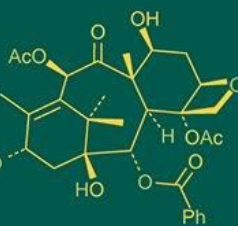
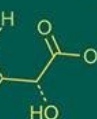


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Studies on evaluation of β -tricalcium phosphate (β -TCP) as a bone graft in femur fracture repair with bone defect by bone plating in dogs

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Abstract

Femur fractures in dogs are common orthopaedic problem resulting from the trauma viz., automobile accidents and fall from the height, often these fractures leading to bone defects that ravel repair process. The therapeutic efficacy of β -tricalcium phosphate (β -TCP) combined with locking compression plate fixation for femur fracture treatment in six dogs was investigated. The diagnosis involves a physical examination, as well as radiography, to determine fracture configuration and healing progression. The fractures were reduced and stabilized using locking compression plate with the bone defects filled with β -tricalcium phosphate (β -TCP). The postoperative care includes antibiotics, analgesics and physiotherapy. Pain scores steadily declined between before and 60 days post-surgery. Clinically, all dogs showed progressive improvement in weight bearing and ambulation of the affected limb. Radiographic examination demonstrated early callus formation on day 15 and complete bridging callus on day 60. No adverse reactions to β -tricalcium phosphate (β -TCP) were detected. The combination of bone plating with β -tricalcium phosphate (β -TCP) resulted in stable fixing, improved bone regeneration and facilitated early functional recovery. This method was helpful for treating femur fractures in dogs with bone defects.

Keywords: Femur, fracture, bone defects, β -tricalcium phosphate (β -TCP) and locking compression plate

Introduction

A fracture is a break in the structural integrity of the bone, which can be either full or incomplete. The incidence of femur fracture in dogs was highest in automobile accident (66.86%), followed by fall from height (22.48), dog bite (5.32%), hitting by object (3.55%), unknown etiology (1.18%) and caught in wire fencing (0.59%) (Jain *et al.*, 2014) [5]. Physical examination and imaging modalities like as radiography or computed tomography are commonly used in the diagnosis to determine fracture configuration and involvement of neighbouring tissues (Scherer *et al.*, 2019) [13]. Fractures associated with bone defects requires stabilization with suitable fixation devices, placement of appropriate bone grafts to fill up the bone defects for enhanced bone regeneration. Segmental bone loss and non-union fractures of long bones are challenging problems for orthopaedic surgeons (Rao *et al.*, 2016) [12]. To overcome these complications, research is now more emphasized on role of bone healing enhancers in fracture management. Bone graft, synthetic bone graft materials, composite bone grafts, bone marrow, BMP, TGFs, hydroxyapatite etc. were commonly used as bone healing enhancers (Devescovi *et al.*, 2008) [2]. The study was conducted to determine the clinical efficacy of β -tricalcium phosphate (β -TCP) combined with a bone plating technique for the healing of femoral fractures with bone defects in dogs.

Materials and Methods

The current study was carried out among the six clinical cases of dogs presented to the Department of Veterinary Surgery and Radiology, Veterinary College Hospital, Hebbal, Bengaluru. Femur fracture with bone defect cases were selected for the study with irrespective of breed and sex. Anamnesis, neurological and orthopaedic examination conducted in all selected cases (Table 1). Pain scoring, clinical and radiographic examination was recorded on before surgery, immediately after the surgery and on 7th, 15th, 30th, 45th and

60th day post-operatively. The cases with femur fracture were stabilized with bone plating technique and defect was filled with β -tricalcium phosphate (β -TCP).

Surgical implants

Locking compression plate (2.7 mm and 3.5mm) and locking screws (2.7 mm and 3.5 mm diameter) were used. Screw length was selected based on the thickness of the femur (Fig. 1).

Material used for Bone Regeneration

The β -tricalcium phosphate (Biomed Pharmaceutical Ltd.,

Hyderabad) for providing BIOTCP® of particle size 0.5mm to 1mm were employed to fill the defect at the fracture site (Fig. 2). The β -tricalcium phosphate were aseptically mixed with patients blood before filling into the defect.

Radiographic examination

Animals selected for the study were subjected to radiography of antero-posterior and medio-lateral views of affected femur. The radiographs were evaluated for the type of fracture and progress of bone healing, where defect was filled with MCHC granules.

Table 1: Anamnesis of the animals considered for the study

Case no.	Breed	Age	Sex	B. W. (in kg)	Cause	Limb affected	Duration of illness
1	Siberian Husky	1 yrs	F	18.5	Fallen from height	Left	4 days
2	Non-Descript	2 yrs	M	19.5	Accident	Right	2 days
3	Non-Descript	2 yrs	F	18.5	Accident	Right	3 days
4	Indian Spitz	8 yrs	M	14.5	Accident	Left	2 days
5	Non-Descript	5 yrs	M	19.6	Fallen from height	Right	1 day
6	Siberian Husky	1 yrs	M	21.5	Accident	Right	2 days



Fig 1: Locking compression plate, Cortical screws



Fig 2: Beta Tricalcium Phosphate (β -TCP)

Pre-operative preparation

All pet owners were advised to withhold food for 12 hours and water for 6 hours prior to the surgery. The surgical site *i.e.* lateral and medial thigh region of the affected limb including the proximal hip region and distal stifle joint was prepared aseptically by clipping hairs and shaving. The surgical site was cleaned using Povidone Iodine (7.5%) scrub solution followed by surgical spirit (70%) and finally swabbed with Povidone Iodine (5%) solution to reduce microbial load on the skin. All animals in the study were pre-medicated with Inj. Atropine Sulphate and after 10 minutes Xylazine Hydrochloride was injected as a sedative. Ceftriaxone, an antibiotic injection, and Meloxicam, a pre-emptive analgesic injection, were administered subcutaneously 10 minutes before anaesthesia was induced. The general anaesthesia was produced with an intravenous

2.5% solution of Thiopental sodium at 12.5 mg per kg body weight and maintained with the same "to effect" dose.

Surgical Procedure

After draping the surgical site, followed standard surgical approach to exposure the fracture site and with manual reduction fractured fragments were brought into normal anatomical alignment and a suitable locking compression plate was positioned on the lateral surface of femur. The holes were pre-drilled using suitable size drill bit. The locking compression plate was fixed using suitable size screws of varying lengths according to femur thickness. The area was cleansed with sterile saline to remove debris following rigid fixation. beta tricalcium phosphate (β -TCP) was rehydrated with 1 mL of blood collected from same animal in a sterile petridish. The defect was filled with rehydrated beta tricalcium phosphate (β -TCP). Muscles were sutured with suitable size Polyglactin 910 in simple interrupted pattern. The subcutaneous tissue was apposed with same suitable size Catgut in simple continuous pattern. The skin incision was closed with suitable size Polyamide in horizontal mattress pattern (Fig. 3).

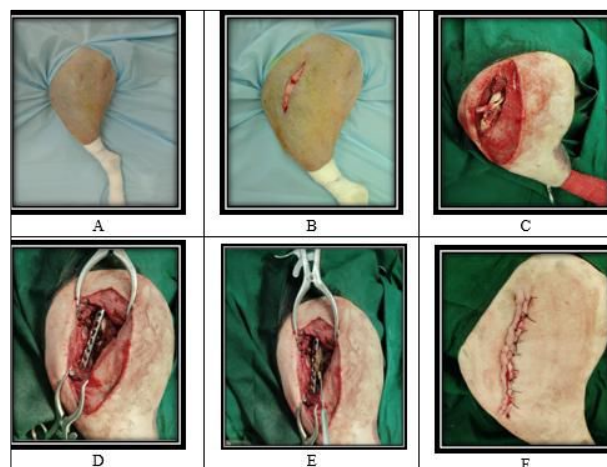


Fig 3: Surgical Procedure. A – Surgical site, B – Skin incision, C – Exposure of fracture fragments, D – Stabilized fracture fragments with locking compression plate, E – Defect filled with rehydrated beta tricalcium phosphate (β -TCP) and F – Skin closure

Postoperative care and management

Post-operatively the surgical wound site was cleaned with povidone iodine solution, ointment povidone-iodine was applied and the dressing was done using thin two layered sterile gauze bandage and was supported by dynaplast adhesive bandage. Post-operatively antibiotic cover was given with Cephalexin at the dose rate of 25 mg per kg body weight, twice a day, per oral for seven days and Carprofen was given at the dose rate of 2 mg per kg body weight, once a day, per oral for three days to address the post-operative pain. The pet owners were advised to restrict the movement of the pet for initial two weeks and to administer the calcium supplement daily for a minimum of three weeks. To facilitate early recovery and to avoid muscle atrophy, owners were advised to start physiotherapy like short leashed walk, extension and flexion of the limb, and massaging of the affected limb. An Elizabethan collar was used in all patients until the sutures were removed on the 10th post-operative day, after the wound had healed completely.

Results and Discussion

Clinical observations

Immediately after surgery, the femur showed normal alignment. By the 7th post-operative day, animal started lifting the affected limb off the ground and not bearing weight at rest and while walking. By day 15, partial weight bearing at rest and while walking was noticed in the affected limb. After 30 days, the affected limb complete weight bearing at rest and soft callus was palpable at the fracture site. By day 60, all dogs exhibited complete fracture stabilization, normal femur symmetry and complete weight bearing while walking and at the rest (Fig. 4). Similar findings were reported by Manjunath (2010) [7], Inas *et al.* (2012) [4], Badigera (2013) [1], Patil *et al.* (2017) [10], Harshitha (2021) [3], Preethi *et al.* (2021) [11], Ojus (2022) [9] and Yashvanth (2023) [14].

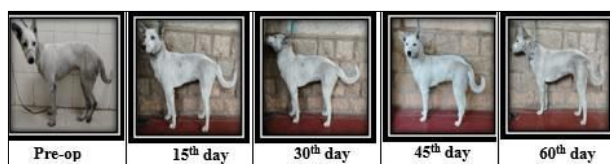


Fig 4: Clinical presentation of animal on different days

Radiographic observations

Radiographs taken immediately after surgery revealed that the locking compression plate and screws were properly placed, with fracture fragments aligned. By the 7th post-operative day, the plate had stayed intact without screw loosening and a prominent fracture gap was apparent, indicating an early repair phase with radiographically undetectable granulation and fibrous tissue. On day 15, the plate and screws were stable, the fracture orientation remained intact and the fracture line decreased slightly, indicating early callus formation. By day 30, the alignment was still intact, the plate was securely fastened and the bridging callus was plainly evident, indicating that healing was progressing. On day 45, radiographs revealed extensive bridging callus with the fracture line scarcely visible, indicating continuing bone regeneration. By day 60, the bridging callus was complete and the fracture line was obscure, with stable fixation and full healing process (Fig. 5). These findings aligned with the research carried out by

Mahesh (2009) [6], Manjunath (2010) [7], Nilajagi (2021) [8] and Ojus (2022) [9].

In all six cases of femoral fractures were stabilized using suitable sized locking compression plate and screws. The implant allowed for weight bearing as soon as possible and gave the fracture site sufficient stiffness, strength and stability over the research period. Locking compression plate had a combination of fatigue resistance, strength and biocompatibility enabled long-term durability and decreased the risk of mechanical failure. Following the administration of beta tricalcium phosphate (β -TCP), no adverse tissue reactions were seen in any of the cases, indicating its complete biocompatibility and aiding in quicker recovery. Beta tricalcium phosphate (β -TCP) was technically easier to apply, economical, biocompatible, osteoconductivity, potentially yielding positive outcomes in terms of structural restoration and fracture stabilization. Thus, serve as a beneficial option for the managing fractures with bone defects in dogs.

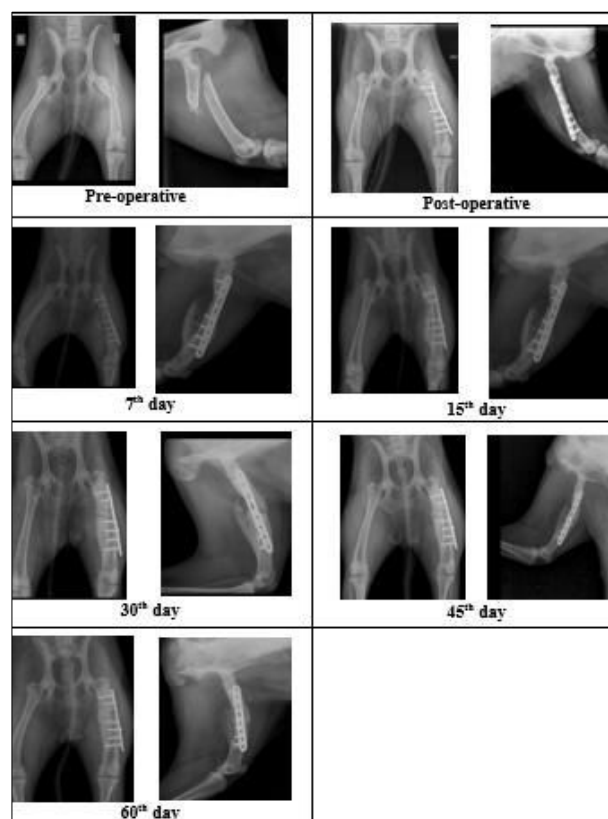


Fig 5: Ventro-dorsal view of hip joint and medio-lateral view of femur radiographs on pre-operative and post-operative days

Conclusion

Beta tricalcium phosphate (β -TCP) was found to effectively fill defects in femur fracture repair, increasing early callus development and decreasing healing time due to its osteoconductive qualities. Locking compression plate implants were shown to be ideal for femur fractures since the plating process was easy, time-saving, and easily adjustable to the contour of the femoral bone.

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