Radiological and Clinical Outcomes of Locking Compression Plating Technique in Long Fracture of Dog : 12 Cases

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Abstract:- The research was carried out on twelve canines that presented with long fractures at Veterinary clinical complex, Nagpur veterinary college, Nagpur. The fracture was identified pre-operatively with orthopaedic and radiographic examinations. Fracture stabilization using the method of open reduction and internal fixation was used in all twelve canines. This procedure included the utilization of 3.5mm locking compression plates. Furthermore, the use of applied appropriate plate size and cortical screws size is seen. As a consequence, the outcome yielded effective fracture repair and immobilization. Radiographic analysis disclosed the presence of periosteal and the production of endosteal callus begins during the second week after the surgical procedure. The complete elimination of the fracture line and the achievement of radiographic union in the fracture site. Fragments were observed during the sixth week after the surgical procedure seen indicating successful healing of the broken bone with little production of callus. The presence of stable fixation was noted in all instances by the eighth postoperative week. Recorede lameness at different interval post operstively. The research did not include records of frequently seen problems such as osteomyelitis, delayed union, malunion, and nonunion.The application of the LCP plate was determined to be efficacious in the management of long bone fractures in canines by the use of early pain-free ambulation.

Keywords:- *Fracture Healing, Dogs, Long Bone Fracture, Locking Compression Plate, Radiology.*

I. INTRODUCTION

Bone is a specialized type of connective tissue that consists cells, fibers and ground substance. The long bone is a form of bone that extends from one end to the other and has a central shaft in between. The ends, known as epiphysis, are made up of cancellous bone, whereas the bulk of the shaft, known as the diaphysis, is made up of cortical bone. Acute non-physiological stresses that exceed ultimate tensile strength over bone are the most prevalent cause of bone fractures (Burns, 2010).

The dog is still the most common animal model for long bone fractures seen in veterinary hospitals, especially those in large cities (Julie et al., 2007). In instance, femur fractures account for 37% of all long bone fractures, followed by those in the radius and ulna (28.5%), tibia and fibula (20.4%), and humerus (7.9%) (Kallianpur et al., 2018).

The primary goals of fracture therapy are the preservation of intramedullary and periosteal vascularization, anatomical reduction, interfragmentory compression of bone fragments, and the fast restoration of normal locomotor function (Newton, 1985).

The fracture's prognosis and the speed with which an ambulance is sent depend on accurate diagnosis and treatment. Fracture fixation can be accomplished through a variety of methods (Dueland et al., 1999; Piermattei et al., 2008; Coutinho et al., 2015) including external coaptation, external skeletal fixation, platting technique with dynamic compression plate, locking compression plate, string of pearls plate, intramedullary pinning, cross pinning, and so on.

According to Niemeyer and Sudkamp (2006), the locking compression plate combines the principles of direct anatomical reduction osteosynthesis and bridging plate osteosynthesis into a single implant. If the vascularity of soft and stiff tissues is not thoroughly studied, even the greatest stabilizing system is of little help. In order to make the change from external to internal fixators, the locking compression plate is used.

Among the external coaptation problems include soft tissue injuries and fracture diseases such as joint stiffness, muscle atrophy, and disuse osteopenia (Harasen, 2012). But there are other risks linked with metallic implants. When implants are placed, they disrupt blood flow because soft tissue and periosteum must be removed. The use of high-velocity drills causes injury to the blood vessels during screw installation (Rochat and Payne, 1993). Open fractures have been associated to a greater risk of infection and post-healing complications (Zalavras et al., 2007).

II. MATERIALS AND METHODS

The present study was conducted on 12 clinical cases of dogs having long bone fracture presented to the Department of Veterinary Surgery & Radiology, Nagpur Veterinary College, Nagpur selected for the study with different age group. Fracture was immobilized by locking compressive bone plating alone. The fracture repair was investigated using a variety of criteria. Animals was fasted for 12 hours and water withdraw for 6-8 hours prior to surgery. Prior to surgery, all patients received intravenous fluid treatment in the form of Ringers Lactate solution @ 60 ml/kg b.w. Similarly, an hour before surgery, preventive antibiotics like Inj. Cefotaxime (25 mg/kg) and anti-inflammatory drugs Inj. Meloxicam (0.2-0.3 mg/kg) was given intramuscularly to reduce the pain. All the animals included in the research was fasted for 12 hours overnight, while the water was withheld for 6 hours before anaesthesia. Intra-cath catheter was inserted in the cephalic vein for ease in the administration of anaesthetic drugs in each group. The surgical site was prepared aseptically after shaving and scrubbing with chlorhexidine- cetrimide solution. The surgical site was sprayed with 95 % ethanol and the animals was covered with sterile drape during surgical procedure. Inj. Atropine sulphate was injected at the 0.04mg/kg body weight by IM route in all the dogs in both the groups. After 10 minutes administered Inj. Xylazine @ 1 mg/kg body weight I/M in both the groups. After 10 minutes of administration of premedicants an over the needle intravenous catheter was fixed in either the right or left cephalic vein. In all animals 10 min after pre-anaesthetic administration, induction was achieved with Inj. Ketamine and Inj. Diazepam in both the groups slowly in order to just achieve endotracheal intubation by depressing the epiglottis with a laryngoscope and achieved (absence of pedal reflex and ventral rotation of the eye). The patient was observed for eye position, absence of palpebral reflex, muscle tone, response to opening of mouth and tongue movement etc. for intubation. Then anaesthesia was maintained with Inj. Isoflurane upto complete operation. Endotracheal intubation was performed in lateral recumbency with suitable endotracheal tube of (4.5 to 9 OD mm) with guidance of laryngoscope in both the groups. Endotracheal tube and laryngoscope was used to maintain patency of the airway and to counter any respiratory emergency beforehand which could have arisen during the operative procedure. In the instance of an open surgical technique, the fracture site was exposed using normal methods and the fracture was manually reduced by applying enough traction and counter-traction. Incisions was made on the lateral surface of the femur. The lowman's bone clamp was used to maintain the bone fragments in good apposition after they had been properly reduced. Then a suitable locking compression plate (LCP) was placed and secured with screws on each side of the fracture line. Then suture the muscles with No. 1 chromic catgut with simple irrupted suture. The skin incision was closed in a row of cruciate mattress suture using 2-0 polyamide. Then, suture line was covered with a thin layer of sterile gauze bandage dipped in 5% povidone-iodine solution and a thick layer of cotton pad was overwrapped. It was then covered with gauze bandage and finally, a layer of surgical paper tape was applied to provide additional protection. The dressing was changed every alternate day until the sutures were removed on the 12th post-operative day. Ceftriaxone sodium was administered at the rate of 25 mg/kg body weight as intramuscular injection twice a day for 7 days post-operatively. Meloxicam was administered once a day at the rate of 0.3 mg/kg by intramuscular injection for 3 days. Owners were advised to restrict the movement of the animal for the first 2 weeks of surgery and then to allow leash walking for next few days. The surgical wounds healed well in all the dogs without any complications. The skin sutures were removed on the 12th postoperative day in all the dogs. To determine the orientation of the fracture, radiographs of the afflicted limb in anterio-posterior (AP) and mediolateral (ML) views was taken before surgery and immediately after surgery in all the dogs. Radiographs of the affected bone was taken immediately after surgery, as well as on 7th, 14th, 28th and 45th day later to examine the fracture fragment alignment, callus formation, plate and screw status and fracture healing in both the groups. Parameters was evaluated in radiography including plate and screw position, Bone fragment alignment, Bone fragment anatomical apposition, Callus production, Implant material employed and its response with bone, Fracture healing in the radiographic stage.

III. RESULTS AND DISCUSSION

In present study, total 12 clinical cases of the dogs with long bone fracture presented at Veterinary clinical complex, Nagpur veterinary college , Nagpur. Locking compression bone plating was done to immobilise the fracture. The healing of the long bone fracture bones was assessed by evaluating the different parameters at different time intervals. Pre operative medio lateral (ML) and anterio-posterior (AP) radiographs of long bone of affected limb were taken.

The details of study of case in both groups were recorded and deplected in table 1. This study revealed that Non descript dogs (n-10) had higher prevalence followed by rottweiler (n-1) and German shefered (n-1) breeds. The total of 8 female dog and four male dog between age groups of 1-4 years were recprded. Etological factores responsible for fracture of lone bone in dog (n-12) were due to automobile accidents with four wheelers / two wheelers.

Table 1 Details of Cases when LCP Bone Plating was Performed

Case No.	Breed	Gender (M/F)	Age (Years)	Etiology	Location	Type of Fracture	Left/ Right Limb
1	ND	F	2 year	Automobile accident	Midshaft Femur	Transverse	Left
2	ND	F	1.5 year	accident	Midshaft Femur	Transvers	Left
3	ND	F	2 year	accident	Distal 1/3rd Tibia	Short oblique	Right
4	Rottweiler	M	2 year	Automobile accident	Proximal 1/3rd Femur	Long Oblique	Left
5	ND	M	1.2 year	Accident	Proximal 1/3rd Femur	Short oblique	Left
6	ND	M	1.5 year	Accident	Midshaft Femur	Transvers	Left
7	ND	M	1 year	Automobile accident	Proximal 1/3rd Radius and Ulna	Transverse	Left
8	ND	F	2 year	Accident	Midshaft Radius and Ulna	Transverse	Right
9	ND	F	1.5 year	Accident	Distal 1/3rd Femur	Short oblique	Right
10	German shefferd	F	4 year	Accident	Proximal 1/3rd femur	Short oblique	Left
11	ND	F	2 year	Automobile accident	Midshaft Humerus	Transverse	Right
12	ND	F	1.5 year	Automobile accident	Midshaft Tibia	Short oblique	Left

The selection of plates and locking head screws in both the groups were done by measurement of length and diameter of bone on preoperative survey radiographs as well as on actual assessment of bone during surgical procedure. The details of plates and locking head screws sizes used in the cases are given in Table 2 .

Table 2 Size of the Locking Compression Plate (LCP) and Locking Head Screws

Case No.	Locking Compression Plate (Holes)	Locking Head Screws	
		Diameter (mm)	Length (mm)
1	6 Holes	3.5	10 to 28
2	9 Holes	3.5	10 to 28
3	9 Holes	3.5	10 to 28
4	8 Holes	3.5	10 to 28
5	10 Holes	3.5	10 to 28
6	8 Holes	3.5	10 to 28
7	8 Holes	3.5	10 to 28
8	10 Holes	3.5	10 to 28
9	7 Holes	3.5	10 to 28
10	8 Holes	3.5	10 to 28
11	8 Holes	3.5	10 to 28
12	8 Holes	3.5	10 to 28

Aithal (1996) recorded that majority of the fractures (54%) were in young animals, aged less than one year while Simon *et al.,* (2010) found a higher incidence of fractures like 46.02 %, in dogs below one year of age. Dakhane (2021) found 50% were in young animals, age less 1 year. Earlier researchers also noted a high incidence of femur fractures in dogs Patil *et al.,* (1991) recorded in femur (35 %), followed by tibia (23%) humerus (13.3 %) and radius-ulna (11.4%). Raghunath et al., (2007) noted highest incidence of fractures in femur (78.0%) followed by humerus (12%) and tibia (10%) respectively out of 103 long bone fractures in a retrospective study of 100 dog. Bennour *et al.,* (2014) assessed the prevalence of the most common long bone fractures in dogs and cats and noted that in both the species, femoral bone was the most affected (19/46 cases) and the frequency of femoral bone fracture (19/46 cases) was significantly higher than tibio fibular bone fracture (9/46 cases). Patil *et al.,* (2018) recorded highest fracture prevalence in femur bone (36.59%) and the type of fracture based on direction of fracture line was simple transverse (36.59%) in canine species respectively.

Weight bearing of affected limb was recorded from 1st to 10th post operative day. The weight bearing was recorded and analysed critically and it was scored at different levels by observing while standing, walking and running as per observations by to Aithals (1996).

In all instances were observed carrying the limb while standing observed in three cases on 3rd day, two cases on 4th day and one case on 5th day. During walking partially touching toe was recorded on 6th day in two cases, partially touching toe on 6th day in two cases while on 7th day in two cases. During running, frequent touching toe in one case, partially touching toe in three cases and touching toe in two cases were observed on 10th day postoperatively.

Table 3 Details of Weight Bearing in Group I

Case . No	Standing	Walking	Running
1	Carrying limb on 3rd days	Partially touching toe 5th day	Frequent touching on 10th day
2	Carrying limb on 4th days	Partially touching toe 6th day	Touching toe on 10th day
3	Carrying limb on 5th days	Partially touching toe 7h day	Partially touching toe on 10th day
4	Carrying limb on 3rd days	Partially touching toe 6th day	Partially touching toe on 10th day
5	Carrying limb on 3rd days	Partially touching toe 5th day	Touching toe on 10th day
6	Carrying limb on 4h days	Partially touching toe 7th day	Partially touching toe on 10th day
7	Carrying limb on 4th days	Partially touching toe 6th day	Frequent touching on 10th day
8	Carrying limb on 4th days	Partially touching toe 6th day	Touching toe on 10th day
9	Carrying limb on 5th days	Partially touching toe 7th day	Partially touching toe on 10th day
10	Carrying limb on 4th days	Partially touching toe 6th day	Touching toe on 10th day
11	Carrying limb on 5th days	Partially touching toe 7th day	Partially touching toe on 10th day
12	Carrying limb on 3rd days	Partially touching toe 5th day	Touching toe on 10th day

In locking compression plating the less time required to attain normal gait could be due to minimum contact of plate to periosteum of bone which could have reduced pain and also helped in good amount of soft callus formation on both sides of plate (cis and trans cortex) providing extra stability at the fracture site. Minimal exposure of fracture fragments together with gentle manipulation of bone segments during surgery could also have helped in reduction of pain and excellent limb usage by the cases.

In all cases no change in the shape of the limb with respect to angulation, rotation and muscle atrophy was observed during the entire study in all the cases**.** Normal shape of the operated limb in all the cases could be due to rigid and stable fixation in all cases was observed. During this study no change in shape of limb in the cases could be due to the rigid and stable fixation provided by the locking compression plates in group was observed. The absence of joint stiffness, rotational deformities and limb shortening added to normal usage of the affected limb. Similar findings were observed by Chavan, 2013 and Dakhane, 2021.

In all cases not observed any soft tissue damage on post operatively

Complication due to implant failure was observed in case (n-5) observed that loosening of implant on 28th day post operatively.

➢ *Radiographic Evaluation*

To determine the orientation of the fracture, radiographs of the affected limb in anterio-posterior (AP) and mediolateral (ML) views was taken before surgery and immediately after surgery and on 0th 7th, 14th , 28th and 45th day post surgery and the following parameters were evaluated in both the groups.

- *Plate and Screw Position*

The status of the apparatus (plate and srcew) was evaluated on the 0th 7th , 14th , 28th and 45th day post operative day.

Radiographs taken immediately after surgery showed the status of fracture reduction, alignment, fixation and proper positioning of the plate and screws was observed. Similar finding were recorded by (Chavan, 2013) when he used the locking compression plate in long bone fracture in dogs.

- *Bone Fragment Alignment*

Radiographs (ML and AP views) were evaluated on 0th 7th , 14th , 28th and 45th day for alignment of fracture fragments.

Good alignment of fracture fragments was observed throughout the study period in cases treated with locking compression plate indicating proper fixation of locking compression of plate in all cases.The good alignment of fracture fragments throughout the study indicate rigid and stable fixation was observed due to stability provided by the plate. Locking of screw head in plate hole eliminated toggling of screws and loss of reduction. In all cases alignment is basically an assessment of the restoration of the bone as a whole and return to normal alignment was necessary for normal bone function Piermattei et al. (1991) and Chavan, (2013).

- *Bone Fragment Anatomical Apposition*

The apposition of femur fracture fragments was recorded and evaluated on 0th , 7th , 14th , 28th and 45th day.

All the cases exhibited good apposition of fracture fragments throughout the study period were the cases treated with locking compression plate in dogs whereas backing out of all the proximal locking head screws and loosening of implant on 34th day . Good apposition of fracture fragments throughout the study indicates sufficient stability at fracture site and also it was effective neutralization of axial loading, bending, shearing and rotational forces acting on the bone by the locking plate construct. Similar observations recorded by Chavan, 2013.

- *Callus Production*

Newton (1985) reported that in a complete bone fracture, there is a loss of bone continuity, resulting in severe inflammation and pain at the fracture site and callus formation between the fractured fragments is impossible in the absence of appropriate immobilisation.

In all cases, a radiograph taken immediately after surgery provided fracture reduction, alignment and fixation of bone. In this group , the placement of Locking compression plate was satisfactory in all animals. The presence of alignment indicate sufficient stability at fracture site.

Radiograph examination on 14th day revealed that in ten cases early callus formation at fracture line While in two cases observed that no evidence of callus formation. According to Sirin et al., (2013), humeral, radial, femoral, and tibial fractures that were immobilised by LCP and further radiographic examinations on the 10th post-operative day revealed disappearance of pointed extremities of the fractured fragments as well as early callus formation.

Radiograph examination on 28th day revealed that bridging of periosteal callus at fracture line and disappearance of fracture line in ten cases while in two cases initiation of periosteal proliferation at fracture line and fracture line invisible.

Sirin *et al.* (2013) found that by immobilising humeral, radial, femoral and tibial bone fractures with LCP for 4 weeks after surgery, the fracture line disappeared and a callus formation.

Radiograph examination on 45th day revealed that bridging and mineralisation callus covering fracture line in eleven cases while in one cases callus formation at fracture line was observed.

Humeral, radial, femoral and tibial fractures were immobilised by LCP and reconfiguration had begun by the eighth week post-operatively (Sirin et al., 2013). Schwandt and Montavon (2005) observed that complete bridging and remodelling of the callus 53 days after surgery. According to Haaland et al. (2009), observed that the average healing time for canine appendicular fractures treated with LCP was seven weeks. Locking internal fixators permit callus formation by increasing the flexibility of stabilisation through the use of LCP (Greiwe and Archdeacon, 2007).

- *Implant Material Employed and Its Response with Bone*

The implant material employed and its was evaluated all cases. None of cases exhibited any on towards reaction to implant which was evident on radiographs taken in both the groups at 0th , 7th , 14th , 28th and 45th day. This could be due to the non bio-reactive and inert nature of plates and screw in both the groups. Similar findings were recorded by Chavan, 2013 when he used the locking compression plating in long bone fracture in dogs.

- *Fracture Healing in the Radiographic Stage*

Prior to surgery, no radiographic union was observed between fractured fragments in all cases. In the event of a fracture, the continuity of the bone is broken. Without appropriate immobilisation, callus formation between the fractured fragments is impossible (Newton, 1985), resulting in severe inflammation and pain at the fracture site.

In all cases, a radiograph taken immediately after surgery provided fracture reduction, alignment and fixation of bone. In this group , the placement of Locking compression plate was satisfactory in all animals. The presence of alignment indicate sufficient stability at fracture site.

Radiograph taken on 7th day revealed that sufficient stability at fracture site peoper position of plate and screw.

On the 14th day, a radiograph revealed that the formation of early periosteal callus in the fracture line and the precise alignment of the fracture fragment. In two case observed that no periosteal proliferation observed while in ten Cases early periosteal proliferation at fracture line with callus formation.

In case According to Rajhans (2013) and Kumar (2016), there may be a moderate periosteal reaction around the fracture site and the area of bone loss, accompanied by the formation of a trace callus. Activated periosteum has a deceptive anatomical consistency, and the change is accompanied by the production of matrix and the proliferation and death of cells. The configuration of a periosteal reaction was indicative of the nature and severity of the inciting process (Ragsdale *et al*., 1981).

On 28th day, a radiograph revealed the formation of periosteal callus, a faintly visible fracture line, and the proper positioning of the plate and screw. In ten cases observed that periosteal bridging callus and fracture line were visible, whereas in two cases observed that periosteal reaction initiated at the fracture line and fracture line were visible.

Due to the use of periarticular locking devices in the stabilisation of distal femur fractures, inconsistent and asymmetric periosteal callus formation was observed (Lujan *et al.,* 2010). Yadav (2016) observed that fracture union was excellent and radio dense callus was observed at the fracture fragment four weeks after surgery. Initiation of periosteal reaction at a distance from the fracture site on the 15th post-operative day transformed into a mild radiolucent area on the 30th post-operative day, according to Kumar (2016).

On 45th day, radiograph revealed that perfect alignment of bone, periosteal bridging callus and callus appeared densified. In one cases observed that the primary callus formation between the periosteal space and fracture line was partially visible, whereas in eleven cases, the bridging callus almost formed and the bone fragments united perfectly.

Hespel *et al.* (2013) radiographically observed evidence of normal bone healing, including the formation of bridging callus at the tibial fracture site and secondary bone healing at the fibular fracture site, in a grey seal treated with a string of pearls (SOP) locking plate after six weeks.

Gupta (2015) and Kumar (2016) observed that complete union and bridging of the fracture line occurred in the eighth week following surgery. Johnson et al. (1996), Nadkarni *et al.* (2008), Raghunath and Singh (2008), Manjunatha *et al*. (2011), Coutinho (2012), and Sirin *et al.* (2013) have also reported findings similar to ours.

IV. CONCLUSION

On the basis of observation recorded during present study, following conclusions are drawn :

- Incidence of fractures was more common in non-descript dogs compared to other breeds of dogs. Femoral fracture were the highest incidence due to automobile accident is the major cause of fracture.
- Locking Compression plate provided good healing of fracture supported by dense periosteal bridging callus and less delayed in mean time to attain full mobility.
- None of cases exhibited any reaction to implant used during study in all cases.
- Locking compression bone plating used in all animals provide satisfactory fracture stability and early weight bearing.
- Hematobiochemical variations did not altered the fracture healing process in all cases.
- Locking compression plate show similarity in all bending direction in fracture of long bones.
- The fixation accomplished via the use of a locking compression plate exhibits both flexibility and stability, hence facilitating the expeditious healing of fractures through the creation of callus.
- The total immobilization of the screw head inside the plate hole effectively mitigates the potential for screw toggling and subsequent loss of reduction.
- This research demonstrates that the use of locking compression plates for fracture repair is associated with favorable outcomes, including early rehabilitation and a high likelihood of achieving satisfactory recovery of limb function.
- Locking compression plates have shown efficacy as implants for diaphyseal fractures of long bones, as evidenced by the high success rates and low complication rates seen in the current research. These plates are poised to play a significant role in the future of bone plating.

Fig 1 Before Surgery Tibia

Fig 2 7th Day Tibia

Fig 3 14th Tibia

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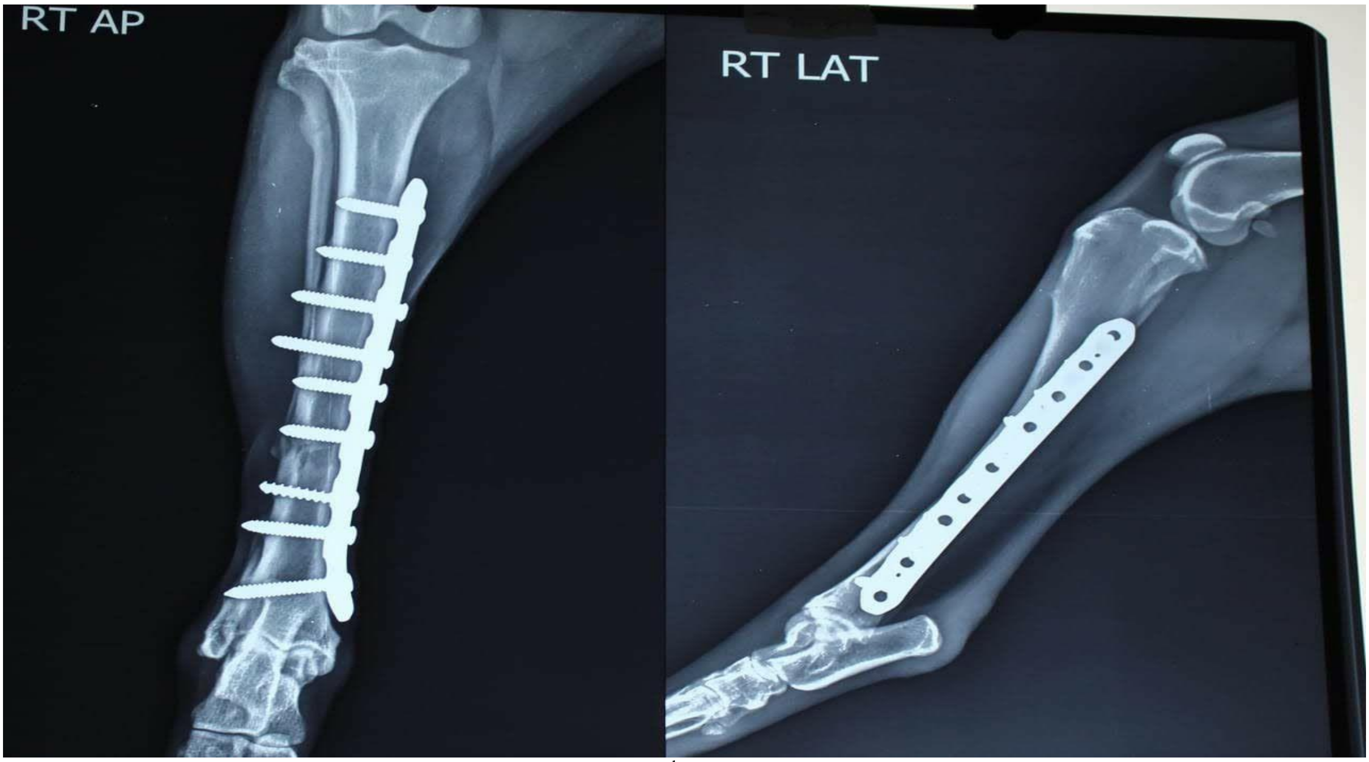

Fig 4 45th Day Tibia

Fig 5 28th Day

Fig 6 28th Day

➢ *Femur*

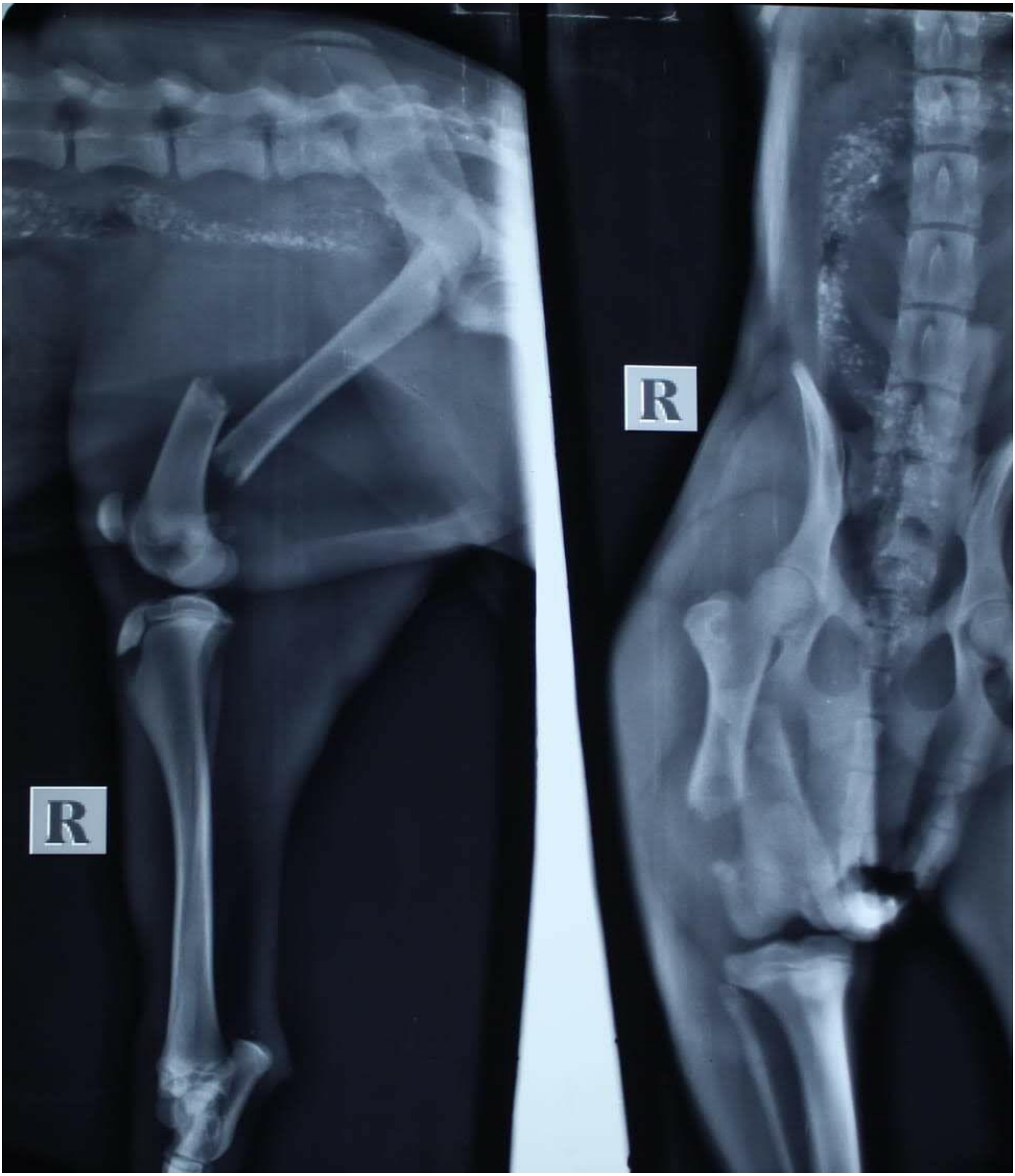

Fig 7 Before

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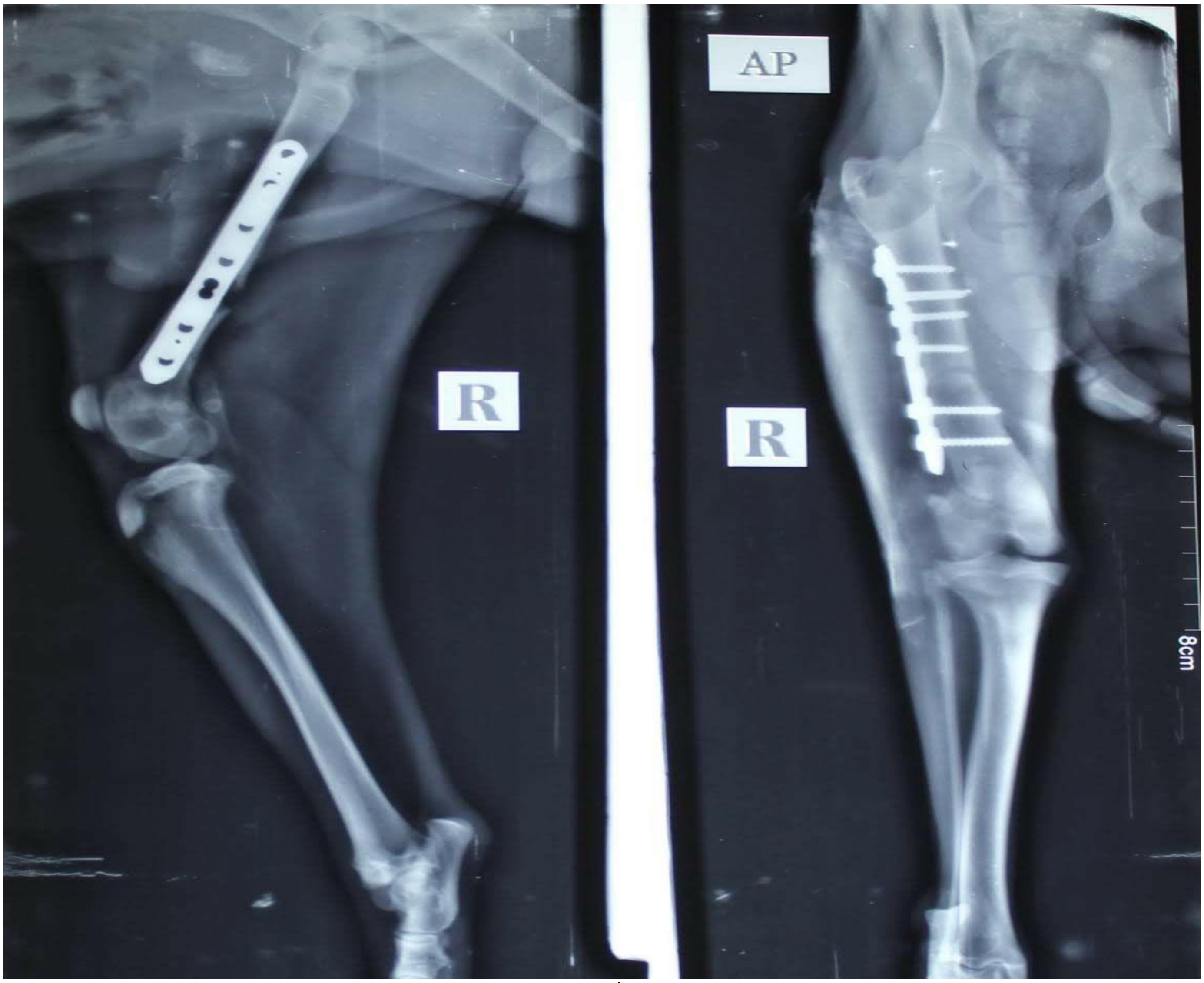

Fig 8 14th Day

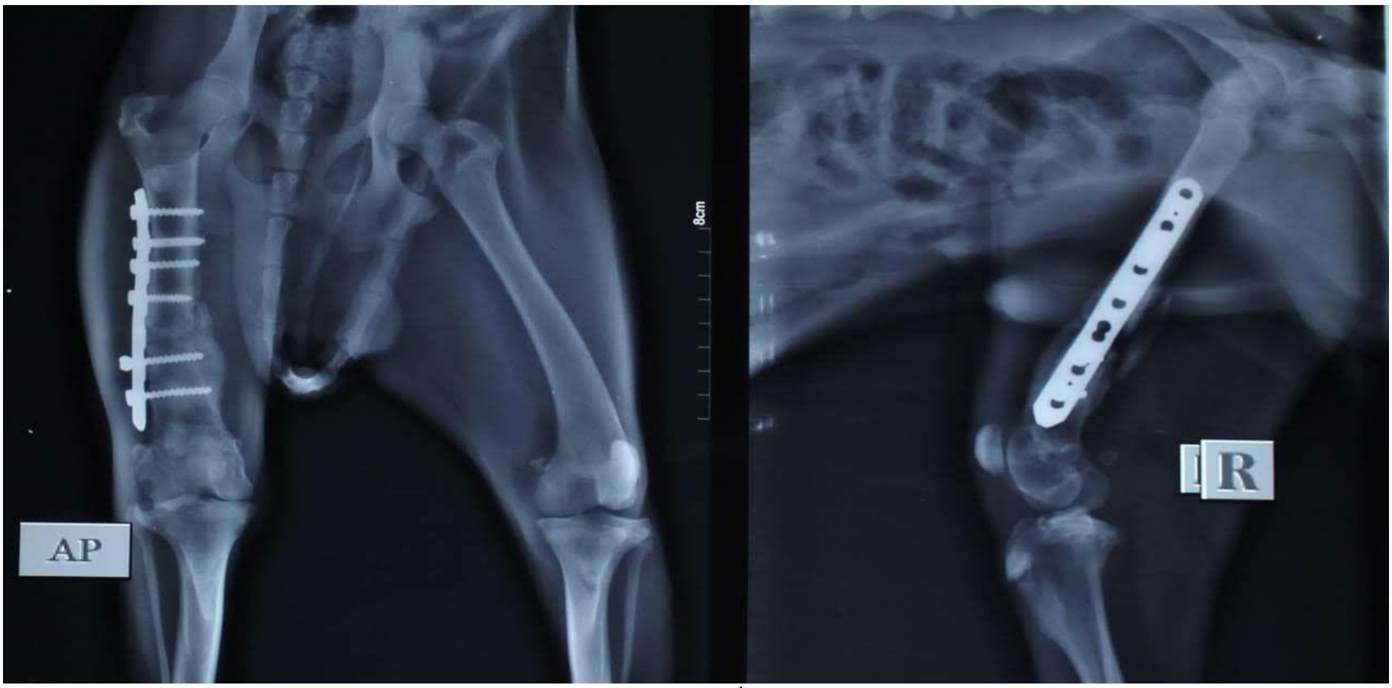

Fig 9 28th

Fig 10 45th Day

- *How to Cite This Article::*
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