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# Physiological and biochemical analysis of dogs undergoing femoral fracture repair using advanced locking plate system II and locking compression plate

**Ojus S, D Dilipkumar, Bhagavantappa B, Vijay Kumar M, Sandeep Halmandge, Manjunath Patil and Venkatgiri**

**Abstract**
Analysis of the physiological and biochemical parameters was performed on 12 dogs that underwent surgical repair of diaphyseal femoral fracture using either advanced locking plate system II or locking compression plate. Fracture healing characteristics were studied based on physiological and biochemical parameters. Physiological parameters *viz.*, respiratory rate, heart rate and rectal temperature were analysed on $0^{th}$, $15^{th}$, $30^{th}$ and $60^{th}$ post-operative days. Biochemical parameters *viz.*, serum alkaline phosphatase, serum calcium and serum phosphorous were analysed on pre-operative and $0^{th}$, $15^{th}$, $30^{th}$ and $60^{th}$ post-operative days. Fluctuations with respect to the physiological parameters were observed in both the groups in all post-operative days. Serum alkaline phosphatase showed a decreasing trend up to $30^{th}$ post-operative day after which, there was an increase on $60^{th}$ post-operative day. Serum calcium levels peaked on the $15^{th}$ post-operative day followed by a steady decrease on $30^{th}$ and $60^{th}$ post-operative days. Serum phosphorous levels displayed an increase up to $30^{th}$ post-operative day followed by a decrease on $60^{th}$ post-operative day. All the observed values of the physiological and biochemical parameters during the period of study were within the acceptable physiological limits.

**Keywords:** femur, dog, physiological, biochemical, fracture, ALPS II, LCP

## 1. Introduction
A fracture occurs when the forces that are directly transmitted to the bone exceed the ultimate strength of the bone [1]. There is a steady increase in the incidence of fractures in dogs which may be attributed to the increase in the population of dogs as well as the change in the lifestyle of humans. Femur fracture accounts for the highest number of long bone fractures in dogs, followed by tibia-fibula, radius-ulna and humerus [2]. Though femur fractures are exclusively closed type of fractures, highest incidence of complications such as non-union and osteomyelitis have been observed, which pose a challenge during the healing phase. The extensive musculature around the femur bone, coupled with the limited stabilization provided by external coaptation, necessitates the use of open reduction and internal fixation techniques to achieve biological osteosynthesis. Though the evaluation of fracture healing is primarily done using post-operative radiographs, physiological and biochemical analysis during the post-operative period also aids in supportive assessment of fracture healing in conditions where radiographical analysis poses a challenge.

## 2. Materials and Methods
Twelve dogs presented to the Department of Veterinary Surgery and Radiology, Veterinary College, Bidar with femoral fractures were selected for open reduction and internal fixation with either advanced locking plate system II or locking compression plate. Detailed physical, clinical, physiological, orthopaedic, neurological and radiographic examination to confirm the diagnosis of femur fracture. Surgical repair of the femoral fracture was performed following the principles for fixation of advanced locking plate system II and locking compression plate [3, 4, 5]. The physiological parameters *viz.*, respiratory rate (breaths/minute), heart rate (beats/minute) and rectal temperature (°F) were recorded on post-operative $0^{th}$, $15^{th}$, $30^{th}$ and $60^{th}$ days in both Groups of animals. Respiratory rate was monitored by observing the movement of rib cage, heart rate was monitored by auscultation using stethoscope and rectal temperature was recorded by placing clinical thermometer in the rectum of the dog. 4 mL of blood was collected in clot activator vials to separate the serum.

The collection was done on pre-operative, 0th, 15th, 30th and 60th post-operative days in both the Groups for estimation of serum calcium (mg/dL), serum inorganic phosphorus (mg/dL) and serum alkaline phosphatase (IU/L). These parameters were estimated by using biochemical serum analyser using their respective diagnostic kits. The statistical analysis was done using student's t test [6].

## 3. Results
### 3.1 Physiological Parameters
#### 3.1.1 Respiratory Rate
The Mean ± SE values for the respiratory rate in both the Groups are given in Table 1. The dogs treated with advanced locking plate system II showed an increase up to 30th post-operative day followed by a marginal decrease on 60th post-operative day. The dogs treated with locking compression plate showed decrease up to 15th post-operative followed by an increase on 30th post-operative day and a marginal decrease on 60th post-operative day. The values of respiratory rate were statistically non-significant within the group. The observed fluctuations were within the normal physiological limits.

#### 3.1.2 Heart Rate
The Mean ± SE values for the heart rate in both the Groups are given in Table 1. The dogs treated with advanced locking plate system II showed a decreasing trend up to 15th post-operative day followed by an increase on 30th post-operative day and a marginal decrease on 60th post-operative day. The dogs treated with locking compression plate showed an increase up to 15th post-operative day followed by a decrease on 30th post-operative day and an increase on 60th post-operative day. The values of heart rate were statistically non-significant within the group. The observed fluctuations were within the normal physiological limits.

#### 3.1.3 Rectal Temperature
The Mean ± SE values for the rectal temperature in both the groups are given in Table 1. The dogs treated with advanced locking plate system II showed a peak value on 0th post-operative day followed by a decrease on 15th post-operative day, a marginal increase on 30th post-operative day and a further decrease on 60th post-operative day. The dogs treated with locking compression plate showed a peak value on 0th post-operative day followed by a decrease up to 30th post-operative day and a marginal increase on 60th post-operative day. The observed values of rectal temperature were within the normal physiological limits.

### 3.2 Biochemical Parameters
#### 3.2.1 Serum Alkaline Phosphatase
The Mean ± SE values for the serum alkaline phosphatase in both the groups are given in Table 2 and Fig. 1. The values differed significantly ($p$<0.01) on the 0th, 15th, 30th and 60th post-operative days in both the groups, when compared with their respective pre-operative values. In both the groups, the mean values were highest on the pre-operative day following which, there was a gradual decrease in its concentration up to the 30th post-operative day. Observations on the 60th post-operative day revealed a slight increase in the concentration when compared to the 30th post-operative day. All the values recorded appeared to be within the normal physiological limits.

#### 3.2.2 Serum Calcium
The Mean ± SE values for the serum calcium in both the groups are given in Table 2 and Fig. 2. Among the dogs treated with advanced locking plate system II, the values for the serum calcium differed significantly ($p$<0.01) on the 15th and 60th post-operative days and ($p$<0.05) on the 0th post-operative day when compared with pre-operative value. There was no significant difference between the means of the pre-operative and the 30th post-operative days. Among the dogs treated with locking compression plate, the values for the serum calcium differed significantly ($p$<0.01) on the 0th, 15th, 30th and 60th post-operative days when compared to the pre-operative value.
Elevated levels of serum calcium were observed in all the dogs throughout the period of study. In both the groups, the mean values gradually increased from the pre-operative day up to the 15th post-operative day, after which, the concentration gradually reduced till the 60th post-operative day. The peak values were achieved on the 15th post-operative day in both the groups. All the values recorded appeared to be within the normal physiological limits.

#### 3.2.3 Serum Phosphorous
The Mean ± SE values for the serum phosphorous are given in Table 2 and Fig. 3. Among the dogs treated with advanced locking plate system II, the values for the serum phosphorous differed significantly ($p$<0.01) on the 15th, 30th and 60th post-operative days when compared with pre-operative value. There was no significant difference between the means of the pre-operative and the 0th post-operative days. Among the dogs treated with locking compression plate, the values for the serum phosphorous differed significantly ($p$<0.01) on the 0th, 15th, 30th post-operative days when compared to pre-operative value. There was no significant difference between the means of the pre-operative and the 60th post-operative days.
Elevated levels of serum phosphorous were observed in all the dogs throughout the period of study. In both the groups, the mean values gradually increased from the pre-operative day up to the 30th post-operative day, after which the concentration gradually reduced till the 60th post-operative day. The peak values were achieved on the 30th post-operative day in both the groups. All the values recorded appeared to be within the normal physiological limits.

## 4. Discussion
### 4.1 Physiological Parameters
The observed fluctuations in the physiological parameters were non-significant and well within the normal physiological limits. This was observed because both the implants were inert and did not cause any reactions within the body. Also, the animals selected for the study did not have any signs of concurrent infections. The higher rectal temperature on the 0th post-operative day might be due to the imparted surgical stress.

### 4.2 Biochemical Parameters
#### 4.2.1 Serum Alkaline Phosphatase
The elevated levels of ALP may be attributed to proliferation of osteogenic cells at the fracture site. The maximum contribution of serum ALP may be from periosteum of destructed bone, which is a rich source of alkaline phosphatase. Similar results were documented by Hegade *et al.* (2007) [7], Patil *et al.* (2017) [8], Singh *et al.* (2017) [9] and Reddy (2021) [10]. Contradicting results were reported by

Sousa *et al.* (2011) [11], Hansa *et al.* (2012) [12], Phaneendra *et al.* (2016) [13], Kumar *et al.* (2018) [14], Bidari (2021) [15] and Vani *et al.* (2021) [16].

### 4.2.2 Serum Calcium
The increased levels of serum calcium from pre-operative to 15th post-operative days of fracture healing could be due to increased osteoclastic activity at the fracture site, which leads of resorption of dead bone. The gradual reduction in serum calcium after 15th post-operative day may be due to lowered level of extracellular calcium, thus stimulating the release of calcium metabolising hormones, as documented by Komnenou *et al.* (2005) [17]. All the values recorded appeared to be within the normal physiological limits. Similar results were documented by Singh *et al.* (2017) [9], Kumar *et al.* (2018) [14], Bidari (2021) [15] and Vani *et al.* (2021) [16]. Contrasting results were obtained by Hegade *et al.* (2007) [7], Sousa *et al.* (2011) [11], Patil *et al.* (2017) [8] and Reddy (2021) [10].

### 4.2.3 Serum Phosphorous
The gradual decrease in concentration of serum phosphorous may be due to osteoclastic activity at the fracture site which leads to resorption of dead bone, as documented by Komnenou *et al.* (2005) [17]. Similar results were observed by Singh *et al.* (2008) [18], Bidari (2021) [15] and Reddy (2021) [10]. Opposing results were documented by Hegade *et al.* (2007) [7], Sousa *et al.* (2011) [11], Patil *et al.* (2017) [8], Kumar *et al.* (2018) [14], Vani *et al.* (2021) [16].

**Table 1:** Mean ± SE values for respiratory rate (breaths/min), heart rate (beats/min) and rectal temperature (°F) of dogs

| Group | 0th Day | 15th Day | 30th Day | 60th Day |
|---|---|---|---|---|
| **Respiratory Rate (breaths/min)** | | | | |
| I | 23.50±1.06 | 26.83±2.12 | 28.17±2.46 | 26.67±2.28 |
| II | 26.00±2.18 | 24.33±1.20 | 26.67±1.69 | 25.50±0.99 |
| **Heart Rate (beats/min)** | | | | |
| I | 83.67±1.80 | 79.83±2.30 | 84.83±1.99 | 83.83±2.17 |
| II | 83.17±2.56 | 85.83±2.04 | 83.67±2.97 | 85.17±1.30 |
| **Rectal Temperature (°F)** | | | | |
| I | 101.45±0.23 | 101.10±0.41 | 101.25±0.44 | 100.25±0.28 |
| II | 101.68±0.23 | 100.75±0.28 | 100.68±0.26 | 100.77±0.39 |

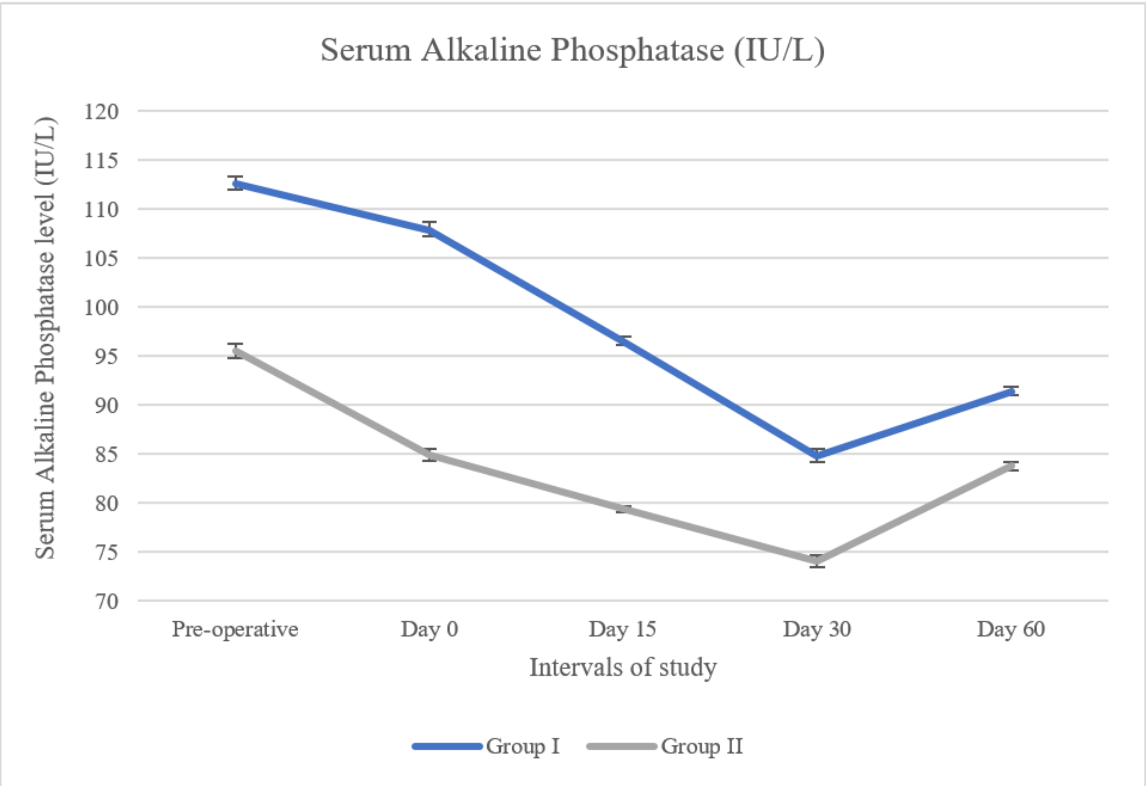


**Fig 1:** Mean ± SE values for the serum alkaline phosphatase (IU/L)

**Table 2:** Mean ± SE values for serum alkaline phosphatase (IU/L), serum calcium (mg/dL) and serum phosphorous (mg/dL) of dogs

| Group | Pre-operative | 0th Day | 15th Day | 30th Day | 60th Day |
|---|---|---|---|---|---|
| **Serum Alkaline Phosphatase (IU/L)** | | | | | |
| I | 112.59±0.66 | 107.77±0.93** | 96.46±0.54** | 84.76±0.78** | 91.36±0.46** |
| II | 95.47±0.70 | 84.89±0.63** | 79.32±0.35** | 74.04±0.65** | 83.72±0.42** |
| **Serum Calcium (mg/dL)** | | | | | |
| I | 8.58±0.13 | 8.92±0.02* | 9.52±0.05** | 8.55±0.04 | 8.13±0.04** |
| II | 9.44±0.09 | 10.05±0.07** | 11.66±0.18** | 10.84±0.13** | 10.11±0.09** |
| **Serum Phosphorous (mg/dL)** | | | | | |
| I | 3.25±0.07 | 3.56±0.02 | 4.37±0.01** | 4.89±0.02** | 4.27±0.05** |
| II | 4.66±0.07 | 4.98±0.03** | 5.34±0.03** | 5.42±0.03** | 4.88±0.02 |

Means bearing superscript * differ significantly ($p<0.05$) from pre-operative intervals within the Group
Means bearing superscript ** differ significantly ($p<0.01$) from pre-operative intervals within the Group

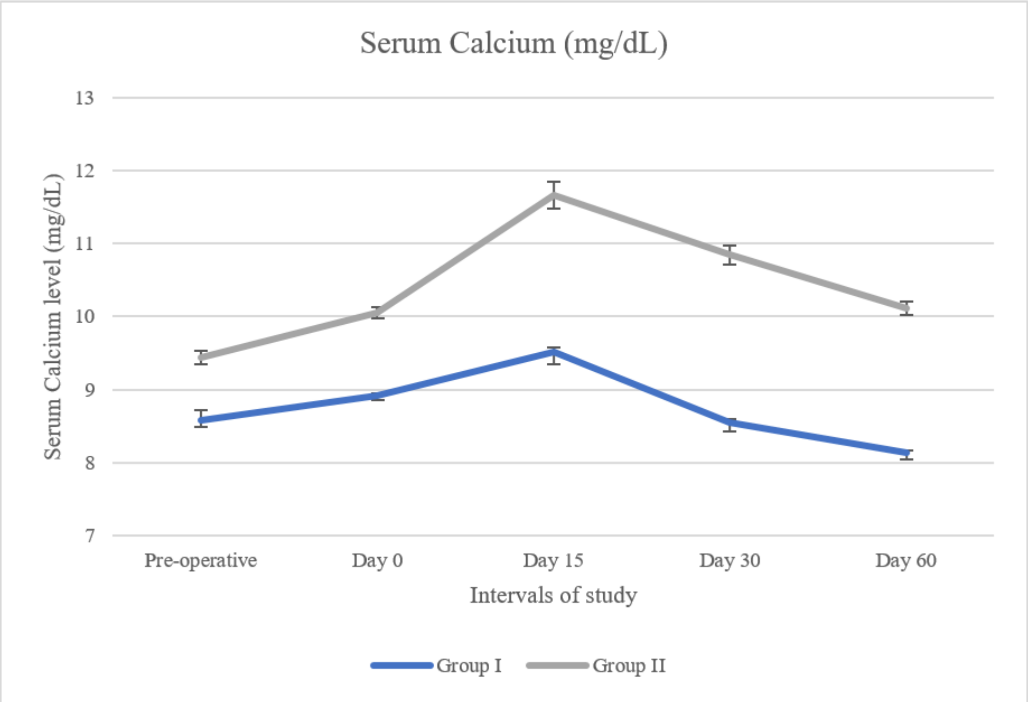


**Fig 2:** Mean ± SE values for the serum calcium (mg/dL)

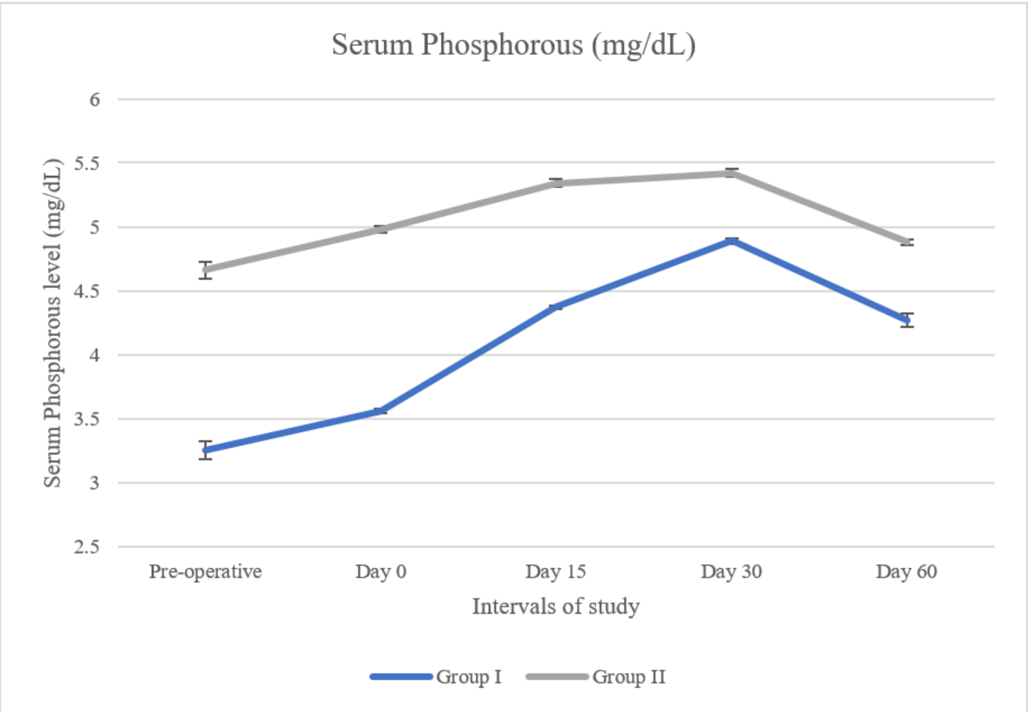


**Fig 3:** Mean ± SE values for the serum phosphorous (mg/dL)

## 5. Conclusion

The observations made in the present study provide a significant understanding of the fluctuations in the physiological and biochemical parameters throughout the fracture healing phase. Though a non-significant difference was obtained for the physiological values, their increase at the 0th post-operative day is indicative of the surgical stress the dogs undergo after the repair of femoral fractures. The fluctuations of the biochemical parameters are indicative of osteosynthesis and can be effectively used as a supporting data for assessment of fracture healing.

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