evaluations of weight-bearing, functional limb usage and lameness grading at above intervals. On clinical observations of weight bearing of lameness grading, dogs treated with PRC showed early weight bearing compared to bone plating. Post-operative radiographic evaluation showed progressive healing of fracture site with lesser callus formation in group II compared to group I. The biochemical parameters obtained on the 0, 15th, 30th and 60th day showed a fluctuating trend. Values were within the normal physiological limit. Post-operative complication of screw loosening observed in one case on 10th day in group I. In conclusion, rigid fracture fixation by LCP with or without intramedullary pin was helpful in achieving primary fracture union in moderate body weight animals. Bone plating is ideal in treating transverse fractures, whereas PRC is ideal in treating comminuted diaphyseal fractures allowing early ambulation with tibial fractures.

Keywords: Dogs, Locking compression plate (LCP), Plate rod construct (PRC), Tibia bone fracture .

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Introduction

Fractures in animals, especially in dogs are often the result of trauma and can have serious implications on their overall health and mobility. Keosengthong *et al.* (2019) analysed the occurrence of long bone fractures in dogs and found that the femur had the highest frequency at 57.69%, followed by the tibia-fibula 10.26%. The predominant reasons for long bone fractures in dogs were due to road traffic accidents (79.40%), while 9.90% were caused by unknown trauma, 4.70% resulted from falls from height, 3.50% from animal bites, 1.40% from human abuse, and 1.10% from indoor trauma. After a diagnosis of a tibial fracture, it is suggested to use a Robert Jones bandage without delay to secure the fracture and prevent harm to the nearby soft tissues (Harari *et al.,* 1996). The use of internal fixation involves visualizing and returning each fracture fragment to its original position before stabilizing it firmly to promote bone healing. The locking compression plate (LCP) is a unique implant that has the advantages of the LC-DCP (Limited contact - dynamic compression plate) system for preserving vascularity and eliminates the need for compressive forces on the bone. The LCP is a combination of hole plate that accommodates standard screws and locking screws. As a result, only a few screws are needed for fixation, which reduces the priority of contouring the plate and they are used in a long span bridging configuration (Niederhauser *et al.,* 2015).

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The plate rod technique for treating fractures is based on the idea of biological osteosynthesis. It involves using both an intramedullary pin and a locking compression plate to fix comminuted fractures in the long bones. This technique increases the strength of the bone plate by combining it with the pin, which can neutralize various forces such as bending, compression and rotation. It provides complete stiffness to the broken bone and prevents plate fatigue and breakage due to decreased strain, resulting in a 10-fold increase in the plate's lifespan (Konning *et al.,* 2013). The current clinical research of tibial fracture repair in dogs was undertaken to

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compare and evaluate locking compression plate as bone plating and plate-rod construct through clinical, radiological and biochemical changes for tibial fracture repair in dogs.

Materials and Methods

The study was carried out following approval from the Institutional Animal Ethics Committee (IAEC) of Veterinary College, Bidar (No. VCB/IAEC/VSR-22/dated 13-01-2024) in 12 clinical cases of tibial fractures in dogs presented to the Department of Veterinary Surgery and Radiology, Veterinary College, Bidar (Karnataka, India). All clinical cases presented with history of trauma to the hind limbs and symptoms suggestive of tibial diaphyseal fractures were selected for the study. The dogs were divided into two groups with six dogs in each group. In group I, fractures were repaired by bone plating using 2.7 mm or 3.5 mm locking compression plate (LCP) and in Group II, fractures were repaired by plate rod construct (PRC) using 3.5 mm locking compression plate with 1.8 mm or 2 mm K-wire. Before operation, an "informed consent form" was obtained from the owner of each animal.

Pre-operative medio-lateral and cranio-caudal radiographs of the contralateral limb were obtained to determine the size and length of the plate and screws in groups I and II. In case of group II, the length of intramedullary pin (K-wire) was evaluated, and diameter was measured at narrowest site of tibia excluding cortices occupying 30 to 40% of the medullary cavity, enabling room for screws to be implanted (Reems *et al.,* 2003). The dogs were kept off-fed for 12 h and off water for 6 h. Premedication with atropine sulphate (0.04 mg/kg b.wt.) intramuscularly was done 10 min prior to administration of xylazine hydrochloride (1 mg/kg b.wt.) intravenously. After 15 min, propofol (5 mg/kg b.wt.) was injected intravenously "to-effect" to produce general anaesthesia. Once the jaw relaxed, dogs were intubated with endotracheal tubes of suitable size and connected to inhalant circuit. After intubation, anaesthesia was maintained by 2-2.50 % isoflurane with oxygenation. The surgical procedures followed were as per standard norms described by Reems *et al.* (2003).

Post-operatively, the suture site was cleaned using colloidal silver ointment with a layer of sterile bandage. It was then rolled with soft gauze and was supported by crepe bandage for 5 days. The dressing was changed every alternate day until the sutures were removed on the post-operative day 12. Amoxicillin-sulbactam (10 mg/kg b.wt.) b.i.d., for 7 days, and tramadol (4 mg/kg b.wt.) s.i.d., for 3 days, were administered intravenously. For 4-6 weeks, animals were permitted to engage in brief leash walks and restricted exercise. Owners were advised passive range of motion to the affected limb on every alternate day post-operatively during the change of bandage and for a few days after discontinuing bandage to facilitate movement of joint.

Fracture healing was evaluated clinically, radiographically and biochemically in individual cases of both the groups. Clinically and radiographically, cases were evaluated pre-operatively and on post-operative days 0, 15th, 30th 45th and 60th days. Clinical evaluation was performed to assess the weight-bearing for lameness grading as recommended by Vasseur *et al.* (1995). Based on the radiographs implant position, union of fragments and callus formation were studied. A radiographic scoring was carried out to each radiograph to evaluate the fracture healing as given by Cook *et al.* (1999). Biochemical parameters such as serum alkaline phosphatase, serum calcium and serum phosphorus were recorded on 0, 15th, 30th and 60th post-operative days in both groups. Intra-operative and post-operative complications were studied in both the groups. The data obtained was subjected to statistical analysis by using student's 't' test (Snedecor and Cochran, 1994).

Results and Discussion

Details of clinical evaluation for post-operative lameness grading are recorded in Table 1. Pre-operatively, all dogs of group I and II exhibited grade V lameness. In group I, all the six dogs achieved lameness Grade I during the period of study. By the end of the 30th post-operative day, three dogs out of six dogs achieved a Grade I lameness, three dogs achieved a Grade II lameness. By the end of the 45th post-operative day, all dogs achieved a Grade I lameness. Similar findings were observed by Garcia *et al.* (2020) and Namreen *et al.* (2022). In group II, six dogs achieved Grade I lameness over the course of the study. By the end of the 30th post-operative day, five dogs out of six dogs achieved a Grade I lameness, one dog achieved a Grade II lameness. By the end of day 45th post-operative day, all the dogs achieved Grade I lameness. Similar finding was observed by Wangchuk *et al.* (2021).

Details of biochemical parameters of post-operative fracture healing are recorded in Table 2. In group I and II, the average level of serum alkaline phosphatase was found to be highest on the day before surgery, consistent with the findings of Patil *et al.* (2017) and Pooja *et al.* (2025). The lowest level of serum alkaline phosphatase was observed on the 30th day after surgery, with a slight increase in concentration on the 60th day. All measured values fell within the normal physiological range. Previous studies by Ojus *et al.* (2022) and Pooja *et al.* (2025) have suggested that two factors - increased chondroblastic proliferation during fracture repair and the high concentration of serum alkaline phosphatase in the periosteum of destroyed bone - contribute to increased levels of serum alkaline phosphatase.

Both groups displayed a gradual escalation in the average serum calcium concentration from the day before the operation to the 15th day after it, followed by a subsequent gradual decline until the 60th day. The peak values were seen on the 15th day in both groups. All recorded values fell within the normal physiological range. These results were in accordance with Bhavani *et al.* (2022). The rise in serum calcium levels observed between the pre-operative day and 15th post-operative day during fracture healing might be attributed to heightened osteoclastic activity at the

fracture site, resulting in the breakdown of necrotic bone (Pooja *et al.,* 2025). In both study groups, the average values of serum phosphorus levels gradually increased from the pre-operative day until the 30th post-operative day, after which the concentrations steadily decreased until the 60th post-operative day. The maximum concentrations were observed on the 30th post-operative day in both groups, and all measured values fell within the physiological range. Bidari (2021) suggested that osteoclastic activity at the fracture site might contribute to the gradual decline in serum phosphorus levels due to the resorption of necrotic bone.

Radiologically, in group I (Fig.1), day 0 and post-operative 15th day radiographs depicted the appropriate alignment and apposition of fracture fragments in all the five dogs. The edges of the fracture displayed reduced sharpness, and mild callus formation in four of the six dogs, while bridging callus was observed in one case. Similar findings were observed by Mehdi (2023) and Radha (2023). In one case, screw loosening was observed. On the 30th day after surgery, radiographs showed that five cases had effectively formed bridging callus at the fracture site, while the stability of the implant and fracture fragments were deemed satisfactory in six dogs. The formation of callus during fracture healing indicates a process of osteogenesis and osteoblastic activity. This was in accordance with Doijode *et al.* (2018) and Singh (2019). On the 45th day, radiographic assessment showed gradual disappearance of the fracture line and the formation of a bony callus at the fracture site. The callus demonstrated a radiopacity like that of healthy bone. One case showed no visible fracture line on radiographs, earning a radiographic score of zero in accordance with Khan *et al*. (2022). Radiographic images taken on the 60th day post-surgery revealed complete healing in four canines with no evidence of a fracture line on the radiograph. The observations on the 60th day revealed complete union of bones with absence of fractured line. This was in accordance with Dakhane *et al.* (2021) and Mehdi (2023).

In group II (Fig. 2), immediately following the operation, appropriate contact and alignment of the fractured fragments were observed in all six dogs. The radiographs

Table 1: Mean (±SE, n=6) grading of lameness in dogs under tibial fractures repair by LCP (Gr-I) and PRC (Gr-II) techniques

Group	Pre-operative	Day 0	Day 15	Day 30	Day 45	Day 60
I	5.00±0.00	3.66±0.51	2.16±0.75	1.50±0.22	1.00±0.00	1.00±0.00
II	5.00±0.00	3.83+0.40	2.16±0.40	1.16±0.40	1.00±0.00	1.00±0.00

Table 2: Mean ± SE values for biochemical parameters of dogs undergoing tibial fractures repair by LCP (Gr-I) and PRC (Gr-II) techniques

Parameter	Group	Pre-operative	0 Day	15th Day	30th Day	60th Day
Serum alkaline phosphatase (IU/L)	I	114.17±1.28	104.33±1.12**	94.67±1.26^{**a}	83.50±1.12**	88.33±2.09**
	II	111.17±1.17	103.33±2.16**	86.50±2.36^{**b}	83.17±2.63**	89.83±1.92**
Serum calcium (mg/dL)	I	9.17±0.03	9.76±0.03**	11.05±0.04^{**a}	10.67±0.05**	10.28±0.03**
	II	9.19±0.03	9.71±0.02**	11.44±0.05^{**b}	10.74±0.04**	10.33±0.03**
Serum phosphorus (mg/dL)	I	3.30±0.04	3.54±0.03^{**a}	4.22±0.05**	4.75±0.04**	4.33±0.06**
	II	3.26±0.04	3.72±0.05^{**b}	4.24±0.03**	4.84±0.04**	4.45±0.06**

Means within the row with the superscript **(p≤0.01) and *(p≤0.05) differ significantly from pre-operative values. Means within the column with superscript ($^{a, b}$) differ significantly (p≤0.05) between the groups.



Fig. 1: Sequential radiographs in medio-lateral views of Group I at pre-operative, post-operative 0, 15th, 30th, 45th and 60th day showing the repair of transverse mid diaphyseal tibial fracture with locking compression plating.

taken on the 15th day after surgery showed satisfactory alignment and stability of the fractured fragments in all cases. There was an observed loss of distinctness at the edges of the fractures. Additionally, radiolucent fracture lines were evident in all the cases. Radiographs taken on the 30th day after surgery showed that three cases had developed good callus formation while the other three showed moderate callus formation. There was periosteal and endosteal callus formation during the 30th day following the surgical operation. On the 45th day after the surgery, radiographic assessment showed gradual filling of the fracture site with the formation of a bony callus, which appeared similar to normal bone tissue. The fracture line became increasingly faint. On the 60th day after surgery, radiographic images showed significant development of callus towards bone healing in all the cases. The implant and fractured fragments remained stable in all cases. This was in accordance with Wangchuk *et al.* (2021).

No intra-operative complications were observed in any of the groups. Post-operative complication was seen in Group I, one out of six dogs experienced screw loosening on the 10th day after surgery and repeat surgery was performed two days after, using a 2.7 mm locking compression plate and cerclage wiring to improve the stability of the distal fracture fragment. This was in accordance with El-shafey *et al.* (2022). In Group II, no post-operative complication was observed in any of the dogs.

Conclusion

Based on the current findings, it is concluded that bone plating using locking compression plate provides a satisfactory result with proper realignment of bone fragments, ideal for transverse diaphyseal fractures, while plate rod construct technique offers a versatile and effective solution for managing comminuted diaphyseal tibial fractures in dogs. Early ambulation with complete weight bearing could be obtained equally by both techniques, *i.e.,* bone plating and plate rod construct. Utilization of two implants for load sharing results in a more robust and rigid repair in comparison to solely using a bridging plate.

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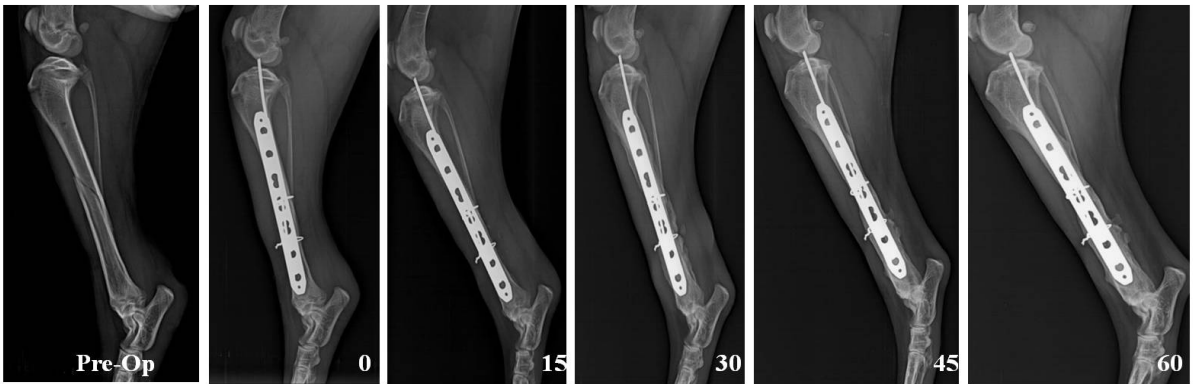


Fig. 2: Sequential radiographs of medio-lateral views of Group II at pre-operative, post-operative 0, 15th, 30th, 45th and 60th day showing the repair of comminuted spiral diaphyseal tibial fracture with plate rod construct (PRC).

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