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Clinical study on the use of limited contact dynamic compression plate (LC-DCP) for stabilization of long bone fractures in dogs

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Abstract

The current study was undertaken to evaluate the clinical efficacy of LC-DCP for stabilization of long bone fractures in dogs.

This study was conducted on six dogs presented with fractures to The Department of Veterinary Surgery and Radiology at the College of Veterinary Science, Hyderabad. The six cases of fractures were diagnosed by clinical signs, orthopaedic examination and survey radiography. The symptoms observed in the dogs presented for treatment were pain on manipulation, abnormal angulation and lameness immediately after trauma, swelling, non-weight bearing, dangling of the limb and crepitation at the fracture site. Pre-operative radiographic examination in plain orthogonal views, i.e., craniocaudal and mediolateral radiographs revealed mid-diaphyseal fractures in five dogs and distal diaphyseal fracture in one dog. Pre-operative radiographs also showed the type of fractures as transverse fractures in four dogs and short oblique fractures in two dogs. These fractures were stabilized with 2.7 mm LC-DCP in two dogs and 3.5 mm LC-DCP in four dogs.

Good implant stability throughout the treatment period without any complications was achieved in five dogs. In one dog with femur fracture, screw breakage was observed by 30th post-operative day and alignment of fracture line was slightly disturbed. However, intermittent weight bearing was noticed by 45th post-operative day. All the dogs which were diagnosed as femur and tibia fractures showed grade V lameness before surgical treatment. Post-operatively, five dogs progressed to grade I lameness by the end of 30th post-operative day and one dog progressed to grade II lameness by the end of 45th post-operative day.

Based on present study, it was concluded that LC-DCP was successful in the treatment of long bone fractures in dogs and offered good recompense and remarkable improvement in the limb function, with good fracture stability till the completion of the bone healing. The application of LC-DCP was found to be effective with features like undercut between the holes had even levels of stiffness along the entire plate, allowing smoother, easier contouring and distributed stress more evenly and also maintaining less plate-bone contact area, thereby reducing cortical ischaemia and preserving viability of the bone fragments.

Keywords: LC-DCP, Internal fixation. Blood Supply, cortical ischaemia

Introduction

The incidence of musculoskeletal injuries has been increasing constantly and among the small animal surgical cases the incidence of fractures was about 17.80%, out of which, fractures in dogs constituted about 67%. Among all the fractures, the incidence of long bone fractures constituted about 84.48% [1]. The goals of fracture treatment are to encourage healing, restore function of the affected bone and soft tissue with cosmetically acceptable appearance [2]. This can be achieved with rigid internal fixation, atraumatic tissue handling and early motion of joints [3]. Various internal fixation devices have been used to repair the long bone fractures depending upon the stability required [4]. There are three systems applicable for stabilization of long bone fractures- intramedullary devices, external skeletal fixators and bone plates and screws [5]. Among the internal fixation techniques, bone plating was widely used because bone plates have the potential to restore rigid stability to the reconstructed fracture bone and also effectively resist the axial loading, bending and torsional forces acting on the fractures bones. The introduction of rigid plates had greatest impact on plate fixation of fractures. However, it led to cortical porosis, delayed bridging and refractures after plate removal. These unwarranted effects were said to be caused by bone-plate contact interfering with cortical perfusion. Consequently, further plate modifications aimed to reduce this contact area to minimize, necrosis and subsequent porosis. The dynamic compression plate (DCP) is a special plate developed by the AO group and it is standard plate type for many decades in the veterinary profession. Limited Contact Dynamic Compression Plate (LC-DCP) was the second generation plate developed by the AO group to address some of these difficulties. The differences between the plates include a different shape and additional design features like undercut between the holes had even levels of stiffness along the entire plate, allowing smoother, easier contouring and distributed stress more evenly and also maintaining less plate-bone contact area, thereby reducing cortical ischaemia and preserving viability of the bone fragments [6].

Hence the present study was was undertaken with the following objectives:

1. To diagnose and surgically treat long bone fractures in dogs using Limited Contact Dynamic Compression Plates (LC-DCP).
2. To study the fracture healing by clinical and radiographical evaluation.
3. To study the efficacy of the Limited Contact Dynamic Compression Plates (LC-DCP) used for stabilization of long bone fractures in dogs.

Materials and Methods

Selection of Dogs with Long Bone Fractures

A total of 65 cases of fractures were recorded in dogs during the period of the study. Out of these 65 cases, fractures involving long bones were encountered in 55 cases (84.61%). Out of these 55 cases, fractures involving femur were encountered in 30 cases (55%) and tibia were encountered in 10 cases (18%) [7]. Out of these 40 cases, six dogs that were considered suitable for fracture fixation using Limited Contact Dynamic Compression Plates (LC-DCP) were selected. Fracture fixation in these six dogs was performed using Limited Contact Dynamic Compression Plates (LC-DCP).

Anamnesis

The age of the six dogs ranged from of 5-36 months with a mean of 16.66 ± 4.82 months [8]. Out of these six dogs, five were males and one was a female [9]. Among them two dogs belonged to Labrador Retriever breed, two were Mongrels, one each belonged to Sptiz and Pomeranian breeds. The body weight of the dogs ranged from 10 to 23 kg with a mean body weight of 16.66 ± 2.38 kg.

Etiology and Age of the Fracture

The main cause of fracture in the six dogs was found to be automobile accident in five (83.33%) dogs followed by fall from height in one (16.66%) dog [10]. The dogs were presented for treatment between 2 to 7 days with a mean of 4.66 ± 0.84 days after sustaining fracture. No other concurrent illness or other orthopaedic conditions were reported in any of the dogs. Details of the cases are presented in Table 1.

Table 1: Clinical history of the dogs selected for the study

Case No.	Breed	Age (months)	Sex	Body weight (Kg)	Cause	Days since fracture
1	Mongrel	18	Male	20	Automobile accident	3
2	Mongrel	5	Male	10	Automobile accident	2
3	Pomeranian	9	Male	15	Automobile accident	4
4	Labrador Retriever	8	Male	22	Automobile accident	5
5	Spitz	36	Female	10	Fall from height	7
6	Labrador Retriever	24	Male	23	Automobile accident	7
Mean ± SE		16.66 ± 4.82		16.66 ± 2.38		4.66 ± 0.84

Pre-Operative Observations

Pre-operative Clinical Observations

The six dogs presented for treatment of long bone 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 (11). In all the dogs, crepitation was noticed at the fracture site on physical manipulation. None of the dogs had neurological deficit. All the six dogs had closed fractures.

Pre-operative Radiographic Observations

Two plain orthogonal views of mediolateral and craniocaudal radiographs of the affected limbs including the proximal and distal joints confirmed fractures (12). Out of six dogs, radiographs revealed transverse fractures in four dogs and short oblique fractures in two dogs (Fig. 1). The details regarding the fractures encountered in all the dogs are presented in Table 2.

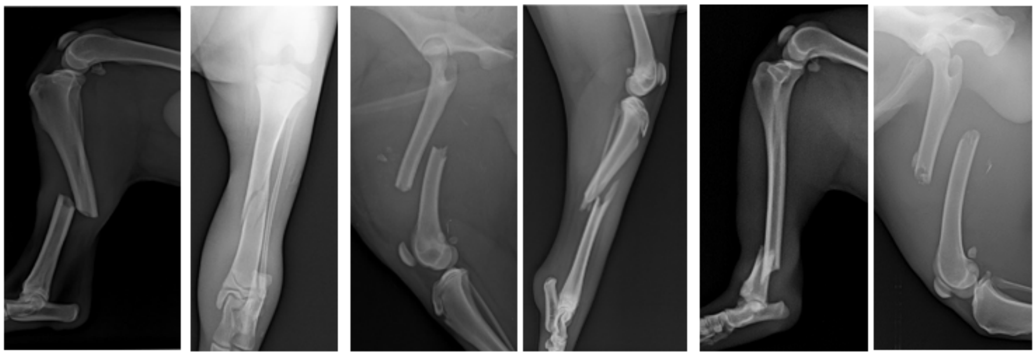

Fig 1: Preoperative radiographs of dogs with femoral and tibial fractures

Table 2: Pre-operative radiographic observations

S. No	Side	Location of fracture	Type of fracture
1	Left tibia	Mid-diaphyseal	Closed complete transverse fracture
2	Left tibia	Mid-diaphyseal	Closed complete short oblique fracture
3	Left femur	Mid-diaphyseal	Closed complete transverse fracture
4	Left tibia	Mid-diaphyseal	Closed complete short oblique fracture
5	Right tibia	Dist-diaphyseal	Closed complete transverse fracture
6	Right femur	Mid-diaphyseal	Closed complete transverse fracture

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 limited contact dynamic compression plates and the length of the screws to be used precisely in fracture fixation of femur and tibial fractures (Fig. 2) [13].

Fig 2: Radiographs showing transcortical diameter of tibia at different distances from the fracture site in craniocaudal view and also length of tibia in mediolateral 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 cephalic vein on both fore 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 [14]. Ten minutes later, general anaesthesia was induced with intramuscular injection of ketamine hydrochloride at the rate of 10 mg/kg body weight [15]. 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 femur was positioned in lateral recumbency with the fractured limb up whereas dogs with fractures of tibia were positioned in lateral recumbency with the fractured limb down and the contralateral limb secured out of the way.

Materials Used

Orthopaedic Instruments

A general surgical instrument set and orthopaedic instruments as needed for a particular procedure were used. Orthopaedic instruments including Gelpi retractors, Bone holding forceps, Hohmann's retractors, Senn retractors, Orthopaedic hexagonal screw drivers, 2.0 mm and 2.7 mm Drill bits, Depth gauge and Low speed high torque electric drill were used for performing Limited Contact Dynamic Compression Plating.

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 ten holes of 2.7 mm and 3.5 mm LC-DCP were used. The plate width was 7.0 mm, and 10 mm with distance between holes 9 mm, and 13 mm. The thickness of the plates was 2.7 mm, and 3.5 mm. Fully threaded 2.7 mm and 3.5 mm self-tapping cortical screws ranging from 12 mm to 28 mm length were used (Fig. 3).

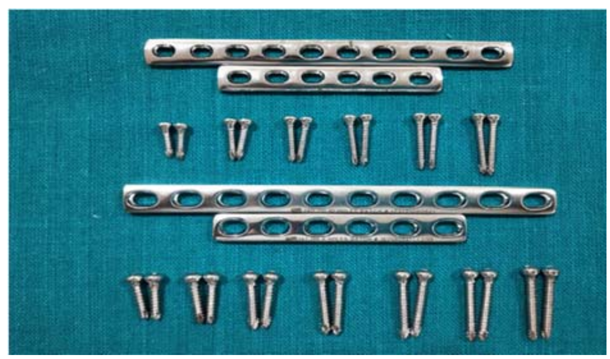

Fig 3: 2.7 mm and 3.5 mm LC-DCPs and 12 mm to 28 mm cortical Screws

Surgical Procedure

The craniolateral border of thigh approach was used for exposure of fractured diaphysis region of femur bone to perform bone plating using LC-DCP (Fig. 4) [16]. The craniomedial border of tibia approach was used for exposure of fractured distal diaphyseal and mid diaphyseal region of tibia to perform bone plating using LC-DCP (Fig. 5) [17].
Following the surgical exposure of the fracture site (Fig. 6&7) as described, the fracture fragments were aligned and reduced to restore the length and correct rotational orientation (Fig. 8&9). Limited contact dynamic compression 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 cortical screws. The bone was drilled with 2.0 mm and 2.7 mm drill bit 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 limited contact dynamic compression plate 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. A screw of suitable length was then placed at the drilled hole and tightened using a hexagonal orthopaedic screw driver until the taper end of screw exited the far cortex to secure the LC-DCP 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&11).

Fig 4: craniolateral Skin incision of femur

Fig 5: Craniomedial skin incision of tibial

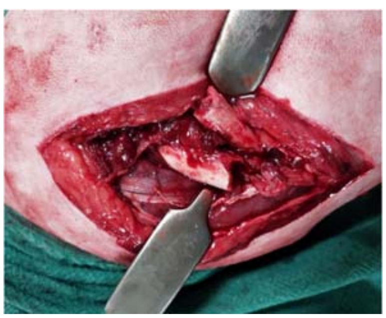

Fig 6: Femoral fracture fragments exposed

Fig 7: Tibial fracture fragments were exposed

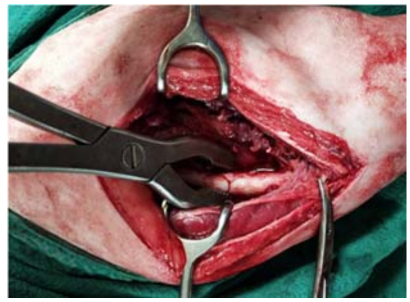

Fig 8: Femoral fracture reduced and fragments aligned

Fig 9: Tibial fracture reduced and fragments were aligned

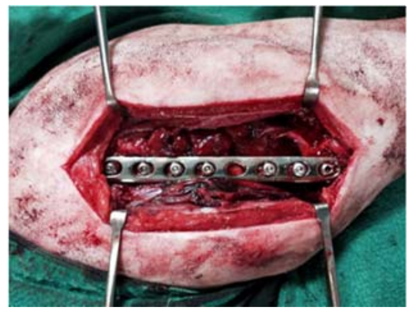

Fig 10: Bone plating completed

Fig 11: Bone plating completed

Closure of the incision

In case of femoral approach, the fascia lata was sutured with 2-0 polyglactin 910 in a simple continuous suture pattern. Subcuticular sutures were applied with 2-0 polyglactin 910. Skin incision was closed with a row of cruciate mattress sutures of 2-0 polyamide.

In the case of tibia, subcutaneous fascia was closed with continuous sutures of 2-0 polyglactin 910. The skin incision was closed in a row of cruciate mattress sutures of 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. 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.

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.

A lameness grade was assigned in all cases respectively during pre and post-operative periods based on the weight bearing nature during stance and while walking. Weight bearing was graded as follows.

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.

Plain craniocaudal and lateral radiographs of the operated femur and tibia were obtained immediately after surgery and on the 7th, 15th, 45th and 60th post-operative days and whenever needed, on later dates to assess the progress of bone healing.

Results

Post-Operative Clinical Observations

Dressing the surgical wound with 5% povidone iodine pads was found to be effective in keeping the site clean in all the dogs. 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 10th to 12th post-operative day in all the dogs.

None of the dogs developed post-operative swelling and suture dehiscence and the surgical wounds healed well in all the dogs without any complications.

Post-Operative Lameness Grading

All the six dogs in the present study showed partial weight bearing from the 1st post-operative day. Three dogs achieved complete weight bearing by 7th post-operative day, two dogs by 30th postoperative day and one dog by 45th post-operative day. The details of lameness grading are presented in Table. 3.

Table 3: Postoperative details of lameness grading

Case No	LC-DCP	Pre - operative	Post-operative lameness grades				
			Day 1	Day 7	Day 15	Day 30	Day 45
1	3.5 mm	V	III	I	I	I	I
2	2.7 mm	V	IV	III	II	I	I
3	3.5 mm	V	III	I	I	I	I
4	3.5 mm	V	III	II	II	I	I
5	2.7 mm	V	III	I	I	I	I
6	3.5 mm	V	IV	III	II	II	II
Mean ± SE			3.33±0.21	1.83±0.40	1.5±0.22	1.16±0.16	1.16±0.16

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.

Stability of The Implant

In the present study, 2.7 mm and 3.5 mm Limited contact dynamic compression plates with cortical screws produced rigid fixation and resulted in remarkable improvement with normal limb function. Good implant stability throughout the observation period without any complications was achieved in five dogs and in dog with femur fracture, screw (proximal most) breakage was observed by 30th post-operative day due to subsequent fall from height. However, intermittent weight bearing was observed by 45th postoperative day.

Post-Operative Radiographic Observations

post-operative radiographic evaluation confirmed proper placement of the plates and screws, apposition and alignment of the fracture fragments in all the six dogs (Fig. 12). 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 7th, 15th, 30th, 45th and 60th post-operative days revealed primary bone healing with minimal callus formation (Fig. 13). Good implant stability throughout the treatment period without any complications was achieved in five dogs. In one dog with femur fracture, screw (proximal most) breakage was observed by 30th post-operative day and alignment of fracture line was slightly disturbed (Fig. 14). However, intermittent weight bearing was noticed by 45th post-operative day.

Fig 12: Immediate post-operative craniocaudal radiographs of the dogs with tibial and femoral fractures showing good alignment of the fractured fragments

Fig 13: Progressive radiographic changes in a dog with tibial fracture

Fig 14: Craniocaudal radiograph of the femur fracture showing screw (proximal most) breakage by 30th post-operative day

Discussion

In the present study, dressing of the surgical wound with 5% povidone iodine pads was found to be effective in keeping the site clean in all the cases [18].

Lameness grading based on weight bearing was recorded in all cases pre-operatively, showed grade V lameness. Post-operatively, five dogs progressed to grade I lameness by the end of 30th post-operative day and one dog progressed to grade II lameness by the end of 45th post-operative day [19].

Post-operative radiographic evaluation confirmed proper placement of the plates and screws, apposition and alignment of the fracture fragments in all the six dogs [20]. 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 7th, 15th, 30th, 45th and 60th post-operative days revealed primary bone healing with minimal callus formation [21].

Good implant stability throughout the treatment period without any complications was achieved in five dogs. In one dog with femur fracture, screw (proximal most) breakage was observed by 30th post-operative day and alignment of fracture line was slightly disturbed [22]. However, intermittent weight bearing was noticed by 45th post-operative day.

Conclusion

Based on present study, it was concluded that Limited Contact Dynamic Compression Plates (LC-DCP) was successful in the treatment of long bone fractures in dogs and offered good recompense and remarkable improvement in the limb function, with good fracture stability till the completion of the bone healing in five out of six dogs [23]. The application of LC-DCP plates was found to be effective with features like undercut between the holes had even levels of stiffness along the entire plate, allowing smoother, easier contouring and distributed stress more evenly (24) and also maintaining less plate-bone contact area, thereby reducing cortical ischaemia and preserving viability of the bone fragments [25]. The implant used in this technique was economical, making it amenable for use in veterinary practice.

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