SHORT COMMUNICATION

Biochemical Changes during Evaluation of the Fixin Conical Coupling Locking Plate (CCP) System for Repair of Femoral Fractures in Cats

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Abstract

The study evaluated changes in serum biochemical parameters during the healing of femoral fractures in cats treated with the Intrauma Mini Fixin® Conical coupling locking plate (CCP) system. Six cats with femoral fractures were randomly selected for the study. Serum creatinine, calcium, phosphorus, alkaline phosphatase, and alanine aminotransferase (ALT) were measured before surgery, immediately after surgery, and on days 15, 30, 45 and 60 post-operatively. Calcium, phosphorus, creatinine and ALT remained within physiological limits, with no statistically significant differences ($p > 0.05$) throughout the observation period. Alkaline phosphatase increased markedly on day 15 and day 30, reflecting active osteoblastic activity and early callus formation, before declining, as healing progressed. Stable creatinine and ALT suggested that the anaesthetic protocol and perioperative medications did not compromise renal or hepatic function. Overall, biochemical evaluation indicated favourable physiological progression of fracture healing without systemic adverse effects.

Key words: Biochemical markers, Feline, Femur fracture, Fixin plate, Fracture healing.

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Introduction

Femoral fractures are among the most common long bone injuries in cats due to falls, vehicular trauma and high-energy impacts (Cardoso *et al.*, 2016; Abo-Soliman *et al.*, 2020; Catalkaya *et al.*, 2022). Modern bone plating systems provide strong resistance to bending, rotational and shear forces, and locking plates further enhance construct stability through fixed angle screw plate engagement, reducing dependence on plate bone friction and preserving periosteal blood supply (Kapler and Dycus, 2015). The Fixin® system is an angular stable method using a conical coupling between the screw head and a titanium insert in a stainless-steel plate, providing strong stability and easy implant removal, it preserves periosteal blood supply through minimal bone plate contact and uses guided bicortical screw placement, the screws and bushings can be removed separately. Finite element analyses have shown favourable stress distribution (Petazzoni *et al.*, 2010).

Biochemical parameters, particularly calcium, phosphorus, alkaline phosphatase (ALP), creatinine, and alanine aminotransferase (ALT), serve as important markers for monitoring physiological changes during fracture repair. ALP is a well-established indicator of osteoblastic activity and early callus formation, while calcium and phosphorus reflect mineral metabolism during bone regeneration (Kumar and Poddar, 2025). Creatinine and ALT help to assess renal and hepatic safety during anesthesia, surgery, and post-operative medication. This study was aimed to assess perioperative biochemical changes in cats undergoing femoral fracture repair with the Fixin® conical coupling plate system and to interpret these changes with respect to healing progress and systemic safety.

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Materials and Methods

The clinical study was carried out in the Department of Veterinary Surgery and Radiology, Veterinary College, Hebbal, Bengaluru, to evaluate the effectiveness of the Fixin conical

coupling locking plate (CCP) system for management of femoral fractures in cats. A total of six cats with femoral fracturs were randomly selected for the study, irrespective of age, sex or body weight. Preoperative haematological and biochemical evaluations were performed to assess fitness for surgery. Each cat was subjected to thorough clinical examination, and a fracture case assessment score (FCAS) was assigned as per Palmer (1994). Pain was assessed throughout the study using the Glasgow Feline Composite Measure Pain Scale (CMPS-Feline). Clinical signs such as pain, lameness, swelling and crepitus were recorded. Radiographic evaluation was performed using mediolateral and craniocaudal views to determine fracture configuration and implant dimensions. Plate length and screw length were selected using radiographs of the contralateral limb. Pre-emptive antibiotic, inj. amoxicillin-sulbactum (12.5 mg/kg, SC), was administered until the day of surgery. Buprenorphine hydrochloride (@ 0.02 mg/kg IM) was used as an analgesic.

Cats were fasted for 12 h for food and 6 h for water prior to surgery. The surgical site was clipped and prepared using 4% chlorhexidine gluconate solution and surgical spirit to ensure adequate asepsis. The anaesthesia protocol followed was: Inj. Dexmedetomidine at 7.5 mg/kg IM, Inj. Butorphanol hydrochloride at 0.2 mg/kg IM and Inj. Tiletamine-Zolazepam at 7.5 mg/kg IM. This balanced anaesthesia protocol provided good analgesia, muscle relaxation and sedation in all cats that underwent the surgical repair.

Cats were positioned in a hanging limb position for 15-20 min to facilitate adequate muscle relaxation, and aseptic field draping, the cat was then positioned in lateral recumbency, and a craniolateral approach to the femur was used, involving separation of the superficial and deep heads of the tensor fascia lata, followed by blunt dissection of the biceps femoris and vastus lateralis muscles. Fractures were anatomically reduced and stabilized using Mini Fixin CCP plates (1.9-2.5 mm) with appropriate self tapping morse cone taper screws. Screw insertion into the plates was performed using standard instrumentations ensuring accurate alignment and fixation. The surgical site was closed routinely in layers using polydioxanone sutures for the musculature, subcutaneous tissue, and intradermal skin closure.

Parameters analyzed included serum calcium, phosphorus, creatinine, alkaline phosphatase, and alanine aminotransferase. Mean ± standard error (SE) values were calculated for all parameters. Statistical analysis was performed using one-way analysis of variance (ANOVA) to compare values across different time points, with the level of significance set at p-value less than 0.05.

Results and Discussion

Table 1 presents the Mean ±SE values of serum biochemical parameters recorded during the study period. All parameters remained within physiological limits, except for a significant rise in serum alkaline phosphatase on days 15 and 30 post-surgery.

Serum calcium ranged from 9.6 ± 0.4 to 10.1± 0.2 mg/dL. A mild decrease was observed till day 30, followed by an increase from day 45, with no statistically significant differences ($p>0.05$). Although the changes in the levels of serum calcium were not statistically significant, the minor reduction in calcium may reflect increased osteoblastic activity, and deposition of calcium salt at the fracture site. Elevated alkaline phosphatase activity enhances local inorganic phosphate availability, facilitating calcium salt deposition during callus formation, which may transiently lowering circulating calcium concentrations. This physiological response likely stimulates calcium regulating hormones to maintain homeostasis. Comparable trends during fracture healing have also been reported by Shreevani (2023) and Ruchika (2024).

Serum phosphorus ranged from 3.9 ± 0.1 to 4.4 ± 0.3 mg/dL, increasing gradually to day 45 before returning toward baseline values (Table 1). Serum phosphorus showed a mild rise until day 45 before gradually declining, with all values remaining within normal limits without significant variation. The early increase likely reflects bone resorption during the initial healing phase, while the later decline corresponds to osteoblastic activity and new bone formation. Similar patterns have been reported by Kumar *et al.* (2018), Ojus (2022), Shreevani (2023), Ruchika (2024) and Mohan *et al.* (2024).

Serum creatinine remained between 0.9 ± 0.1 and 1.2 ± 0.2 mg/dL, with no statistically significant changes, indicating normal renal function. Serum creatinine levels remained stable throughout, indicating that anaesthetic protocol and perioperative medications did not exert measurable renal stress. These findings are consistent with previous reports of Tembhurne *et al.* (2010) and Ruchika (2024).

Table 1: Mean ± SE values of serum biochemical parameters (Mean ± SE, n=6)

Days of surgery	Calcium (mg/dL)	Phosphorus (mg/dL)	Creatinine (mg/dL)	Alkaline phosphatase (IU/L)	Alanine Aminotrans-ferase (IU/L)
Before Surgery	10.1 ± 0.2	3.9 ± 0.1	0.9 ± 0.1	81.5 ± 17.4[a]	56.7 ± 2.8
Day 0	9.9 ± 0.4	3.9 ± 0.2	1.2 ± 0.2	78.9 ± 19.3[a]	56.7 ± 2.8
Day 15	9.7 ± 0.2	4.2 ± 0.1	0.9 ± 0.1	165.8 ± 22.2[b]	50.0 ± 0.5
Day 30	9.6 ± 0.4	4.4 ± 0.1	1.0 ± 0.1	169.0 ± 25.7[b]	48.3 ± 6.0
Day 45	10.1 ± 0.2	4.4 ± 0.3	1.2 ± 0.2	96.5 ± 12.6[a]	50.8 ± 2.3
Day 60	10.1 ± 0.1	4.0 ± 0.2	1.0 ± 0.1	89.5 ± 22.5[a]	48.8 ± 2.3

Means with different superscripts (a,b) within the column differ significantly between periods ($p < 0.05$).

Serum alkaline phosphatase (ALP) increased significantly on days 15 (165.8 ±22.2 IU/L) and 30 (169.0 ± 25.7 IU/L) ($p< 0.05$), and then declined by days 45 and 60 to 96.5 ± 12.6 IU/L and 89.5 ± 22.5 IU/L, respectively (Table 1). The significant elevation in serum alkaline phosphatase levels on postoperative days 15 and 30 corresponds to the early reparative phase of fracture healing and reflects increased osteoprogenitor and osteoblastic activity associated with callus formation and mineralization. The subsequent decline in ALP levels by days 45 and 60 indicated progression toward fracture consolidation. Similar observations have been reported by Komnenou *et al.* (2005), Vidiastuti and Pirwatiningsih (2022), Mohammed (2023), and Murthy (2024).

Serum alanine aminotransferase (ALT) values ranged from 48.3 ± 6.0 to 56.7 ± 2.8 U/L with no significant fluctuations, remaining within normal limits postoperatively (Table 1), indicating that the anaesthetic protocol and perioperative medications did not produce any hepatotoxic effects. Similar observations were reported by Ruchika (2024). Overall, biochemical changes observed in this study aligned with expected physiological fracture healing and demonstrated the safety and efficacy of the Fixin® conical coupling plate system

In conclusion, cats undergoing femoral fracture repair using the Fixin® conical coupling plate system demonstrated favorable perioperative biochemical responses without evidence of adverse systemic effects. A significant rise in serum alkaline phosphatase indicated active osteogenesis during the early reparative phase, while serum calcium, phosphorus, creatinine and alanine aminotransferase values remained within normal physiological ranges throughout the postoperative period. The observed biochemical profile suggests physiological progression of fracture healing and confirms that the implant system and perioperative regimen were well tolerated in cats.

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