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A clinical study on the use of point contact fixator plate system (PC-FIX) in the treatment of radius ulna fractures in dogs

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Abstract
The present clinical study on the use of Point contact Fixator (PC-Fix) plate in the treatment of radius ulna fractures was conducted in four dogs presented for treatment at the Department of Surgery and Radiology, College of Veterinary Science, Rajendranagar, Hyderabad. The age of the dogs ranged from 5 - 48 months. Out of these four dogs, three were females and one male. All dog were Mongrels. The body weight of the dogs ranged from 10 to 20 kg.

The fractures were diagnosed by clinical signs, orthopaedic examination and survey radiography. Pre-operative radiographic examination in two plain orthogonal views, i.e., cranio-caudal and medio-lateral radiographs revealed closed mid diaphyseal transverse fractures of radius and ulna.

These fractures were stabilized with 2.7 mm PC-Fix in one dog and 3.5 mm PC-Fix in three dogs and resulted in good fracture fixation and immobilization. In dogs weighing less than 10 kg, 2.7mm Point Contact Fixator (PC-Fix) plates were used and in dogs weighing more than 10kg, 3.5mm Point Contact Fixator (PC-Fix) plates were used. The length of the plates and screws to be used was determined by the length of the bone and trascortical diameteras measured from the mediolateral and cranio-caudal radiographs obtained pre-operatively.

Immediate post-operative radiographic evaluation confirmed proper placement of the plates and screws, apposition and alignment of the fracture fragments in all the eight dogs. Immobilization was considered satisfactory in all the cases. The plate length, size and position were appropriate in all the cases. Screw length, size and position were found to be appropriate in all the cases. Follow-up radiographs taken on 15^{th}, 30^{th}, 45^{th} and 60^{th} post-operative days revealed primary bone healing with minimal callus formation. Good implant stability throughout the treatment period without any complications was achieved in all dogs. All the dogs which were diagnosed showed grade V lameness before surgical treatment. Post-operatively, all dogs progressed to grade I lameness by the end of 30^{th} post-operative Based on the present study, it was concluded that Point Contact Fixator plating was successful in treatment of radius ulna fractures in dogs and offered good recompense and remarkable improvement in limb function with good fracture stability till the completion of the bone healing.

Keywords: point contact fixator (PC-Fix) plate, internal fixation, radius ulna fracture, fracture repair, dogs

Introduction
Trauma is the most common cause of fractures in small animals and can occur due to bending, torsional, shearing and compression forces, eventually resulting in oblique, wedge fragment fractures, spiral or comminuted fractures. In dogs, fractures are commonly seen in femur, followed by tibia and radius-ulna [1].

Plate osteosynthesis is a versatile method of fracture stabilization and used to treat animals with high, medium and low fracture assessment scores. Bone plates when applied properly effectively resist the axial loading, bending and torsional forces acting on the fractured bones [2]. Preservation of intramedullary and periosteal vascularization, anatomical reduction, interfragmentory compression of bone fragments and early return to normal locomotory function are the main goals of fracture treatment [3].

In conventional plating, the screw functions as an anchor, its axial force being exploited to press the under surface of the plate against the bone, resulting in large frictional force at the bone plate interface achieving motionless rigid transmission of forces between the plate and bone surface. This contact causes vascular damage, in particular, to periosteum and its blood supply leading to partial necrosis of underlying cortical bone [4].

Extensive plate bone contact can negatively affect periosteal blood flow, resulting in bone

necrosis and resorption under the plate. Any loss of cortical purchase in either cortex due to bone resorption or micro fracture may allow the screw to toggle in the plate hole, and the bone fragment to shift under the plate [5].

The Point Contact Fixator (PC-Fix) was designed as a part of the developmental evolution of more biological devices for internal fixations. The development of Point Contact Fixator (PC-Fix) means that the contact area is reduced to a few small isolated points only. Fixation is achieved by shear between the screws and the bone rather than the friction between the undersurface of the plate and the bone. Minimal contact of the plate to the underlying periosteum and bone minimizes potential damage to perfusion [6]. The design of Point Contact Fixator (PC-Fix) led to a drastic reduction of the implant to bone interface virtually eliminating the impairment of the periosteal blood supply. The design of monocortical screws which engage and lock into the screw hole has achieved the preservation of the endosteal blood supply [7]. Point Contact Fixator (PC-Fix) uses the principle of an (internal) fixator to splint an overall reduced fracture, rather than applying interfragmental and axial compression to precisely reduced fragments, including small intermediate fragments.

Due to paucity of literature on use of PC Fix in dogs, the present study was undertaken to record the clinical efficacy of Point contact fixator in dogs for repair of radius ulna fractures in dogs.

Materials and Methods

Anamensis

The dogs presented for treatment were all Mongrel dogs. The mean age of the dogs was 16.12 ± 3.94 months with ranging from 5 months to 48 months. The body weights of the dogs ranged from 10-20 kg with a mean of 12.87 ± 1.62 kg. The cause of fractures in this group was automobile accident in 3 dogs, fall from an height in one dog. The fractures occurred in 3 female dogs and one male dog. The mean time of gap between the time of fracture and treatment was 4.37 ± 0.90 days with a range of 2- 10 days. The details were shown in table 1.

Table 1: History and Signalment of the dogs selected for the study in Group

Case No.	Breed	Age (months)	Sex	Body weight (Kg)	Cause	Days since fracture	Size of implant used
1	Mongrel	5	Female	10	Automobile accident	2	2.7mm 8h,10mm screws
2	Mongrel	9	Female	15	Automobile accident	5	3.5mm 8h,10mm screws
3	Mongrel	48	Male	20	Automobile accident	3	3.5mm 8h,12mm screws
4	Mongrel	24	Female	12	Fall from Height	10	3.5mm 6h,10mm screws
Mean ± SE		16.12 ± 3.94		12.87 ± 1.62		4.37 ± 0.90	

Pre-Operative Observations

Pre-operative Clinical Observations

The dogs presented for treatment of radius ulna fractures exhibited symptoms like sudden onset of pain and lameness immediately after a trauma. There were symptoms like swelling, dangling of the limb, non-weight bearing and abnormal angulation of the limb at the fracture site (Fig. 1.). In all the dogs, crepitation was noticed at the fracture site on physical manipulation. None of the dogs had neurological deficit.

Pre-operative Radiographic Observations

Two plain orthogonal views of medio-lateral and cranio-caudal radiographs of the affected limbs including the proximal and distal joints confirmed fractures [8]. In all dogs, the radiographs revealed mid shaft diaphyseal transverse fractures of radius ulna. All fractures are closed, three in right forelimb and one in left forelimb. Pre-operative radiographs of the dogs with femur fractures were presented in Fig.2. The details regarding the fractures encountered in all the dogs are presented in Table 2.

Table 2: Pre-operative Radiological Observations (Titanium dynamic compression plate)

S. No	Limb affected	Location of fracture	Type of fracture
1	Right radius and ulna	Mid-diaphyseal	Closed complete transverse fracture
2	Right radius and ulna	Mid-diaphyseal	Closed complete transverse fracture
3	Right radius and ulna	Mid-diaphyseal	Closed complete transverse fracture
4	Left radius and ulna	Mid-diaphyseal	Closed complete transverse fracture

Fig 1: Non weight bearing of the fractured forelimb pre-operatively in dogs.

Case 1 Case 2 Case 3 Case 4

Fig 2: Skiagram showing Complete transverse fracture of radius ulna in a dog (medio-lateral), Pre operative day

Planning of Surgery

Measurements obtained from the pre-operative radiographs of the affected limb like length of the bone and transcortical diameter at different regions proved vital in selecting the length of the PC Fix plates and the length of the screws to be used precisely in fracture fixation of radius and ulna Fig.3.

Fig 3: Skiagram showing lengths of fracture fragments trans-cortical diameter of radius and ulna at different distances from fracture site fracture site (Medio-lateralview) and length of the plate in cranio-caudal view

Patient preparation

The affected limb was aseptically prepared by clipping the hair from a wide area surrounding the fracture site taking care to include upper and lower joints. The operative site was shaved and scrubbed using povidone-iodine surgical scrub, followed by the application of surgical spirit. Similarly, the skin was also prepared over the saphenous vein on both hind limbs for intravenous injections. Normal saline was infused intravenously throughout the duration of surgery.

Anaesthesia

Atropine sulphate at the rate of 0.04 mg/kg body weight was administered subcutaneously as pre-anesthetic medication followed 10-15 minutes later by xylazine hydrochloride at the rate of 1 mg/kg body weight intramuscularly. Ten minutes later, general anaesthesia was induced with intramuscular injection of ketamine hydrochloride at the rate of 10 mg/kg body weight. Following induction, the dogs were intubated with endotracheal tubes of suitable size. Anaesthesia was maintained with intravenous injection of propofol at the rate of 4 mg/kg body weight. Additional doses of propofol were also administered whenever necessary during surgical procedure through the intravenous line.

Positioning of the Animal

The dogs with fracture of radius ulna was positioned in lateral recumbency with the fractured limb down.

Materials Used

Orthopaedic Instruments

A general surgical instrument set and orthopaedic instruments and Low speed high torque electric drill were used for performing Point Contact fixator plating in dogs.

Implants

The implants were made of stainless steel. Implants with AO/ASIF standards were used in the present study. In the present study six to eight holes of 2.7 mm and 3.5 mm PC-Fix were used. The plate width was 7mm, and 8mm with distance between holes 9mm and 13mm. The thickness of the plates was 2.7mm, and 3.5mm. Fully threaded 2.7mm and 3.5 mm self-tapping monocortical screws with conical head ranging from 10 mm length were used (Fig.4). The details of implants used in case wise depicted in table.3

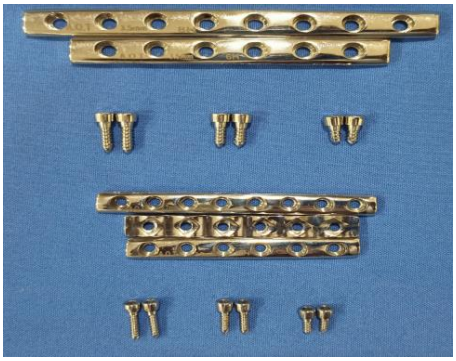


Fig 4: 2.7 mm and 3.5mm PC-Fix plates and 10mm,12mm,14mm monocortical screws with conical head used for the study

Table 3: Clinical details of dogs for Point Contact Fixator plate

Case no.	Breed of dog	Sex	Age (m)	Etiology of fracture	Unilateral /bilateral	Type of fracture	Details of implant used	No of screws used
1	Mongrel	Female	5	Automobile accident	Unilateral	Closed complete transverse fracture	2.7mm, 8h PC fix plate	8 -10mm screws
2	Mongrel	Female	9	Automobile accident	Unilateral	Closed complete transverse fracture	3.5mm, 8h, PC Fix plate	7-10mm screws
3	Mongrel	Male	48	Automobile accident	Unilateral	Closed complete transverse fracture	3.5mm 8h, PC fix plate	8-10mm screws
4	Mongrel	Female	24	Fall from Height	Unilateral	Closed complete transverse fracture	3.5mm 6h, PC fix plate	6-10mm screws

Surgical Procedure

A cranio-medial skin incision of the desired length was made directly over the radius (Fig.5). The subcutaneous tissues were then incised to expose the radial diaphysis (Fig.6) to the described extent. Care was taken to avoid cutting the cephalic vein. The extensor tendons were elevated to expose the cranial surface of the distal metaphysis of the radius. The fracture site was thus exposed.

Fig 5: Cranio-medial skin incision made directly over radius shaft

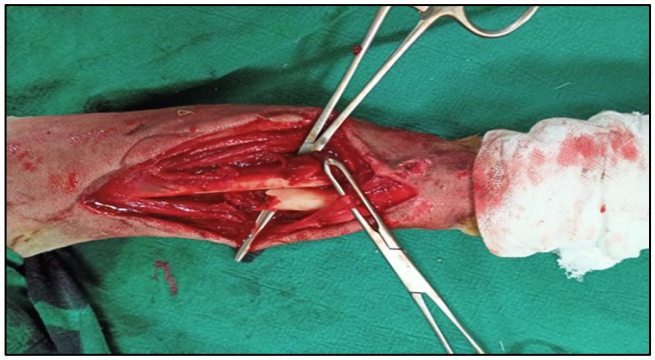


Fig 6: Subcutaneous tissue incised to expose mid-diaphyseal fracture of radius and ulna

Following the surgical exposure of the fracture site as described, the fracture fragments were aligned and reduced to restore the length and correct rotational orientation (Fig.7). Point Contact Fixator (PC-Fix) plate was then placed over the bone and the plate was held in position with bone holding forceps. It was ensured that, the alignment was correct before securing the plate to the bone with monocortical screws. The bone was drilled with 2.0 mm and 2.5 mm drill bit (Fig.8) which corresponded with the inner core diameter of the screw using a low speed high torque electric drill. The length of the screws needed for application of Point Contact Fixator (PC-Fix) in each patient was determined by measuring the transcortical diameter of femur and tibia at different distances from the fracture site of respective bones from the pre-operative radiographs and was confirmed during the surgical procedure by using a depth gauge. Anteroposterior thickness of radius at different distances from the fracture site of the respective bones directly from the mediolateral radiographs was measured to determine the length of the screw needed for application of Point Contact Fixator (PC-Fix).

A screw of suitable length was then placed at the drilled hole and tightened using a hexagonal orthopaedic screw driver (Fig. 9) to secure the Point Contact Fixator (PC-Fix) plate to the bone. Bone plating was accomplished by insertion of additional screws in both proximal and distal fracture fragments leaving the fracture line (Fig. 10).

Fig 7: Fracture reduced and the fragments were aligned

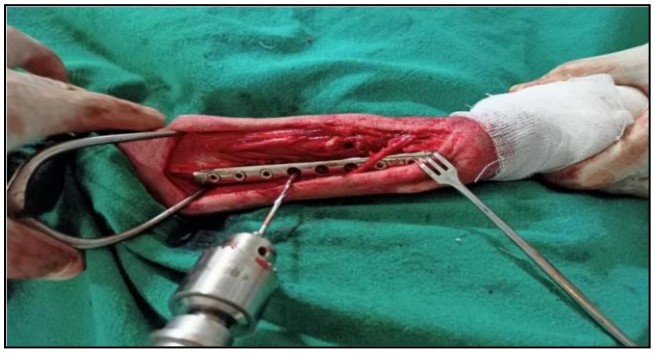


Fig 8: Hole drilled across radial diaphysis

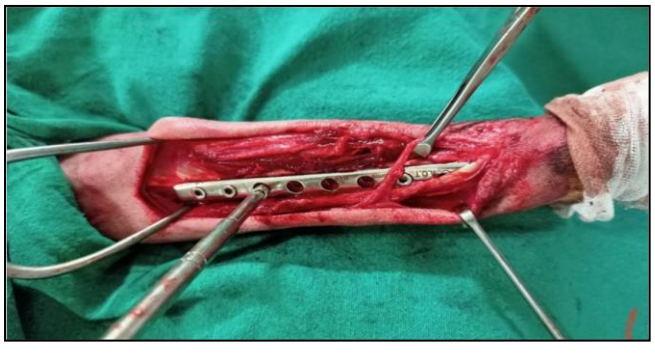


Fig 9: Tightening of the screw using hexagonal orthopaedic screw driver

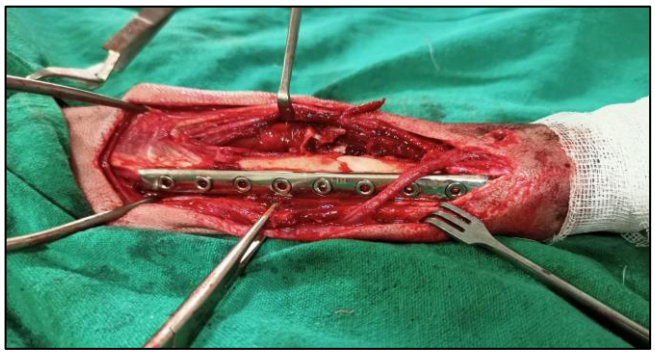


Fig 10: Bone plating completed

Closure of the incision

The incision made for exposure of radius-ulna and plating was closed with a row of simple continuous sutures of 2-0 polyglactin 910 (Fig.11). Subcuticular sutures were applied with 2-0 polyglactin 910 (Fig.12.). The skin incision was closed in a row of cruciate mattress sutures of 2-0 polyamide (Fig. 13).

Fig 11: Incision made for exposure of radius-ulna and plating being closed with a row of simple continuous sutures of 2-0 polyglactin 910

Fig 12: Subcutaneous incision closed with a row of continuous sutures of 2-0 polyglactin 910

Fig 13: Skin incision closed in a row of cruciate mattress suturesof 2-0 polyamide

Post-Operative Care and Management

The suture line was covered with a thin layer of sterile gauze bandage dipped in 5% povidone iodine solution. Over this, a thick layer of cotton pad was wrapped. It was then covered with gauze bandage and finally, a layer of surgical paper tape was applied. (Fig. 14) A bamboo splint applied for support externally for 15 days. The dressing was replaced on every alternate day until the sutures were removed on the 12th post-operative day. Injection ceftriaxone sodium was administered at the rate of 25 mg/kg body weight as intramuscular injection for 7 days post-operatively. Injection meloxicam was administered once a day at the rate of 0.3 mg/kg body weight by intramuscular injection for 3 days post-operatively. Owners were advised to restrict the movement of the animal for the first 2 weeks of surgery and then to allow leash walking for the next few weeks.

Fig 14: Limb stabilized with Robert Jones bandage

Results

Clinical evaluation was carried out every alternate day to check for the presence of swelling, exudation and weight bearing in all the dogs. The appearance of suture line was also examined every alternate day until the sutures were removed. The post- operative day on which the dog started bearing weight was recorded and graded. After suture removal, the dogs were examined once in a week for the limb stability until fracture healing was considered satisfactory. None of the dogs developed any post-operative complications.

Post-Operative Clinical Observations

Application of Robert-Jones bandage provided satisfactory immobilization of the limb. The use of injection ceftriaxone sodium effectively prevented post-operative infection. The skin sutures were removed between 10^{th} to 12^{th} post-operative day in all the dogs.

Lameness grading

In all six dogs in the present study showed partial weight bearing on the 1^{st} post- operative day. All six dogs showed normal weight bearing at rest, the weight bearing of the affected limb while walking. One dog achieved complete weight bearing by 7^{th} post-operative day, one dog by 15^{th} post-operative day and two dogs by 30^{th} post-operative day. The mean lameness grades observed pre-operatively and on 1^{st} day, 7^{th} day, 15^{th} day, 30^{th} day, 45^{th} day and 60^{th} day post-operatively were found to be 5.0±0.0, 3.50±0.28, 2.25±0.95, 1.50±0.28, 1.0±0.0, 1.0±0.0 and 1.0±0.0 respectively. The mean age of this group of dogs to bear the complete weight on

the affected limb were seen on 20.50±5.72 days. Different post-operative weight bearing of the affected limb in all dogs were depicted in Fig. 15. The details of lameness grading [9] were presented in Table 4.

Table 4: Post-operative details of lameness grading

Case No	PC-Fix	Pre - operative	Post-operative lameness grades						Complete weight bearing seen on day
			Day 1	Day 7	Day 15	Day 30	Day 45	Day 60	
1	2.7 mm	V	III	I	I	I	I	I	7
2	3.5 mm	V	III	II	I	I	I	I	15
3	3.5 mm	V	IV	III	II	I	I	I	30
4	3.5 mm	V	IV	III	II	I	I	I	30
Mean ± SE		5.0±0.0	3.5±0.28	2.25±0.95	1.5±0.28	1.0±0.0	1.0±0.0	1.0±0.0	20.5±5.72

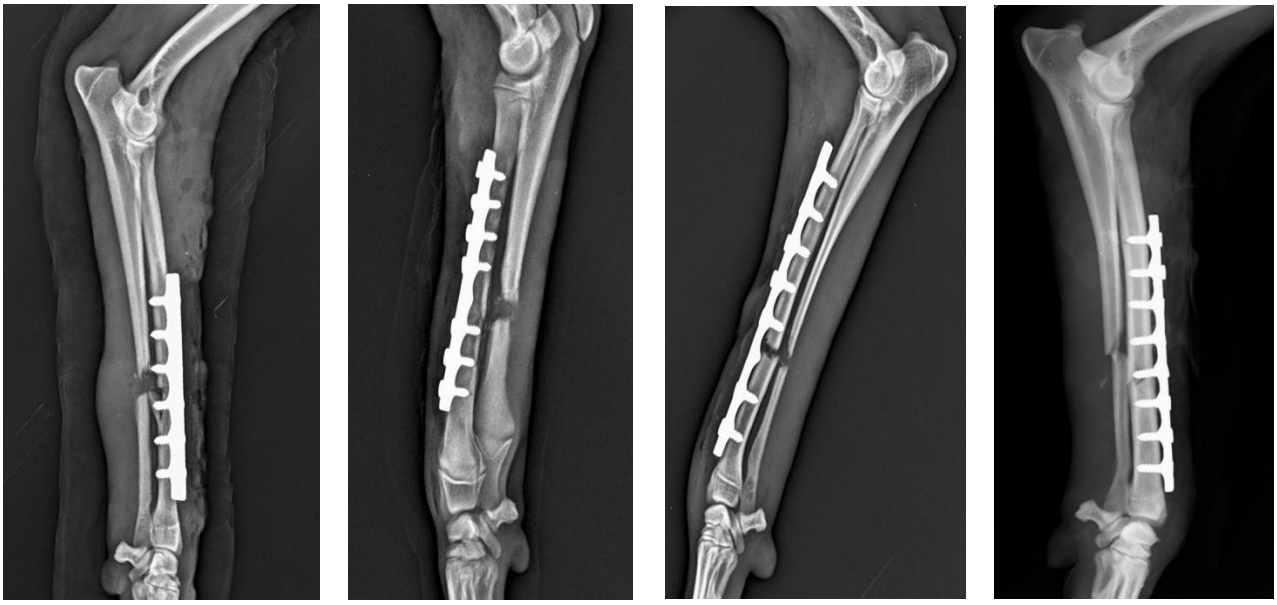
Grade I- Normal weight bearing on all limbs at rest and while walking.
Grade II- Normal weight bearing at rest, favors affected limb while walking.
Grade III- Partial weight bearing at rest and while walking.
Grade IV- Partial weight bearing at rest; does not bear weight on affected limb while walking.
Grade V- Does not bear weight on limb at rest or while walking.

Fig 15: weight bearing on postoperative days in dog with radius and ulna fracture

Post-Operative Radiographic Observations

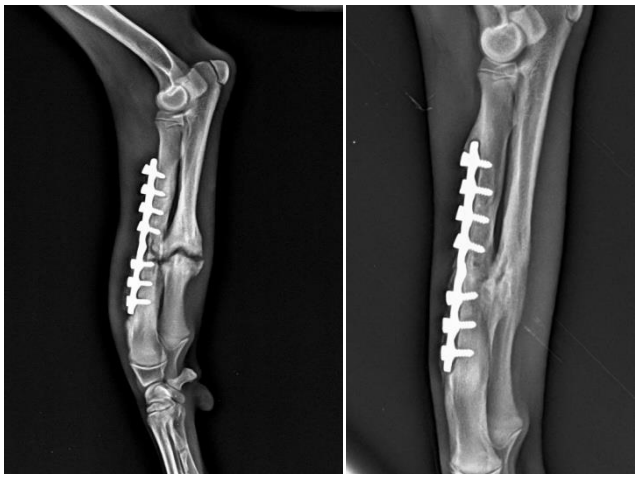
Immediate Post-operative radiographic evaluation confirmed proper placement of PC –Fix plate (Fig.16). Immobilization was considered satisfactory in all cases in this group The radiographs obtained on the 15th Post-operative day revealed proper apposition and alignment of fracture fragments in all the dogs and also presence of callus at the fracture site.

Follow-up radiographs obtained on 30th post-operative day revealed bridging callus considerably reduced in size. The callus was smoother and more opaque and the radiolucent fracture line was faintly visible. By 60th post-operative day the fracture line disappeared and the callus became radio-dense with clear establishment of cortico-medullary canal in all dogs. The progressive radiographic fracture healing was showed in Fig. 17.



Case.1 Case,2 Case.3 Case.4

Fig 16: Skiagram showing immediate post-operatively (medio-lateral view) shows proper placement of implant



15th day 60th day

Fig 17: Skiagram showing progressive radiographic healing (medio-lateral view) in case 2

Discussion

Post-operative lameness grading showed gradual improvement to normal weight bearing over the period of study. The lameness grade was carried out in accordance with protocol developed by Vasseur *et al*. (1995). Lameness grading based on weight bearing was recorded in all animals pre-operatively showed grade V lameness before surgical stabilization of the fracture. Post-operatively, all dogs progressed to grade I lameness by the end of 30th post-operative day without any complication after Point Contact Fixator (PC-Fix) plating technique.

Follow-up radiographs taken on 15th, 30th, and 45th post-operative days revealed primary bone healing with minimal callus formation [15]. By 60th post-operative day the fracture line disappeared and the callus became radio-dense with clear establishment of cortico-medullary canal in all dogs. The process of healing, the callus pointing to the restitution of cortio-medullary continuity well appreciated on the radiograph. Good implant stability throughout the treatment period without any complications was achieved in all dogs and similar results was reported [10].

Conclusion

Based on the present study, it was concluded that Point Contact Fixator plating was successful in treatment of radius ulna fractures in dogs and offered good recompense and remarkable improvement in limb function with good fracture stability till the completion of the bone healing in all dogs. The results of the present study that PC-Fix plates were found to be effective in the treatment of radius ulna fractures since they are replete with features like point only contact with the bone reducing additional injury to the bone, minimizing early temporary porosis under the plate. Monocortical screws do not engage in the far cortex which eliminate impairment of the endosteal and periosteal blood supplies.

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