STUDIES ON A MODIFIED TYPE II EXTERNAL SKELETAL FIXATION FOR THE REPAIR OF TIBIAL FRACTURE IN BOVINES

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON A MODIFIED TYPE II EXTERNAL SKELETAL FIXATION FOR THE REPAIR OF TIBIAL FRACTURE IN BOVINES"** submitted by **Mrs. VARALAKSHMI A ., MVHK 1269** in partial fulfilment of the requirements for the award of **MASTER OF VETERINARY SCIENCE** in **VETERINARY SURGERY AND RADIOLOGY** of the Karnataka Veterinary, Animal & Fisheries Sciences University, Bidar is a record of bonafide research work carried out by her during the period of her study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar titles.

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July, 2016 ***(VARALAKSHMI A)***

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LIST OF ABBREVIATIONS

@	At the rate
%	Per cent
o	Degrees
/	Per
ALT	Alanine aminotransferase
cmm	Cubic millilitre
dl	Decilitre
fig	Figure
IU/ L	International Units per Litre
Kg	Kilogram
mg	Milligrams
mg/dl	Milligram per decilitre
g/dl	Grams per decilitre
mg/kg	Milligrams per kilogram
viz.	Namely
TEC	Total erythrocyte count
TLC	Total leukocyte count
Hb	Haemoglobin
ESF	External skeletal fixation
RTA	Road traffic accidents
BPI	Bone pin interface

Introduction

I. INTRODUCTION

A fracture is dissolution of bony continuity with or without displacement of fragments. It is always accompanied by soft tissue damage of varying degrees; there are torn vessels, bruised muscles, lacerated periosteum, and contused nerve. Fracture management focuses mainly on restoration of function and physical integrity with the minimum deformity of bone (Alam *et al*., 2014).

Limb fractures are common in farm animals are most commonly found in young stock, and often occur subsequent to trauma during distocia or handling. Cattle are excellent patients for treatment of orthopaedic injuries because they spend a majority of time lying down, have a tremendous potential for bone healing, are more resistant than other animals to contra lateral limb breakdown and stress laminitis and usually do not resist having orthopaedic devices on their limbs (Anderson and Jean, 2008).

Managing fracture poses a challenge in the field. Cattle are excellent orthopaedic patients: they have great bone healing properties, most tolerate limb immobilisation well and they rarely suffer from contra lateral limb disorders (Mulon, 2013).

The restoration of bone continuity and bone union are complex processes, and their success is determined by the effectiveness of osteosynthesis .The fractures in cattle occur relatively frequently, resulting in significant economic losses for dairy farming. The economic value of the animal is the main issue to be addressed when it comes to farm animals due to the high costs involved in treatment of fracture (Martins *et al.*, 1981).

Treatment of long bone fractures continues to be a challenge in large animals. Angular placement of the bone and the conical shape of the limb make tibial fractures unsuitable for conservative treatment. Conservative treatment by application of a conventional full limb cast does not immobilize the stifle joint or adequately stabilize tibial fractures (Aithal *et al*., 2010).

Various stabilization techniques are applied in the treatment of bone fractures in animals (Brinker and Verstraete, 1985). The aim of most osteosynthesis techniques is to provide a biological method for fracture treatment and to lower the incidence of the related complications. Only an estimated 5% of bone fractures are not united (Frost, 1989). In most cases, the selection of an adequate osteosynthesis technique and meeting osteosynthesis requirements lead to healing and the formation of healthy bone tissue (Jalynski *et al*., 2004). Disturbances in bone union pose a serious therapeutic problem. Existing treatment methods have been improved and new stabilization techniques have been developed to address this issue. One such solution is the use of a semi-circular external fixator developed by Adamiak, (2010), for the osteosynthesis of long bone fractures. The results of clinical trials investigating the effectiveness of the semi-circular fixator in the treatment of tibia and ulna fractures were discussed by Adamiak (2010) in the Veterinary Record.

Stabilisation of fracture by external fixator is based on the mechanical connecting of the pins, screwed into the proximal and distal bone fragment. Site of fracture is left without any foreign materials, which is essential for prevention of infections (Grubor *et al*., 2011).

Cast immobilization of fracture is most often chosen in ruminants because the most common fractures encountered can be appropriately treated with this form of external coaptation and because casts offer a reasonable economic treatment. Complications of casting include one or more of the following: loss of range of motion of joints because of joint capsule and ligament contracture, reduction in articular cartilage quality and health because of prolonged immobilization, cast ulcers, impingement of soft tissues and vasculature, creation of open wounds that may communicate with the fracture, mal alignment of the fracture, mal union of the fracture, delayed union of the fracture, and prolonged convalescence. Depending on the type of ESF used, these complications can be prevented or minimized. When cast immobilization is not appropriate or does not provide optimal management of fractures, other modalities must be considered. Casts cannot adequately immobilize fractures proximal to the distal radial physis or the distal tibial physis. Also, soft tissue injuries and open fractures may not be managed optimally by use of casts, splints, or splint-cast combinations. ESF presents a better option for stability and healing of fractures in many cases based on fracture configuration, soft tissue injuries, or open fractures (Vogel and Anderson, 2014).

The art of stabilizing fracture fragments is essential for modern surgery and orthopaedic surgery has increased in complexity in terms of stabilizing materials or implants, the choice of implant materials and the techniques of using them are prime factors in the restoration of continuity and functional strength to the fractured bone during the healing process.

With this background, a study on a modified type II external skeletal fixator for the repair of tibial fractures in bovines was undertaken with the following objectives:

1. To study and record the occurrence of tibial fracture in bovines.
2. To standardize the technique of modified type II external skeletal fixation for the repair of tibial fracture in bovines.
3. To evaluate the physiological, hematological and biochemical parameters during the period of study.

Review of Literature

II. REVIEW OF LITERATURE

Available literature on studies on a modified type II external skeletal fixator for the repair of tibial fractures in bovines is reviewed under the following sub titles.

2.1 Occurrence

2.2 Aetiology

2.3 Diagnosis of tibial fracture

2.3.1 Clinical evaluation

2.3.2 Radiological evaluation

2.3.3 Biochemical evaluation

2.4 Anaesthetic protocol

2.5 Pre-operative preparation

2.6 Treatment

2.6.1 Non-surgical

2.6.2 Surgical

2.6.3 Post-operative care

2.7 Post-operative complication.

2.1 Occurrence

Singh *et al*. (1983) recorded that in cattle maximum incidence of fractures in tibia, followed by metatarsus.

Aithal and Singh (1999) recorded high incidence of tibial fracture followed by metatarsal and femur fractures in cattle.

Arnold *et al*. (2001) recorded 75% of left and 25% of right tibial tuberosity fractures in 15 horses involved in the study on conservative management of tibial tuberosity fractures.

Gangl *et al*. (2006) reported that between 2000 and 2003, 99 cattle with limb fractures were treated. Among all treated cases over 50 per cent were tibial fractures, with the femur and os calcis being the second and third most frequently affected bones.

Aithal *et al*. (2010) stated tibial fractures account for 40% of long bone fractures in cattle and repair methods vary depending on animal weight and fracture configuration.

Kushwah *et al.* (2011) according to the study conducted, incidence of tibial fracture is about 50% in cattle and 28.6% in buffaloes.

Shivaprakash (2012) treated 30 bovine patients with compound fracture of radio ulnar , metacarpal , metatarsal and tibial bone and he recorded tibial fracture incidence of 36.6% among 30 treated bovine patients.

Knafo *et al*. (2012) conducted the retrospective study on treatment and outcome of 28 camelids with long bone fracture and they recorded 18% tibial fractures.

Kumar *et al*. (2013) conducted a retrospective study of 986 cases and recorded occurrence and pattern of simple and compound fractures of limb bones in different domestic animals. Among total number of cases the per cent compound fracture in a particular species is more in cattle (47%) followed by horses (32%) and buffaloes (24%).

Arican *et al*. (2014) conducted a retrospective study of fractures in 181 neonatal calves and they recorded 8.8% of tibial fractured cases among total number of cases.

Camara *et al*. (2014) recorded incidence of 22.7% of tibial bone fracture in cattle.

Mohsina *et al*. (2014) conducted a retrospective study on incidence of lameness in domestic animals and they recorded 7% lameness cases in cattle and 5.47% lameness cases in buffaloes.

2.2. Aetiology

Bailey *et al*. (1983) reported tibial fracture in a white-tailed deer which was struck by a motor vehicle on the highway leading to left tibial fracture.

Moll *et al*. (1995) stabilized forelimb fractures in three calves which were due to forced extraction at birth.

Steiner *et al*. (1993) Long-bone fractures may occur as a result of the force applied during parturition, trauma caused by the dam or other animals, during transportation Steiner *et al*., 1993) or as a result of falls or traffic accidents (Aithal *et al*., 2007).

Anderson and St-jean (2008) stated that limb fractures are common in farm animals, are most commonly found in young stock, and often occur subsequent to trauma during distocia.

Nuss *et al*. (2011) in a retrospective study stated that majority of long bone fractures occurs in calves during assisted delivery.

Shivaprakash (2012) stated that the incidence of long bone fractures has increased in recent years due to increased vehicular traffic.

Ahmed and Al-sobayil (2012) stated that trauma was the most frequent cause of fractures in young single humped camels.

Arican *et al*. (2013) conducted a retrospective study of fractures in 181 neonatal calves and they reported fracture of 59 calves were due to excessive force applied during birthing and inaccurate aiding, other 122 fracture cases caused after trauma and badly care.

Kumar *et al*. (2013) reported road traffic accidents were the major cause of fractures in cattle and buffaloes. They have also reported in vehicular accidents, more animals are likely to hit from behind and animals probably are too slow to react so that their rear parts are likely to be hit by vehicles.

2.3. Diagnosis of tibial fracture

2.3.1 Clinical evaluation

Singh *et al.* (1987) treated a mid-shaft radial fracture in a mare by trans fixation pinning with full limb cast. They reported that the weight bearing capacity of the affected limb increased progressively

St- Jean and Debowes (1992) reduced and stabilized radial-ulnar fractures in three calves by transfixation pinning and casting and monitored fracture healing by clinical and radiographic evaluation. They reported that all calves stood and bore weight on the surgically treated limb within 24 hours after surgery. The fractures and the pin hole wounds healed without any complication in 6-8 weeks.

Hamilton and Tulleners (1980) reduced and stabilized proximal tibial fractures in three newborn beef calves by trans fixation pinning showed good radiographic and clinical evidence of stability in 4 to 6 weeks.

St- Jean *et al.* (1991) reduced and stabilized tibial fractures in five calves by trans fixation pinning and casting. They monitored the maintenance of reduction and fracture healing by radiographic evaluation and observed bony union with external callus in all calves by 8^{th} post-operative week.

Martens *et al*. (1998) stabilized tibial fractures in 95 cattle by means of conservative and surgical treatment, pins were removed after a mean (SD) period of 71(14) days.

Joyce *et al.* (2006) conducted a study on use of trans fixation pin casts to treat adult horses with comminuted phalangeal fractures in 20 cases during (1993-2003) with an objective to determine the clinical applications, short and long-term survival, and complications of using transfixation pin casts for treatment of comminuted phalangeal fractures in adult horses. And they stated that horses should be maintained in a transfixation pin cast for a minimum of 40 days, as this was associated with an increase in short-term survival without an increased risk of catastrophic failure.

Bilgili *et al*. (2008) stabilized 3 tibial and 3 metacarpal fractures in calves using an ilizaro ring fixator and they reported that the fixator was tolerated well, the fractures healed and the fixators maintained rigid stability. The calves were able to use their limbs fully after between 15 and 27 days.

Aithal *et al.* (2010) concluded that, CEF provided a stable fixation of tibial fractures and healing within 60 days and functional recovery within 90 days.

Coomer *et al*. (2011) reported successful stabilization of closed, comminuted distal metaphyseal transverse fractures of left tibia and fibula in a tiger using hybrid circular external skeletal fixator. The fracture healed and the fixator was removed 5 weeks after stabilization. Limb length and alignment were similar to the normal contra lateral limb at hospital discharge, 8 weeks after surgery.

Prabhakar *et al*. (2012) reported one month post treatment in two buffalo calves treated for metacarpal and metatarsal fracture follow up revealed complete weight bearing on the treated limb in both the animals and nine weeks post treatment follow up revealed healed wound with healthy scar tissue.

Gahlod *et al.* (2012) stabilized midshaft comminuted fracture of left tibia in black buck using intramedullary pinning in a retrograde fashion and circlage wiring supported by plaster cast under xylazine and ketamine anaesthesia. The healing progress was assessed by periodical radiological examination. Animal showed uneventful recovery with complete weight bearing on affected limb after three months.

Patel *et al.* (2012) stated that, clinical observation showed mild to moderate swelling at all the insertion sites up to 5^{th} to 7^{th} post-operative days. The observation for weight bearing revealed that partial weight bearing on immediate post-operative and early full weight bearing that might be due to rigid fixation. Such rigid fixation with Jalaram Assembly and intramedullary pinning showing less callus formation and early ambulation at 15 to 45 days in young calves and 45 to 60 days in an adult cow. Earlier restoration of normal limb function and joint mobility were observed in all three animals whose tibia fractures were stabilized with intramedullary pinning and jalaram assembly.

Piorek *et al*. (2012) stabilized transverse tibial shaft fracture in six sheep using interlocking nails and type I external fixator and they reported weight bearing on the fractured limb on day 2 to 4 after treatment. Osteosynthesis was monitored by radiological examinations performed weekly, beginning on the day of surgery and ending after nine weeks. And ninth week radiographs revealed complete disappearance of fracture line on treated limbs.

Guzel *et al*. (2013) treated radius and ulna fracture in a llama and the case was clinically evaluated on 30th, 45th, 90th and 120th post-operative days.

George *et al*. (2014) stabilised open dislocated metacarpo-phalangeal joint in a calf using external skeletal fixation and they stated that animal was able to bear weight partial weight on 30th postoperative day on the operated limb and the ESF was removed on 50th post-operative day.

Kofler *et al*. (2014) stabilized comminuted metacarpal fracture in an 870kg bull and the case was clinically evaluated on 30th, 50th, 62nd, and 110th, 130th days post operatively, at 6.5 months overextension of right carpus has resolved and carpal valgus had improved.

Rossignol *et al*. (2014) stabilised 11 adult horses with comminuted phalangeal fractures usings modified transfixation pin cast technique where pin casts were maintained for a minimum of 6 weeks and pins were removed at 6 to 8 weeks.

Alam *et al*. (2014) stated all calves showed good weight bearing in the immediate post-operative period. Severe pain was noticed for first 2 postoperative days in all calves, which gradually lessened and subsided by 14th postoperative day in almost all calves. The fixators applied to different bones were well-tolerated, and the animals could lie down, stand and walk freely with the fixator without any problems after 60 days.

2.3.2 Radiological Evaluation

Tyagi and Gill (1972) studied the healing of long bone fractures in 20 buffalo calves treated by transfixation pinning with cast and reported that radiographs obtained after a week showed practically no periosteal reaction and slight rarefaction adjoining the fracture as evidenced by the blurred appearance of the fractured ends. They further stated that visible callus was small and appeared only at the fifth week.

Verschooten *et al*. (1972) observed severe periosteal reaction developed around the pins in 8 cases of tibial fractures of cattle. Callus formation varied considerably depending on degree of immobilisation acquired with transfixation.

Sahay and Khan (1976) treated experimental metacarpal and metatarsal fractures in 12 buffalo calves by transfixation pins immobilized with acrylic splints. They reported that radiographs taken 35 days after immobilization revealed satisfactory healing with minimal periosteal callus formation.

Hamilton and Tulleners (1980) reported good radiographic and clinical evidence of fracture healing and stability was evident in 4 to 6 weeks post operatively.

Sharma *et al*. (1980) observed early periosteal reaction at 2^{nd} week in the experimentally created midshaft metatarsal fracture of four buffalo calves.

Adams and Fessler (1983) reduced tibial fracture in a calf by transcortical pinning and casting. During radiographic follow-up, observed the formation of exuberant callus at the fracture site, involving all the pieces and allowing the withdrew the device on 52^{nd} postoperative day.

St-Jean *et al*. (1991) reduced and stabilized tibial fractures in five calves by transfixation pinning and casting. They monitored the fracture reduction and healing by radiographic evaluation. Good radiographic and clinical evidence of stability was observed in 5 to 10 weeks (mean 8 weeks), at which time the pins and cast were removed. Return to normal function was rapid and judged to be excellent at follow-up evaluation 3 to 12 months later.

St-Jean and Debowes (1992) treated radial - ulnar fractures in 3 calves by transfixation pinning and casting and monitored the maintenance of fracture reduction and healing by periodic radiographic examinations. Radiographic evaluation of healing consisted of an assessment of callus formation and bony union. They observed a mean fracture healing time of six weeks. They also observed bony lysis in one or more pins in two calves but healing was excellent in all the calves.

X-ray gives important information for diagnosis, healing and prognosis of critical data. It causes variety of positions in particular taken from lateromedial and caudo-cranial positions (Ewoldt *et al*., 2003).

Martins and Camargo (2003) subjected a Simmental calf with metacarpus fracture to transcortical pinning and fibreglass cast technique. They observed that on 30th day after surgery radiographic examination showed osteolysis in the path of the proximal pin. The discomfort caused by osteolysis had resolved after removal of pins and showed that external fixation of fractures with pins and fibreglass cast gave short recovery period (43 days).

In a study of tibial fractures in sheep stabilized with a type I external fixator , histopathological analysis of the callus revealed complete bone union after nine weeks of treatment (Klein *et al*., 2003).

Ramanathan *et al*. (2006) conducted experiment on metacarpal fractures in six calves. They immobilized the calves with bilateral type II external skeletal fixator with Aesculaps model clamps. Two calves showed pin tract osteolysis on 45^{th} day and also on 60^{th}day. Pin bending and breakage was not observed in any of the cases, radiographic evidence of complete healing was observed in 5 animals on 60^{th} post-operative day.

Bilgili *et al*. (2008) stabilized 3 tibial and 3 metacarpal fractures in calves using an ilizaro ring fixator. Radiological examinations were carried out to assess fracture healing, stability of the fixator.

Radiological evaluation showed signs of bone union between days 52 and 68 after surgery in eleven sheep treated for tibial fracture using semicircular fixator (Adamiak and Rotkiewicz., 2010).

Gahlod *et al*. (2012) stabilized tibial fracture in a black buck, the healing progress was assessed by periodical radiological examination.

Prabhakar *et al*. (2012) clinically managed metacarpal and metatarsal fractures in two buffalo calves using “U” splint with pop cast with window at the site of fracture. Radiographs at 9 weeks after the treatment revealed complete union of the fractures with cortical continuity and no evidence of fracture lines.

Piorek *et al.* (2012) conducted a study on treatment of tibial shaft fractures in sheep using interlocking nails, Schanz screws and type I ESF wherein they monitored osteosynthesis by radiological examinations performed weekly, beginning on the day of surgery and ending after nine weeks.

Shivaprakash (2012) reduced and stabilized compound fracture in bovines using transfixation pinning and external casts. Radiological union in two calves on day 50 failed to recover due to re fracture noticed immediately after removing the transfixation pins and plaster casts.

Guzel *et al*. (2013) radiographs taken on 30th post-operative days revealed secondary callus at fracture site which was determined to be sufficient to grip the fracture ends. 45th day post-operative radiograph showed regressed secondary callus and disappearance of fracture gap. 90th day radiograph showed resolved secondary callus and initiation of remodeling process. 120th day radiograph revealed absence of fractured line with complete union of bone fragments.

2.3.3 Biochemical evaluation

Reddi and Huggins (1972) stated that the appearance of bone and mineralisation of the newly induced bone was indicated by an increase in the calcium incorporation into bone mineral from day 9 onwards.

Singh and Nigham (1976) observed no appreciable alteration in the values of serum calcium and it was almost within the normal limit throughout period of their experiment. The values of the inorganic phosphorous slightly decreased in the first week, gradually increased from second week onwards. It remained higher than the normal preoperative value up to the 10^{th} week.

Bailey *et al*. (1983) observed marked elevation of creatinine phosphokinase level (CPK) during clinicopathological examination of the patient.

Saikia *et al*. (1986) recorded the changes in certain blood and bone biochemical constituents during fracture healing in bovines and reported that serum calcium did not show any significant variation during the different stages of fracture healing.

Ramanathan (1996) observed non-significant reduction in the calcium level during first two weeks of the fracture healing in experimentally induced fracture treatment of metacarpal bone in calves. He also reported non-significant increase in the serum phosphorous level on 7^{th} postoperative day and return to normal level at 60^{th} post-operative day.

Ramesh (2000) reported significant increase in the serum calcium during the observation period from 15 to 60 day postoperatively as compared to as preoperative serum calcium level. He also reported significant decrease in the serum phosphorous during the observation period from 15 to 30 day postoperative day, but there was significant increase in level during 30 to 45 days postoperatively after that gradual increase until 60^{th} day post operatively.

2.4 Anesthetic protocol

Toews *et al*. (1998) successfully stabilized long bone fracture in 5 wapiti. The wapiti ranged in weight from 60 kg to 550 kg. Prior to examination, the wapiti were sedated with xylazine (1.1 mg/kg BW, IM), administered by blow dart. Anaesthesia was induced with diazepam (0.2 mg/kg BW) and ketamine (1.1 mg/kg BW) or tiletamine/zolazepam (2.0 mg/kg BW) combination, administered IV. The wapiti were intubated and anaesthesia was maintained with halothane or isoflurane.

Martins and camargo (2003) followed anesthetic protocol which consisted of the use of 2% xylazine (0.2 mg / kg IM), butorphanol (0.02 mg / kg IV) and Bier's anaesthesia with 2% lidocaine in a total volume of 20 ml.

Ramanathan *et al*. (2006) anaesthetised the calves by the administration of xylazine at the rate of 0.2 mg per kg intramuscularly and 10 minutes later ketamine at the rate of 5 mg / kg intravenously. Intravenous regional analgesia was used as an adjunct when the duration of surgery extended up to one hour. It was induced by the administration of 20 ml of 2 % lignocaine hydrochloride into the radial vein, after application of a tourniquet above the carpus.

Aithal *et al*. (2007) reported that sedation with xylazine hydrochloride (2%) were proved to be effective to control the animals in lateral recumbency throughout the surgical procedure with sufficient analgesia for fracture repair near the carpal joint of two calves treated by transarticular fixation with a circular external fixator.

Bilgili *et al*. (2008) premedicated the calves having comminuted fractures of metacarpus and tibia with xylazine hydrochloride (0.1 mg /kg IV) and general anaesthesia was induced and maintained with isoflurane administered by mask.

Ahmed and Al-sobayil (2012) used xylazine hcl 0.3mg / kg BW intravenously to induce deep sedation in camels to stabilize long bone fracture using plaster of paris bandage.

Gahlod *et al*. (2012) reported successful repair of midshaft comminuted fracture of left tibia in black buck by intramedullary nailing and full circlage wiring supported by plaster cast under xylazine and ketamine anesthesia.

Patel *et al*. (2012) sedated the tibia fractured calves with Inj. Xylazine hydrochloride at 0.1 mg/kg body weight intramuscularly. Then after preparation of site the lignocaine hydrochloride (2%) solution (15-20 ml) was infiltrated at the site of treatment.

Shivaprakash (2012) used xylazine and ketamine anaesthesia in treatment of compound fracture in bovines using transfixation pinning and external casts.

Tambe *et al*. (2012) performed different anaesthesia like xylazine, chloral hydrate and lignocaine hydrochloride for the treatment of long bone fractures in bovines.

Guzel *et al*. (2013) stabilized distal radius and ulna fracture in a young llama, the anaesthesia was induced using isoflurane at a concentration 4%, and general anaesthesia was maintained with 1.5 % isoflurane vaporised in 100% oxygen in a semi closed circle system.

George *et al*. (2014) stabilised open dislocated metacarpo-phalangeal joint in a calf using external skeletal fixation. The calf was restrained in lateral recumbency after being sedated with xylazine 0.05mg/kg b.wt, i.m. and after achieving brachial plexus block using 2% lignocain solution.

Alam *et al*. (2014) stabilized long bone fracture in calves where the animal was sedated with Xylazine Hydrochloride 2% (Rompun® Bayer, Leverkusen) @ 0.05mg/kg body weight and local anaesthesia was performed with 2% Lignocaine Hydrochloride (Jasocaine®, Jayson Pharmaceuticals Ltd., Bangladesh)

2.5 Preoperative preparation

Reichel (1956) recommended that two radiographs should be taken and placed in front of the surgeon during performance of surgery for the exact reduction of the fragments.

Bailey *et al*. (1983) administered intravenous fluids, crystalline penicillin and dandrolene, fractured limb was immobilized in a modified Thomas splint prior to surgery.

St-Jean *et al*. (1991) administered sodium ampicillin (10mg/kg of body weight, IV q 12 h) in calves with tibial fractures prior to surgery and continued for 3 to 10 days post operatively. After induction of general anaesthesia, each calf was positioned in dorsal recumbency for access to both sides of the limb and potential benefits of hanging limb traction.

St-Jean and Debowes (1992) administered Sodium ampicillin (10 mg/kg, IV q l2h; and gentamicin sulfate (2.2 mg/kg, IV ql2h) calves prior to surgery and continued for four days in transfixation pinning and casting of radial-lunar fractures in calves. After induction of general anaesthesia, each calf was positioned in dorsal recumbency to permit access to both sides of the forelimb and to facilitate reduction through the technique of hanging limb traction. The fracture site was identified by palpation and radiographic examination.

Toews *et al*. (1998) successfully stabilized long bone fracture in 5 wapiti. The wapiti were placed in lateral recumbency with the affected limb uppermost. All of the wapiti received cefazolin (11 mg/kg BW) IV, at induction. Routine aseptic preparation of the affected limb was carried out. Samples for bacteriological culture were taken from the wounds of the compound fractures, from which necrotic tissue and bone were debrided, and which were lavaged with sterile saline.

Martens *et al*. (1998) performed conservative and surgical treatment of tibial fractures in cattle, for which they fasted the animals for one day and the affected leg was surgically prepared before the animal was placed dorsally in the V-shaped rack. The affected leg was pulled up by means of tackle.

Ramanathan *et al*. (2006) conducted experiment on metacarpal fractures in six calves. They prepared all the calves by withholding feed for 24 hours and water for 12 hours prior to surgery and the site was shaved, washed with soap and painted with povidone iodine. The limb was suitably draped.

Patel *et al*. (2012) treated two young calves and an adult cow for tibial fracture by external fixation; they prepared the animal with fasting for 24-48 hrs prior to surgery. They aseptically prepared the site by washing the site with soap solution and painting with povidone iodine.

Prabhakar *et al*. (2012) for clinical management of metacarpal and metatarsal fractures in two buffalo calves placed the animals in lateral recumbency with the affected limb up. The affected limb was pulled with a cotton rope tied at the fetlock joint and counter traction was provided with a rope passed under the axilla or the groin region depending upon fore limb or hind limb respectively. Limb was cleaned of dust and gross particle with a clean cloth. In open fractures wound was cleaned with 5% povidone iodine solution mixed with 0.9% normal saline solution.

Piorek *et al*. (2012) reported the animals were premeditated with antibiotic amoxicillin trihydrate at 20 mg / kg BW IM and metamizole at 50 mg /kg BW IM for pain relief approximately one hour prior to surgery.

Gahlod *et al*. (2012) reported successful repair of midshaft comminuted fracture of left tibia in black buck by intramedullary nailing and full circlage wiring supported by plaster cast. The animal was kept off fed and water was withheld 18hours prior to the surgery. The left hind limb from stifle to below the hock was prepared for aseptic surgery in a routine fashion.

Patel *et al*. (2012) stabilized tibial fractures in two calves and one cow which were fasted and sedated prior to surgery.

2.6 Treatment of tibial fractures in bovine

2.6.1 Non-surgical treatment

Martens *et al*. (1998) stabilized tibial fractures in 95 cattle. Among 95 cattle twenty two cattle were slaughtered. Conservative treatment with stall confinement and or a splint or cast was applied in 18 cases, with satisfactory results in 8 cases.

Arnold *et al*. (2001) stated that conservative management of tibial tuberosity fractures in the horse is a viable method of treatment provided no other soft tissue damage exists within the affected stifle.

Gamper *et al*. (2006) in a study conducted on clinical evaluation of the CRIF 4.5/5.5 system for long-bone fracture repair in 22 cattle, the successful long term outcome achieved in18 cattle; 4 were euthanized 2-14 days post operatively.

Ahmed and Al-sobayil (2012) concluded that external fixation of fractures by means of plaster of paris bandage alone or with PVC splints and IDW are successful methods of treatment in young camels.

Prabhakar *et al*. (2012) successfully stabilized metacarpal and metatarsal fractures in two buffalo calves by means of u splint and POP cast, both calves bore weight on treated limb by 30^{th} postoperative day.

Arican *et al.* (2013) in a retrospective study of fractures in 181 neonatal calves, one hundred thirty four calves were treated with closed reduction and full limb bandage with plaster and poly vinyl chloride material.

Alam *et al*. (2014) reported that 8 calves with long bone fracture were treated with closed reduction with external fixation using bamboo splints and plaster of paris resulted in poor prognosis.

2.6.2 Surgical treatment

Bailey *et al*. (1983) stabilized tibial in a white tailed deer by means of an intramedullary pin with full circlage wires supported by a plaster cast and he stated that fracture healed uneventfully.

Hamilton and Tulleners (1980) reduced and stabilized proximal tibial fractures in 3 beef calves by means of transfixation pinning. They stated that return to normal function was rapid in two calves. One calf acquired septic arthritis of stifle and was euthanized.

Kaneps *et al*. (1989) stated that transfixation pinning with fiberglass casting is an effective and adaptable method of long bone fracture fixation in llamas and small ruminants.

St-Jean *et al*. (1991) reduced and stabilized tibial fractures in 5 calves by means of transfixation pinning and casting between 1985 to 1989.

St-Jean and Debowes (1992) reviewed the medical records of three calves with radial-ulnar fractures which were reduced and stabilized by transfixation pinning and casting. They concluded that transfixation pinning is a useful means of stabilizing radial-ulnar fracture in pediatric bovine patients.

Moll *et al*. (1995) stabilized metacarpus fracture in three calves using type II external skeletal fixator and they reported that type II external skeletal fixators may be adequate for treatment of selected calves with delayed union of a fracture.

Mills *et al*. (1996) treated three deer's with comminuted fractures using type-III trilateral external skeletal fixation and they concluded that type –III trilateral external skeletal fixation devices can be used for the repair of comminuted fractures in young deer.

Martens *et al*. (1998) treated tibial fractures in 55 cattle where fixation device is fixed externally with Steinmann pins and methyl methacrylate bridges under image intensified fluoroscopy.

Toews *et al*. (1998) reported that external skeletal fixators were used successfully to treat severely comminute d fractures in 5 wapiti and he also stated that type II external skeletal fixators using 2, 3, 4.76-mm diameter, positive profile pins per bone segment and polymethacrylate side bars of 31-mm diameter were sufficiently strong and stiff to resist forces generated by a 75 kg and a 150kg wapiti, respectively.

Hente *et al*. (1999) in an experimental study conducted on fracture healing of the sheep tibia treated using a unilateral external fixator the fracture healed well in all 12 treated cases with optimum callus formation at fractured site.

Gamper *et al*. (2006) in a study conducted on clinical evaluation of the CRIF 4.5/5.5 system for long-bone fracture repair in 22 cattle, the successful long term outcome achieved in18 cattle; 4 were euthanized 2-14 days post operatively.

Bilgili *et al*. (2008) stabilized 3 tibial and 3 metacarpal fractures in calves using an ilizaro ring fixator and they reported that the fixator was tolerated well, the fractures healed and the fixators maintained rigid stability. The calves were able to use their limbs fully after between 15 and 27 days.

Lescun *et al*. (2007) conducted a study on transfixation casting for treatment of third metacarpal, third metatarsal and phalangeal fractures in 37 horses treated from 1994 to 2004 and reported that transfixation casting can be successful in managing fractures distal to the corpus or tarsus in horses.

Singh *et al*. (2007) conducted a study on in vitro biomechanical testing of ESF constructs and they stated that ESF made from mild steel for use in large ruminants could withstand ≤ 300kg load applied under compression and bending moment without any substantial adverse biomechanical effects on the constructs.

Brounts *et al*. (2011) made a case study on comparison of fixation methods for treatment of long bone fractures in llamas and alpacas and they concluded that internal fixation with bone plates was associated with fewer major complications than external fixation with a transfixation pin cast.

Aithal *et al*. (2010) stabilized tibial fractures using a circular external fixator in two calves and they concluded that CEF provided a stable fixation of tibial fractures and healing within 60 days and functional recovery within 90 days.

Nuss *et al*. (2011) recorded that fracture healing occurred after surgical treatment in 44 of 82 calves. The outcome was better in calves with plate and clamp-rod internal fixation (37/58 healed) than with intramedullary pinning (4/16 healed) or external fixation (3/8 healed).

Coomer *et al*. (2011) reported successful stabilization of closed, comminuted distal metaphyseal transverse fractures of left tibia and fibula in a tiger using a hybrid circular external skeletal fixator.

Patel *et al*. (2012) stabilized tibial fractures using internal and external fixation and they reported that the earlier restoration of normal limb function and joint mobility were observed in all three animals whose tibia fractures were stabilized with intramedullary pinning and jalaram assembly.

Gahlod *et al*. (2012) reported successful repair of midshaft comminuted fracture of left tibia in black buck by intramedullary nailing and full circlage wiring supported by plaster cast.

Shivaprakash (2012) compound fracture of different long bone in thirty cows was repaired by transfixation pinning using three different external reinforcement frames or casts.

Knafo *et al*. (2012) reviewed treatment and outcome of camelids with long bone fractures. According to the medical records (1998-2008), 28 camelids long bone fractures were fixed by means of internal fixation, external fixation, combination of internal and external fixation, amputation and external fixation followed by amputation and they opined that internal fixation was associated with superior alignment and outcome.

Prabhakar *et al*. (2012) stabilized metacarpal and metatarsal fractures in two buffalo calves by means of u splint and POP cast.

Piorek *et al.* (2012) conducted a study on treatment of tibial shaft fractures in sheep using interlocking nails, Schanz screws and type I ESF wherein transverse tibial fractures were induced in six merino hybrid female sheep and fractures were stabilized by means of interlocking nails, Schanz screws and type I ESF and they reported that complete restoration of limb function achieved around five weeks after the surgery.

Arican *et al.* (2013) in a retrospective study of fractures in 181 neonatal calves, twenty calves with fracture were operated with intramedullary nailing and two animals operated with dynamic compression platting.

Güzel *et al.* (2013) successful fracture healing was achieved without any complications using combination of external and internal fixation in treatment of a distal radius and ulna fracture in a young llama.

Kofler *et al.* (2014) comminuted right metacarpal fracture in bull was repaired using 2 transfixation pins (6 mm diameter) through the distal metaphysis and diaphysis of the radius and a full limb synthetic resin cast.

George *et al*. (2014) stabilised open dislocated metacarpo-phalangeal joint in a calf using external skeletal fixation and they stated that animal was able to bear weight partial weight on 30^{th} postoperative day on the operated limb and the ESF was removed on 50^{th} postoperative day.

Alam *et al*. (2014) reported that open reduction with internal fixation using stainless steel orthopaedic wires and modified Thomas splints were used to treat 12 fractures in long bones of calves aged 8 days to 5 months. All calves treated with open reduction and internal fixation showed good weight bearing in the immediate post-operative period.

Rossignol *et al*. (2014) stabilised 11 Adult horses with comminuted phalangeal fractures using modified transfixation pin cast technique and they concluded that modified transfixation pin casting technique was associated with good pin longevity and could reduce the risk of secondary pin hole fractures and pin loosening.

2.6.3 Post-operative care

Martins *et al* (1981) administered antimicrobial therapy with florfenicol (20mg / kg, IM) at an interval of 24 hours for three consecutive days, post-operative analgesia with phenylbutazone (4.4 mg/ kg IV) was used every 12 hours for a period of four days during treatment of tibial fracture in a calf by transcortical pinning and fibreglass casting.

St-Jean *et al*. (1991) administered sodium ampicillin (10mg/kg of body weight, IV q 12 h) in calves with tibial fractures prior to surgery and continued for 3 to 10 days post operatively.

St- Jean and Debowes (1992) administered Sodium ampicillin (10 mg/kg, IV q l2h; every calf) and gentamicin sulfate (2.2 mg/kg, IV ql2h, calves 1 and 2) prior to surgery and continued for four days in trans fixation pinning and casting of radial-ulnar fractures in calves.

Martins and camargo (2003) post-operatively provided antibiotic therapy for 10 days with benzathine penicillin at a dose of 20,000 IU / kg every 48 hours (IM), analgesic therapy with phenylbutazone at a dose of 4.4 mg / kg every 12 hours (IV) for three days and restricted the movement of during the whole period of observation in a Simmental calf treated with transcortical pins and fibreglass cast for metacarpal fracture.

Ramanathan *et al.* (2006) post-operatively restricted the calves in stall confinement and administered Sodium ampicillin (10 mg per kg, iv q 12 h) and gentamicin sulphate (3 mg per kg, iv q 12 h) to every calf prior to surgery and continued for 4 days in a study conducted on transfixation on metacarpal fractures using bilateral type II external skeletal fixator in six calves.

Bilgili *et al.* (2008) post operatively carried out clinical and radiological examinations to assess fracture healing, the stability of the fixator and when the calves could make full use of the limb.

Prabhakar *et al*. (2012) post-operatively administered parenteral Ampicillin and Cloxacillin at 5-10 mg/kg body weight IM for 12 days, gentamicin at 2-4 mg/kg body weight. IM for 3 days and oral supplementation of calcium syrup bid was given for 30 days in clinical management of metacarpal and metatarsal fractures in buffalo calves using U splint with plaster of paris. Owners were advised to prevent the plaster from getting wet and allow restricted movement of the calves.

Ahmed and Al-sobayil (2012) compound fractures in camels were treated with local and systemic antibiotics (penicillin-streptomycin at a dose of 30,000 IU/kg of penicillin and 10 mg/kg of streptomycin, Pen & strep, Nor brook Laboratories, UK) with a window on the wound through the cast. The cast was re inspected after 2 weeks. Follow up of the cases was done by a phone call to the camel's owners.

Piorek *et al.* (2012) conducted a study on treatment of tibial shaft fractures in sheep using interlocking nails, Schanz screws and type I ESF wherein patients were post operatively administered the analgesic drug metamizole , at 50 mg/kg BW IM for 6 days, and antibiotic amoxicillin, at 20 mg/kg BW SC every 48 hours for one week. The site of implant was dressed; wound dressing were changed weekly and rinsed with 1% aqueous solution of chlorhexidine gluconate.

Gahlod *et al*. (2012) stabilized left tibial fracture in a black buck where Post-operatively the animal was given Cefodoxim (Cefpet®) 200 mg BD orally for 7 days and Meloxicam suspension (Melonexa suspension) 10 ml orally for 3 days. Dressing sof surgical wound with povidone iodine solution was done on alternate days.

Guzel *et al*. (2013) postoperatively administered cefazolin sodium (25mg/kg, intramuscularly (IM), every 8 hr) for 7 days. Non-steroidal anti-inflammatory drugs (flunixine meglumine 1mg/kg BW, IV every 12 hours) for 5 days .

Alam *et al*. (2014) post-operatively administered Systemic antibiotics, Penicillin and Streptomycin, The analgesic or non-steroidal Anti-inflammatory injection, Ketoprofen and antihistaminic drug containing Pheniraminemeleate was used in intramuscular route. The animals were kept in rest with limited movement was allowed. Follow up of the cases was done. Periodical radiographic assessment (at 15 day, 30 day and 60 day of post-operation) was carried out to evaluate reduction and alignment of bone fragments, and callus formation and complications, if any.

2.7 Post- operative complication.

Oehme and Prier (1974) stated that development of soft tissue infection; bone necrosis and osteomyelitis with pin loosening were common sequelae to the transfixation.

Sahay and Khan (1976) observed no incidence of pin loosening, displacement and breakage of acrylic splint from external immobilization device which was fabricated by self-polymerizing acrylic agent for stabilization of long bone fracture in buffalo calves.

Hamilton and Tulleners (1980) in a case of communited proximal tibial epiphyseal fracture observed osteomyelitis and infectious arthritis of stifle joint on 15th post- operative day, which was treated by trans fixation pinning and casting technique.

Tulleners (1986b) observed osteomyelitis and refracturing of 3 metatarsals out of 33 metacarpal and metatarsal fracture cases treated by application of short or full limb reduction casts. No noticeable angulations, bowing or shortening was seen even after 7-8 months of fracture treatment in the other 30 cases.

Aron *et al*. (1986) reported that the external skeletal fixator became unstable because of pin loosening, predisposing the fracture zone and granulation tissue around the loosened pins for infection in 4 out of 32 treated for unstable fractures of tibia, metacarpal and metatarsal bone by primary external skeletal fixation and further stated that once infection was established, it worsened until the environment was again stabilized by changing the fixation method and providing specific therapy.

Richardson *et al*. (1987) stabilised metacarpo phalangeal joint in horses using external skeletal fixation device where he observed complications like pin loosening and pin tract infection when the device was insitu.

Kaneps *et al*. (1989) encountered most frequent complication of pin loosening was caused by infection in the pin tract, thermal damage to the bone during pin insertion, or motion of the pins. They also reported the pin tracts in the calf had radiographic evidence of osteomyelitis 4 weeks after the initial repair and also reported that delayed union was the another complication encountered in the series of studies of fracture repair with trans fixation pins and fibreglass cast in llama and small ruminants.

Harari (1992) reported the major pin tract sepsis characterized by persistent and excessive purulent drainage, soft tissue inflammation and patient discomfort and further opined that the infection was caused by the invasion of necrotic tissue by skin bacteria around the pin in calves treated with trans fixation pinning for tibial fracture repair.

Anderson and St-Jean (1996) opined that micro movements in the area of pin and bone contact can lead to reactions such as bone resorption, pin tract infection and great discomfort to the animal and also opined that the use of saline solution on the drill bit during drilling of the bone marrow can decrease thermo necrosis giving greater stability to the pin in the path of cortex.

Mills *et al*. (1996) stabilized comminuted fractures of metacarpal and tibial bones in 3 deer where he had recorded minimal complications during healing.

Ramanathan *et al*. (2006) observed loosening of one or two pins with pin tract osteolysis in 3 calves on 45th day and 2 calves on 60th day. They did not observed pin bending and osteoporosis in any of the calves in the experiment conducted on metacarpal fractures in six calves using bilateral type II external skeletal fixator in six calves.

Gamper *et al*. (2006) in a study on clinical evaluation of the CRIF 4.5/5.5 system for long bone- fracture repair in cattle reported movement of clamps on the rod which is unique to CRIF leading to severe callus formation at fracture site.

Lescun *et al*. (2007) reported complications like fracture through a pin hole and pathologic unicortical fracture secondary to a pin hole infection in a study on evaluation of transfixation casting for treatment of third metacarpal, third metatarsal and phalangeal fractures in 37 horses.

Moss *et al*. (2007) in a study on biomechanics of external fixation reported complications like pin loosening and pin tract infection which are thought to be related to thermal necrosis of bone.

Brounts *et al*. (2011) in a comparison study on fixation methods for treatment of long bone fractures in Llamas and Alpacas reported major complications like malunion, ischemia of distal aspect of the limb, non-union and fracture through a trans fixation pin site. He also reported minor complications like osteopenia, implant problems like pin loosening of external fixation pins because of lysis, soft tissue infection at the incision site and cast sores.

Nuss *et al*. (2011) in a retrospective study on treatment of long bone fractures in 125 new born calves, recorded common complications like implant loosening and instability, which were often followed by osteomyelitis and sepsis.

Shivaprakash (2012) observed loosening of one or more pins and wetting of plaster cast due to pus discharge as the most common complication during the treatment of compound fracture in bovines using trans fixation pinning and external casts.

Knafo *et al*. (2012) observed complications like implant failure or pin loosening that led to surgical revision, delayed union, mal union, or non-union, infection or osteomyelitis, and sequestrum formation.

Rossignol *et al*. (2014) reported complications like premature loosening of the transfixation pins at the BPI, ultimately leading to loss of stability of the fracture site and catastrophic fracture of the metacarpus/metatarsus.

Materials and Methods

III. MATERIALS AND METHODS

The present study was conducted on clinical cases of tibial fractures in bovines presented to the department of Veterinary Surgery and Radiology, Veterinary College, Bangalore. A total of 6 clinical cases were studied for the treatment of tibial bone fractures by using Modified type II External Skeletal Fixation technique. The animals treated for the fracture had varied body size, weight, age and sex.

3.1 Occurrence

Outpatient department records for the period from April 2013 to March 2014 were referred and information regarding number of tibial fracture case in bovines with reference to age, breed and sex among the bovine cases presented to Veterinary College Hospital, were recorded and analyzed for twelve months period to calculate the occurrence.

3.2 Case history

Once the tibial fracture was confirmed by physical examination supported by radiography, details regarding anamnesis of patient is made and information like age, breed, sex, body weight, signalment and owners observations were recorded.

3.3 Pre surgical evaluations

3.3.1 Clinical examination

Physiological parameters like rectal temperature (^{0}F), respiration rate (breathe per minute) and heart rate (beats per minute) were recorded prior to surgery and on the respective post-operative days during the study period.

3.3.2 Haematological examination

All the six cases were subjected for haematological evaluation viz. haemoglobin (g%), total erythrocyte count (10^6cells/cmm), total leukocyte count (10^3cells/cmm), differential leukocyte count (%) prior to the surgery and on the 1st, 3rd, 5th, 7th , 15th, 30th, 45th and 60th post- operative days during the study period .

3.3.3 Biochemical examination

All the six cases were subjected for biochemical estimation viz., serum calcium (mg/dl), serum phosphorus (mg/dl), and serum alkaline phosphatase (ALP) (IU/L) prior to the surgery and on the 1st, 3rd, 5th, 7th, 15th, 30th, 45th and 60th post-operative days during the study period.

3.3.4 Radio graphical examination

Radiographs of affected tibial bone (anterioposterior and lateromedial view) were taken prior to surgery and on the 1st, 7th, 15th, 30th, 45th and 60th post-operative days during the study period.

3.3.5 Weight bearing pattern

Weight bearing by the animals was evaluated prior to surgery and on the 1st, 3rd, 5th, 7th, 15th, 30th, 45th and 60th post -operative days during the study period.

3.4 Instrumentation and implants

Steinmann pins of different sizes and lengths were used for transfixation of fractured fragments. The pins were selected based on diameter of bone in radiograph, size of the animal and nature of the fracture. Smaller pins, measuring 225 mm length and 4.5 mm thickness were used for smaller animals weighing less than 100 kg. The medium size pins measuring 250 mm length and 5 mm thickness were used for medium sized animals weighing between 100-300 kg. The pins measuring 300 mm length and 6 mm thickness were used for the animals weighing above 300 kg. Transfixation pins were fixed with two neem wooden blocks on medial and lateral side of the fractured tibial bone. The photographs of instruments and implants used for the tibial fracture repair in bovine cases are furnished from plate 1 to 8.

3.5 Surgical treatment

3.5.1 Pre-operative preparation.

All the cases were prepared by withholding food for 24 hrs and water for 12 hours prior to surgery. Preoperative Injection streptopenicillin antibiotic @ 22,000 IU/ kg bodyweight intramuscular and pre-emptive analgesia with Meloxicam injection (Melonex® 30ml vial Intas pharmaceuticals Ltd., Ahmedabad) at 0.3 mg/ kg body weight intramuscular was given to all the animals. Shaving around the tibial bone, washing with soap solution, swabbing with surgical spirit and painting with povidone iodine was done for aseptic preparation of the fractured site. The limb was completely covered with sterile drape exposing the surgical site. The transfixation pins and other orthopaedic instruments were sterilized by autoclaving.

3.5.2 Anaesthesia and positioning of the animals.

All the animals were sedated with Inj. xylazine hydrochloride (xylaxin, 30 ml vial, Indian Immunological limited) @ 0.1mg/kg body weight intramuscularly 15 minutes prior to surgery. The animals were restrained in lateral recumbency with the affected limb placed upwards (Plate 9). The limb was held in a suspended position by applying traction with a cotton rope tied at the level of coffin joint. The other 3 limbs were secured with the rope. Intravenous regional analgesia induced by the administration of 15 ml of 2 % lignocaine hydrochloride into the lateral superficial vein just below the stifle joint , after application of a tourniquet above the stifle joint.

3.5.3 Surgical procedure:

With the fractured fragments reduction to normal anatomical position, a full length trochar pointed Steinmann pins of suitable length and diameter was inserted lateromedially, in the proximal fragment about 3cm proximal to the fracture line using a power drill, simultaneously sterile, cold physiological normal saline solution flown along the length of pin to prevent thermal tissue necrosis (Plate 10). Another pin was inserted parallel to and about 3 cm proximal to the first pin in a similar manner. Two other pins were inserted in similar fashion in the distal fragment. Sterile gauze soaked in povidone iodine solution was applied around each pin site and cast padding was done. Suitable rectangular neem wooden blocks (Plate 3) of 15cm length, 6cm breadth and 4 cm depth were marked to fix the transfixed pins on both the medial and lateral aspect. Holes were drilled in the wooden blocks at marked points using twist drill bits (Plate.5) and a power drill. Excess pins protruding beyond the wooden blocks were cut with the help of pin cutter (Plate 8). Entire implants covered with sterile gauze, cotton padding and bandage was done.

3.5.4 Postoperative care and management

Post-operatively antibiotic Streptopenicillin (Bistrepen®, 2.5 g vial) @ 22,000 IU/kg body weight intramuscular injection for seven days. Antibiotic therapy was prolonged, wherever needed. Owners were advised to restrict the movement of the animal for three weeks after surgery. External bandage was removed to flush the pin tracts with povidone iodine solution and reapplied on every week till the recovery.

Plate 1: Photograph showing general surgical instruments

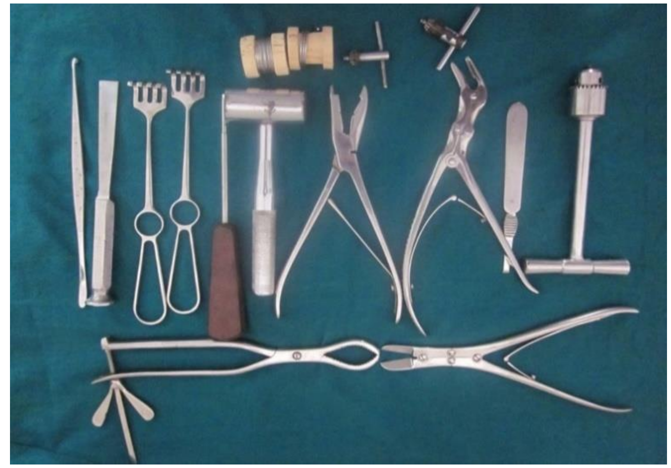

Plate 2: Photograph showing orthopaedic surgical instruments

Plate 3: Photograph showing wooden blocks

Plate 4: Photograph showing power drill

Plate 5: Photograph showing drill bits of different diameter

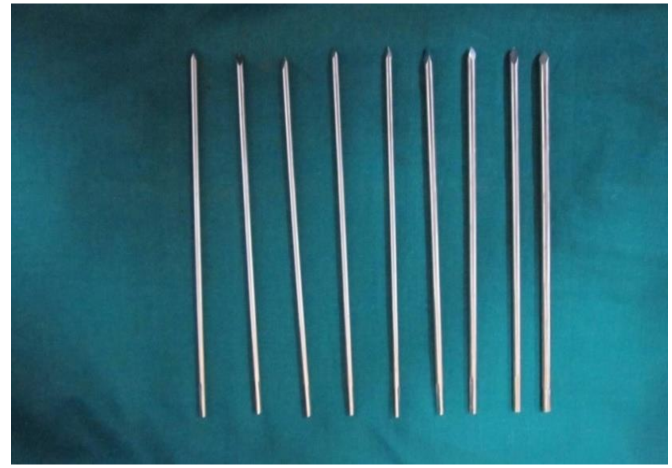

Plate 6: Photograph showing steinmann pins of different diameters

Plate 7: Photograph showing pin benders

Plate 8: Photograph showing pin cutter

Plate 9: Photograph showing positioning of animal on lateral recumbency with fractured limb upwards

Plate 10: Photograph showing positioning of animal on lateral recumbency with fractured limb upwards

Plate 11: Photograph showing application of thick sterile bandage after pin insertion

Plate 12: Photograph showing pouring povidone iodine around inserted pins to prevent pin tract infection

Plate 13: Photograph showing wooden block fixation on either side of the transfixed pins

3.6 Post-surgical evaluation

Physiological parameters viz., temperature, respiration rate and heart rate were recorded on 1^{st}, 3^{rd}, 5^{th} 7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day respectively. For haematological evaluation, two ml of blood was collected in vial containing Ethylene diamine tetra acetate. Haematological parameters viz., total erythrocyte count (10^6 cells/cmm), haemoglobin (g %), total leukocyte count (10^3 cells/cmm), differential leukocyte count (%) were estimated on 1^{st}, 3^{rd},5^{th} , 7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day. Two ml of blood sample was collected in clot activator plain tube and allowed to clot in room temperature for separation of serum. Biochemical parameters viz., serum calcium(mg/dl), serum phosphorus(mg/dl), serum alkaline phosphatase (IU/L), were estimated on 1^{st} , 3^{rd},5^{th},7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day . Evaluation of weight bearing done on 1^{st}, 3^{rd}, 5^{th},7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day respectively. The weight bearing was graded as non-weight bearing, partial weight bearing and complete weight bearing. The follow up was done for 60 days. Radiographs (posterioanterior and lateromedial view) of tibial bone were taken immediately after surgery and on 7^{th}, 15^{th}, 30^{th}, 45^{th} and 60^{th} day respectively

3.7 Statistical analysis

All the results of physiological, clinical, haematological and biochemical parameters were statistically analyzed using one way analysis of variance using computer based statistical programme, graph pad prism, and interpreted as per the procedure described by Snedecor and Cochran (1996).

Results

IV. RESULTS

Six clinical cases of tibial fracture in bovines presented to the Department of Veterinary Surgery and Radiology, Veterinary College, Bangalore during April 2013 to March 2014 were selected for the study. Bovine cases with tibial fracture were stabilized by modified type-II external skeletal fixation technique.

4.1 Occurrence of tibial fracture in bovines

The total number of cases presented to the Veterinary College Hospital, Bangalore was 10743 during the period from April 2013 to March 2014. Out of these, 469 (4.36%) were bovine cases and among these 469 bovine cases, 30 (6.4%) were bovine fracture cases and among them 8 (26.6%) were tibial fractured cases.

4.2 Breed, age and sex wise occurrence of tibial fracture cases in bovines.

4.2.1 Breed wise occurrence of tibial fracture cases in bovines

The breed wise occurrence of tibial fractures recorded was 5 Holstein Friesian cross (62%), 1 Amrithmahal (13%), 1 Deoni (13%) and 1 Hallikar (13%).

4.2.3 Age wise occurrence of tibial fracture in bovines

Age wise occurrence of bovine tibial fracture was 5 cases of less than 1year of age (62%), 2 cases of one to two years of age (25%) and 1 case of above two years of age (13%).

Table 1: Prevalence of fractures in Bovines

Total number of cases (April 2013 to March 2014)	Total number of bovine cases	Total number of fractured cases in bovines	Total number of tibial fractured cases in bovines
10743	469	30	8

Table 2: Breed-wise occurrence of tibial fracture in Bovines

Breeds	Holstein Friesian	Amrithmahal	Deoni	Hallikar
Number of animals	5	1	1	1

Table 3: Age wise occurrence of tibial fracture in Bovines

Age	Less than 1year	Between 1 to 2 years	More than 2 years
Number of animals	5	2	1

Table 4: Sex wise occurrence of tibial fracture in Bovines

Sex	Male	Female
Number of animals	3	5

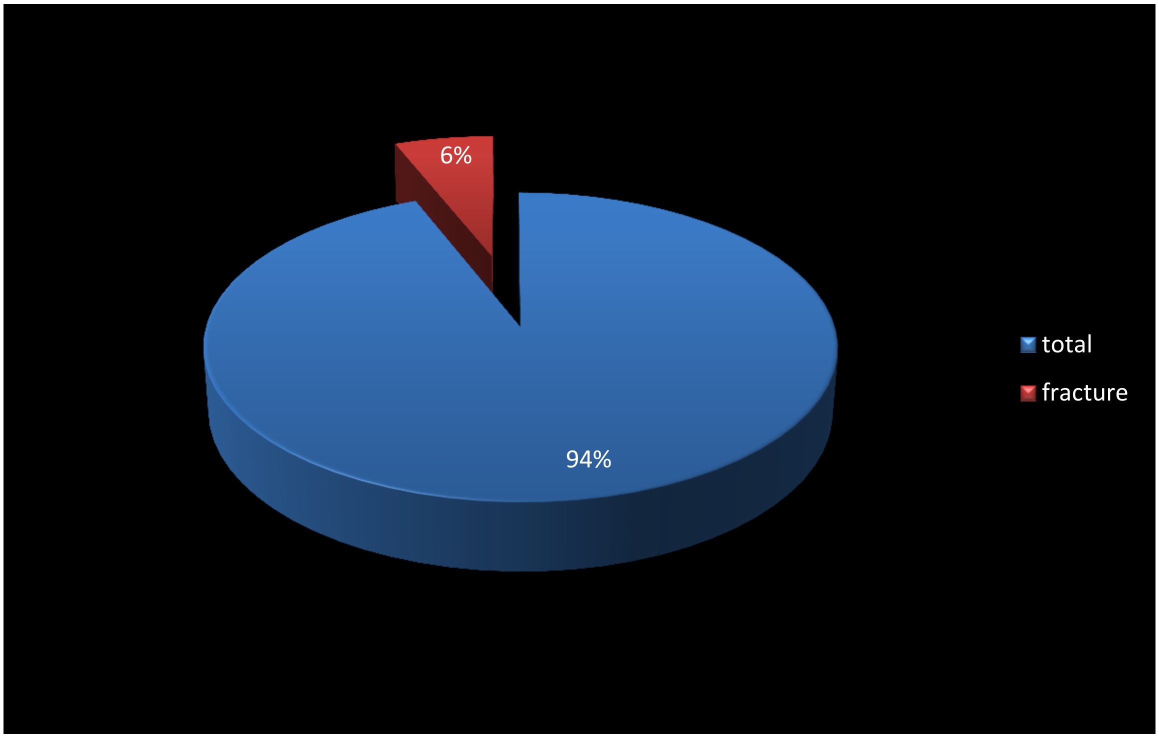

Fig. 1: Pie diagram showing occurrence of long bone fracture in bovines

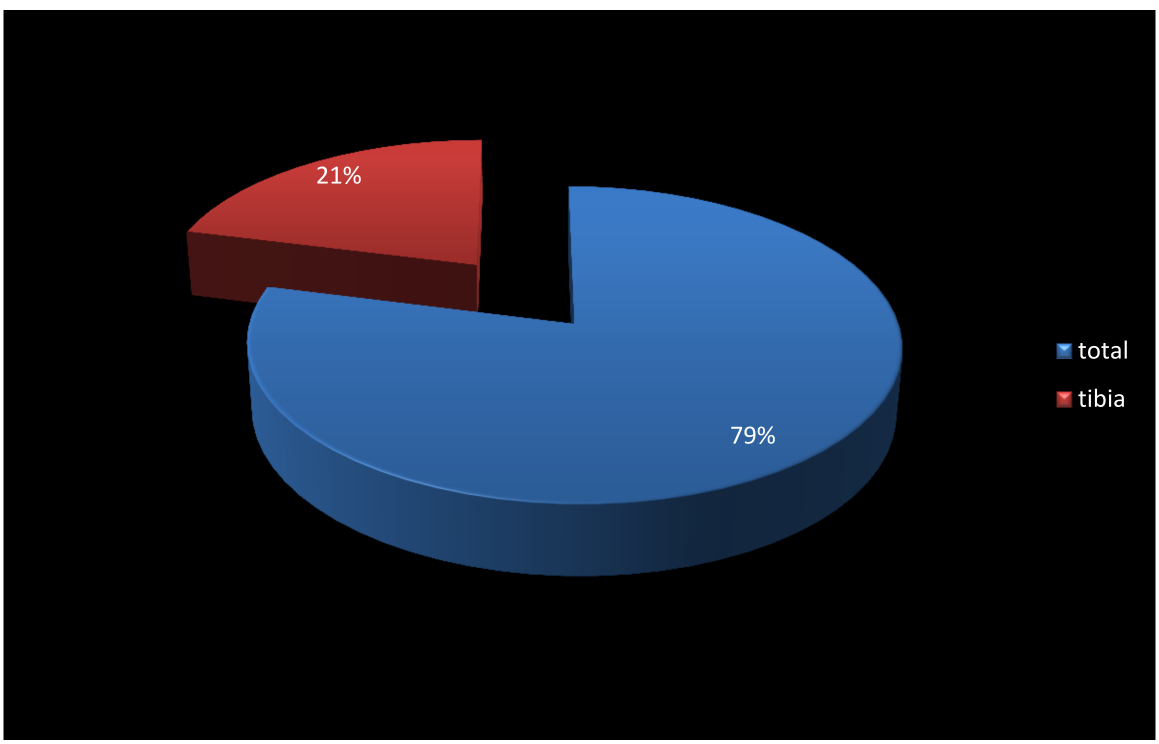

Fig. 2: Pie diagram showing occurrence of tibial fractures in bovines.

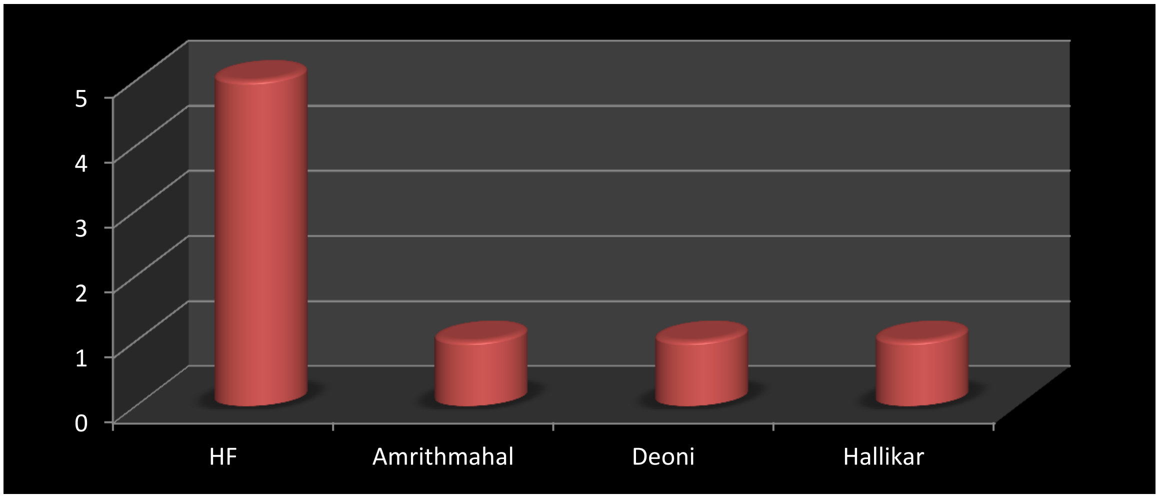

Fig. 3: Bar diagram showing breed wise occurrence of tibial fracture in bovines

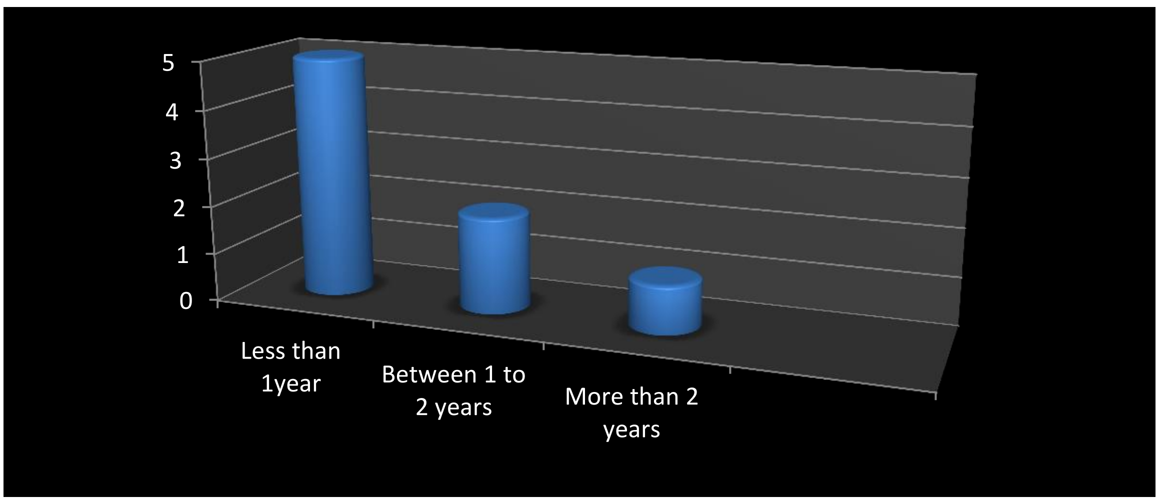

Fig. 4: Bar diagram showing age wise occurrence of tibial fracture in bovines

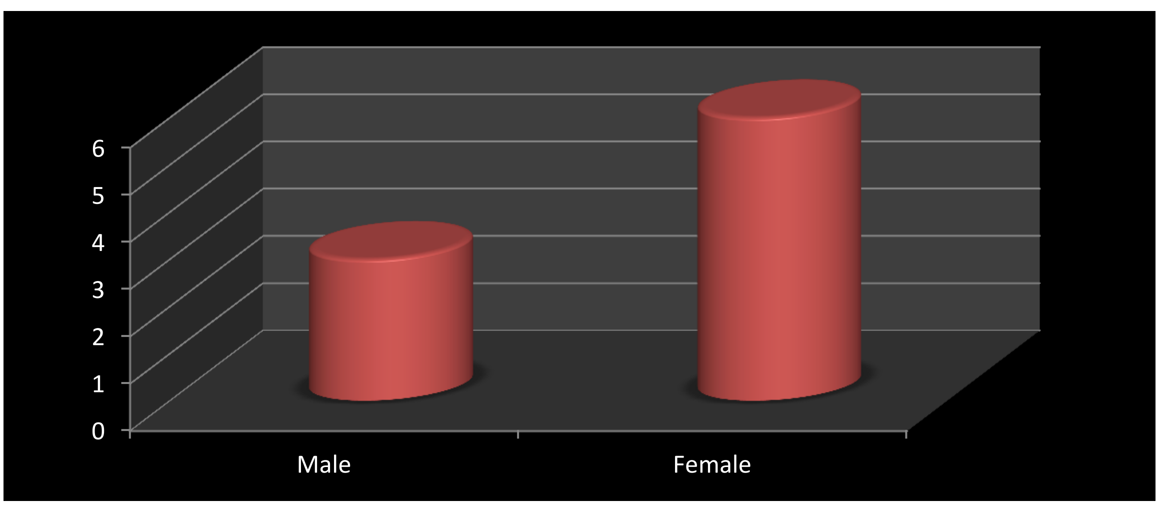

Fig. 5: Bar diagram showing sex wise occurrence of tibial fracture in bovines

4.2.4 Sex wise occurrence of tibial fracture in bovines

Sex wise occurrence of bovine tibial fractured cases were 5 females (62%) and 3 males (38%).

4.3 Aetiology of tibial fracture in bovines.

Aetiology of tibial fractures were recorded in the present study was due to automobile accidents.

4.4 Clinical cases and type of fracture

Six clinical cases were selected out of 8 cases of tibial fracture presented to Dept. of Surgery and Radiology of Veterinary hospital, Veterinary College, Bangalore and were treated with modified type II external skeletal fixation. The cases with different types of fracture treated during the study are shown in the Table.5. Among the six cases treated, all the cases were simple fractures and one animal with compound fracture was presented.

4.5 Materials used for external skeletal fixation

The Steinmann pins of different size and length were used to hold the fractured fragments in position which were connected to two wooden blocks externally on medial and lateral aspect of the limb. Two pins each at proximal and distal fragments along with wooden blocks provided adequate fixation of fractured fragments of tibial bone in the treated animals.

Table 5: Breed, sex, aetiology of fracture, Type of fracture in bovines subjected to modified type II external skeletal fixation

Case No.	Breed	Sex	Aetiology of fracture	Type of fracture
1	HF cross	Female	Automobile accident	Transverse
2	HF cross	Female	Automobile accident	Splintered
3	HF cross	Female	Automobile accident	Compound
4	Amrithmahal	Male	Automobile accident	Communited
5	Deoni	Female	Automobile accident	Communited
6	Hallikar	Male	Automobile accident	Oblique

4.6 FRACTURE REPAIR IN ANIMALS

4.6.1 Pre-operative procedure

The detailed history of cases collected from owners helped to know the clinical status of the animals before the fracture treatment. The pre-operative radiograph helped to diagnose the type and nature of the fracture. Each of these calves had clinical and radiographic evidence of tibial fracture; physiological parameters like respiratory rate, rectal temperature and heart rate were recorded to know the stability of the animal.

4.6.2 Anti-microbial prophylaxis and pre-emptive analgesia

All the animals were administered with Streptopenicillin antibiotic (Bistrepen ® 2.5 g vial, Alembic) preoperatively @ of 22,000 I/U per kg body weight IM pre-operatively and pre-emptive analgesia with Meloxicam (Melonex® inj.Intas pharmaceuticals Ltd., Ahmedabad) was given at a dose rate of 0.3 mg per kg body weight IM. The anti-microbial prophylaxis with Streptopenicillin gave good coverage.

4.6.3 Anaesthetic procedure

All the cases were operated under sedation with Inj.xylazine at 0.1mg/kg body weight given intramuscularly followed by intravenous regional analgesia using Inj. Lignocaine hydrochloride 2% of around 20ml was used. This provided complete analgesia of the affected limb and helped in proper reduction of fracture fragments and fixation of the implant.

4.6.4 Positioning of the animals

The animals were restrained in lateral recumbence with the affected limb placed upwards and limb held in a suspended position by applying traction with a cotton rope tied at the level of fetlock joint and counter traction was provided with a rope passed under the groin region, which helped in providing sufficient reduction of fracture fragments. The other 3 limbs were secured with the cotton rope. The positioning of the animal and the exposure of the area was convenient for the surgical intervention.

4.6.5 Surgical procedure

Lateromedial approach to the tibial fractures provided easy manipulation, reduction and stabilization of fractured fragments. Use of cold physiological saline solution during transfixation of pins helped in preventing thermal bone necrosis and the drilling of transfixation pins using power drill in the proximal and distal fragments of fracture was found to be satisfactory to hold the fragment in position and also drilling the bone with power drill was found to be less laborious and reduced time consumption. Trochar point helped in easy passage of Steinmann pins into the bone. Sterile gauze soaked in povidone iodine solution was applied around each pin site which prevented the pin tract infection. A layer of sterile gauze and cast padding around the transfixed pins established no direct contact between limb and the wooden splint. Rectangular wooden blocks which were used as cast material was found to be good material in terms of strength and stability for external fixation for the treatment of long bone fractures in combination with transfixation. Cutting the excess and protruding ends of the transfixation pins after bending the pins at right angle helped to hold the wooden splints in proper position. Entire implants covered with cotton padding helped in preventing injury to the contra lateral limb.

4.6.6 Post-operative care

Systemic antibiotics, Streptopenicillin antibiotic (Bistrepen ® 2.5 g vial, Alembic) preoperatively @ of 22,000 I/U per kg body weight IM ,The analgesic or non-steroidal Anti-inflammatory injection, Meloxicam (Melonex® inj.Intas pharmaceuticals Ltd., Ahmedabad) was given at a dose rate of 0.3 mg per kg body weight IM .The animals were kept in rest with limited movement. Follow up of the cases was done. Periodical radiographic assessment (at 7th day, 15th day, 30th day, 45th and 60th day of post-operation) was carried out to evaluate reduction and alignment of bone fragments, and callus formation and complications, if any.

4.7 Clinical evaluation

4.7.1 Physiological observation:

4.7.1.1 Rectal temperature

Preoperative rectal temperature (Mean ± SE) was 100.83±0.23 ^{0}F and post-operatively temperature ranged from 101.26±0.03 ^{0}F to 102.33±0.08 ^{0}F and the values were within the normal range. The changes in mean values of rectal temperature were statistically non-significant as depicted in Fig. 6.

4.7.1.2 Heart rate (Beats/min)

Pre-operative Heart rate (Mean ± SE) was 63.33 ± 2.34 beats /min. Post-operatively it ranged from 61.16±0.70 beats/min to 64.33±0.33 beats/min and the values were within the normal range. The changes in mean values of Heart rate were statistically non-significant as depicted in Fig. 7

4.7.1.3 Respiration rate (Breaths/min)

Pre-operative Respiration rate (mean ± SE) was 27.16±0.30 breaths/min. Post-operatively it ranged from 27±0.36 to 30.33±0.42 breaths/min and the values were within the normal range. The variations in mean values of respiration rate were statistically non-significant as depicted in Fig. 8.

4.7.2 Haematological studies

4.7.2.1 Haemoglobin (g %)

The mean value of pre-operative haemoglobin level was 10.95±0.10 g % and post-operatively it ranged from 10.88±0.11 g % to 11.31±0.08 g %, however the values were within the normal range. The variations in mean values of Haemoglobin were statistically non-significant depicted in Fig. 9.

4.7.2.2 Total erythrocyte count (10^6 Cells/mm^3)

The mean value of pre-operative total erythrocyte count level was 6.61±0.03 x10^6 Cells/cmm and post-operatively it ranged from 6.53±0.04 x10^6 Cells/mm^3 to 6.8±0.03 x10^6 Cells/cmm, however the values were within the normal range. The variations in the mean values of total erythrocyte count were statistically non-significant as depicted in Fig. 10.

Table 6: Rectal temperature (^{0}F), respiration rate (Breaths/ minute) and heart rate (Beats/minute) in bovines (Mean ± SE) subjected to Modified type II external skeletal fixation for tibial fracture repair

Days	Rectal temperature (^{0}F) Mean±SE	Heart rate (beats/min) Mean±SE	Respiratory rate (breaths/min) Mean±SE
0	100.83±0.23	62.33±0.88	27.16±0.30
1	102.33±0.08	63.83±1.07	30.33±0.42
3	102.15±0.067	64.16±0.90	29.83±0.40
5	101.53±0.24	64.33±0.33	28±0.36
7	101.46±0.15	63.83±0.30	27±0.36
15	101.28±0.08	63±0.36	27.5±0.34
30	101.43±0.04	61.16±0.70	27±0.25
45	101.26±0.03	61.66±0.61	28.5±0.61
60	101.31±0.07	62.16±0.83	27.83±0.47

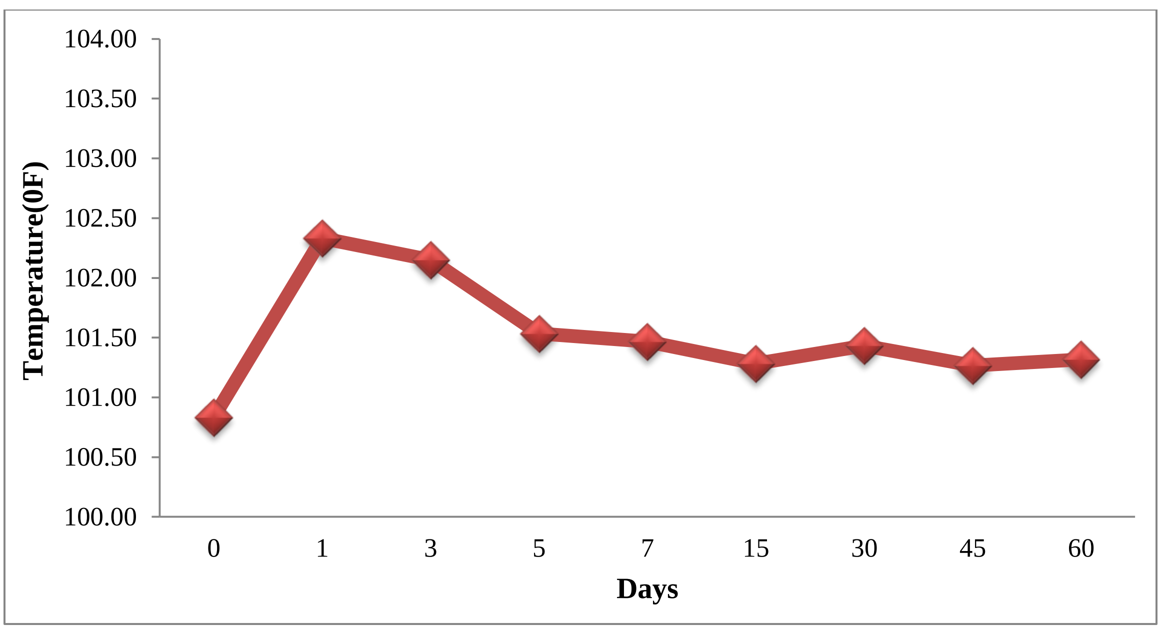

Fig. 6: Mean ± SE values of rectal temperature (^{0}F) in bovines subjected to Modified Type II external skeletal fixation for tibial fracture repair

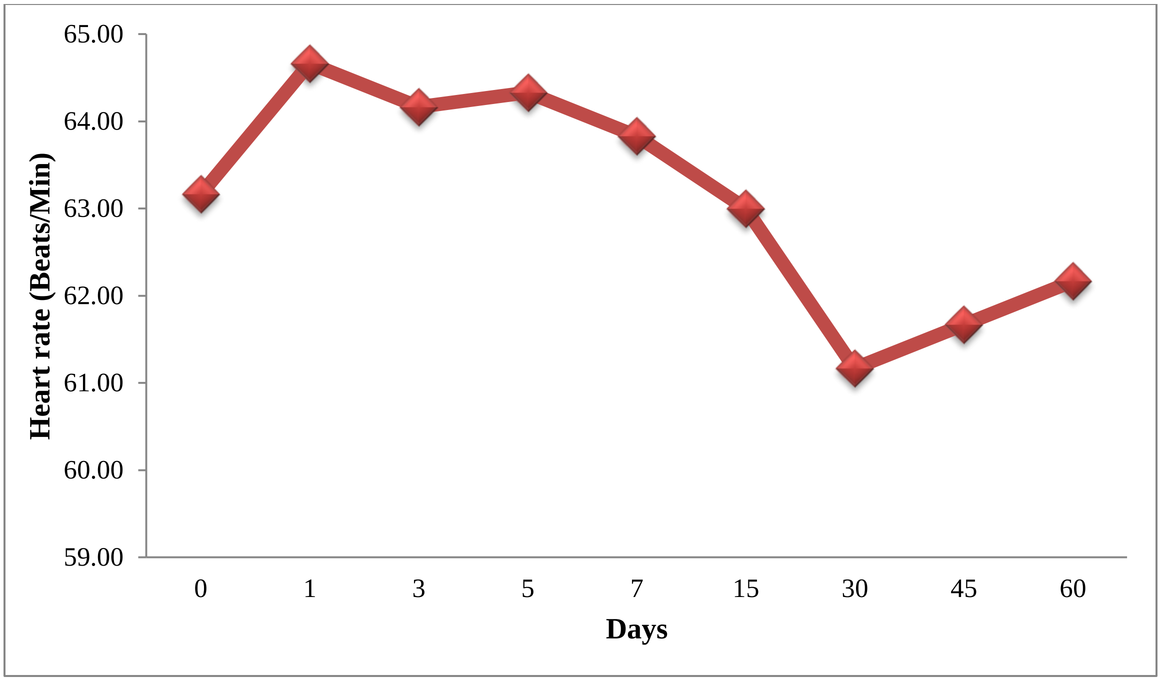

Fig. 7: Mean ± SE values of Heart rate (beats per minute) in bovines subjected to Modified type II external skeletal fixation for tibial fracture repair

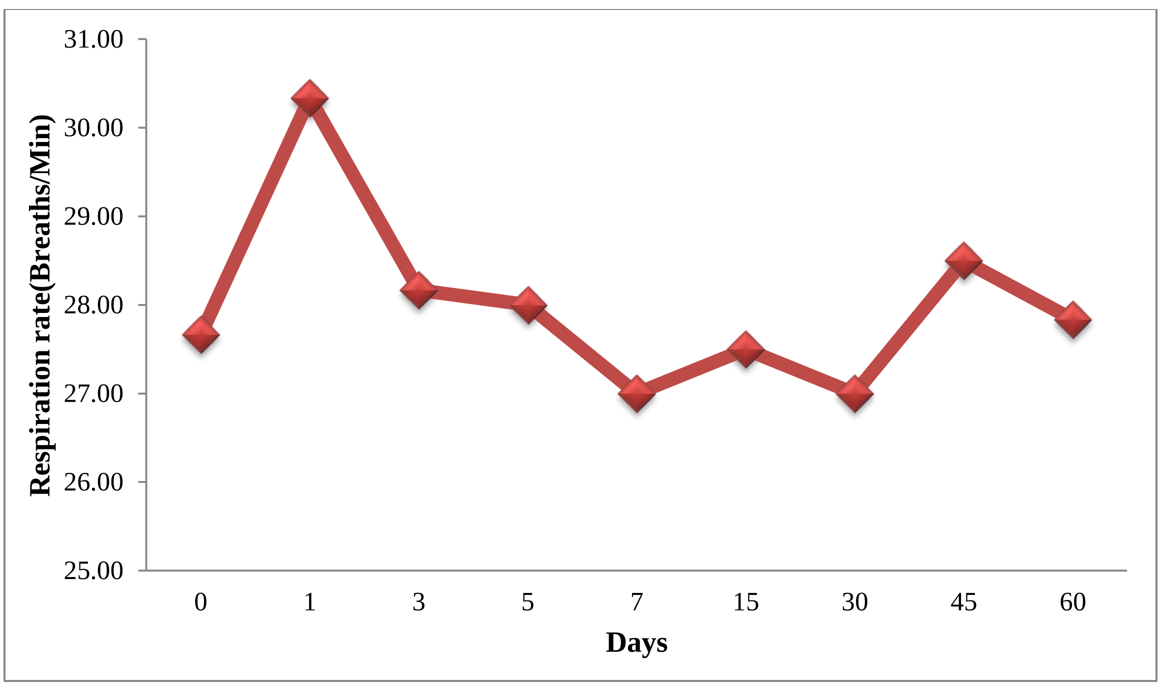

Fig. 8: Mean ± SE values of Respiration rate (breaths per minute) in bovines subjected to Modified type II external skeletal fixation for tibia l fracture repair

4.7.2.3 Total leukocyte count (10^3 Cells/mm^3)

The mean value of pre-operative total leukocyte count level was 8.63±0.01x10^3 Cells/mm^3 and post-operatively it ranged from 7.74±0.04 x103 Cells/mm^3 to 8.81±0.01 x10^3 Cells/mm^3, however the values were within the normal range. The variations in the mean values of total leukocyte count were found to be statistically non-significant as depicted in Fig.11.

4.7.3. Differential leukocyte count

4.7.3.1 Neutrophils (%)

The mean value of pre-operative neutrophils percent was 30.84±0.09 % and post-operatively it ranged from 29.43±0.01 to31.41±0.00, however the values were within the normal range. Initially there was non-significant increase in the neutrophil percent on 1^{st} to 7^{th} postoperative day but gradually receded back to normal level by 15^{th} post-operative day as depicted in Fig. 12.

4.7.3.2 Lymphocytes (%)

The mean value of pre-operative lymphocyte percent was 62.28±0.02 % and post-operatively it ranged from 61.11±0.57 to 63.7 ±0.03, however the values were within the normal range. Variations in the mean value of lymphocyte were found to be non-significant throughout the period of study as depicted in Fig. 13.

4.7.3.3 Monocytes (%)

The mean value of pre-operative monocyte per cent was 4.28±0.01 % and post-operatively it ranged from 4.25±0.02 to 5.00±0.08, however the values were within the normal range. Variations in the mean value of monocytes were found to be non-significant throughout the period of study as depicted in Fig. 14

4.7.3.4 Eosinophil's (%)

The mean value of pre-operative eosinophil per cent was 2.49±0.03 % and post-operatively it ranged from 1.72±0.064 to2.46± 0.023, however the values lie within the normal range. Variations in the value of eosinophil were found to be non-significant throughout the period of study as depicted in Fig. 15.

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Table 7: Hemoglobin, total erythrocyte count and total leukocyte count (Mean± SE) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

Days	Haemoglobin (g %)	Total erythrocyte count (10^6/cmm).	Total leukocyte count (10^3/cmm.)
0	10.95±0.10	6.61±0.03	8.63±0.01
1	10.93±0.11	6.53±0.04	8.81±0.01
3	10.93±0.09	6.63±0.04	8.79±0.02
5	10.88±0.11	6.76±0.02	8.63±0.01
7	10.96±0.12	6.71±0.03	8.51±0.0
15	10.85±0.10	6.73±0.02	8.14±0.01
30	11.13±0.15	6.8±0.03	8.17±0.01
45	11.31±0.09	6.73±0.03	8.04±0.21
60	11.31±0.08	6.8±0.03	7.74±0.04

Table 8: Differential leukocyte count (Mean± SE) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair.

Days	Neutrophils % Mean ± SE	Lymphocytes% Mean ± SE	Monocytes % Mean ± SE	Eosinophil's % Mean ± SE
0	30.84±0.09	62.28±0.02	4.28±0.01	2.49±0.03
1	31.41±0.00	63.19±0.28	4.41±0.01	2.32±0.02
3	30.82±0.00	63.17±0.23	4.58±0.020	2.42±0.01
5	30.50±0.0	63.64±0.171	4.39±0.02	2.17±0.01
7	30.37±0.01	62.43±0.00	5.00±0.08	2.15±0.01
15	29.61±0.00	63.7±0.03	4.73±0.01	1.72±0.064
30	29.43±0.01	61.11±0.57	4.38±0.02	2.10±0.02
45	29.43±0.01	62.64±0.01	4.25±0.02	2.21±0.039
60	30.22±0.03	62.54±0.11	4.61±0.014	2.46±0.023

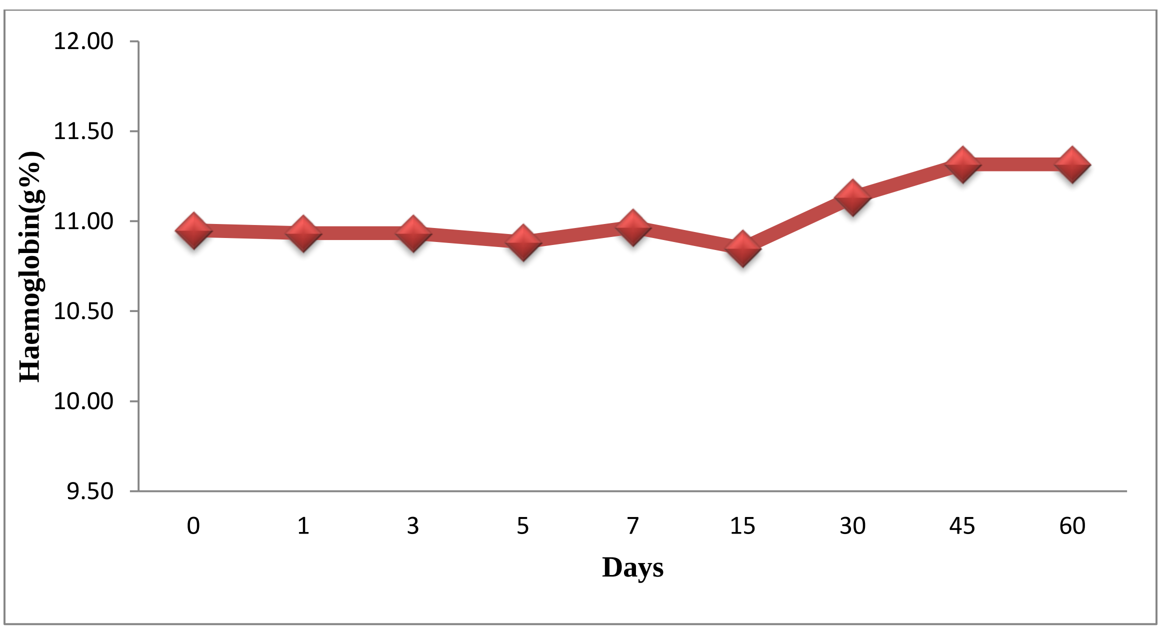

Fig. 9: Mean ± SE values of Haemoglobin (%) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

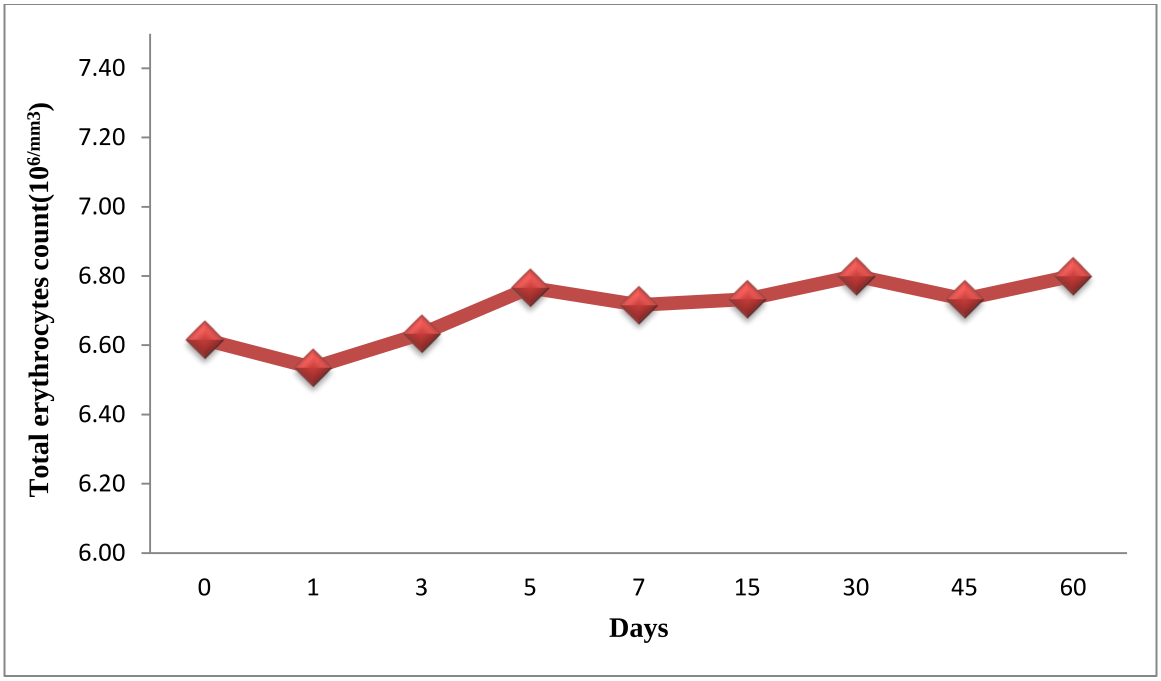

Fig. 10: Mean ± SE values of Total erythrocyte count ($10^6/mm^3$) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

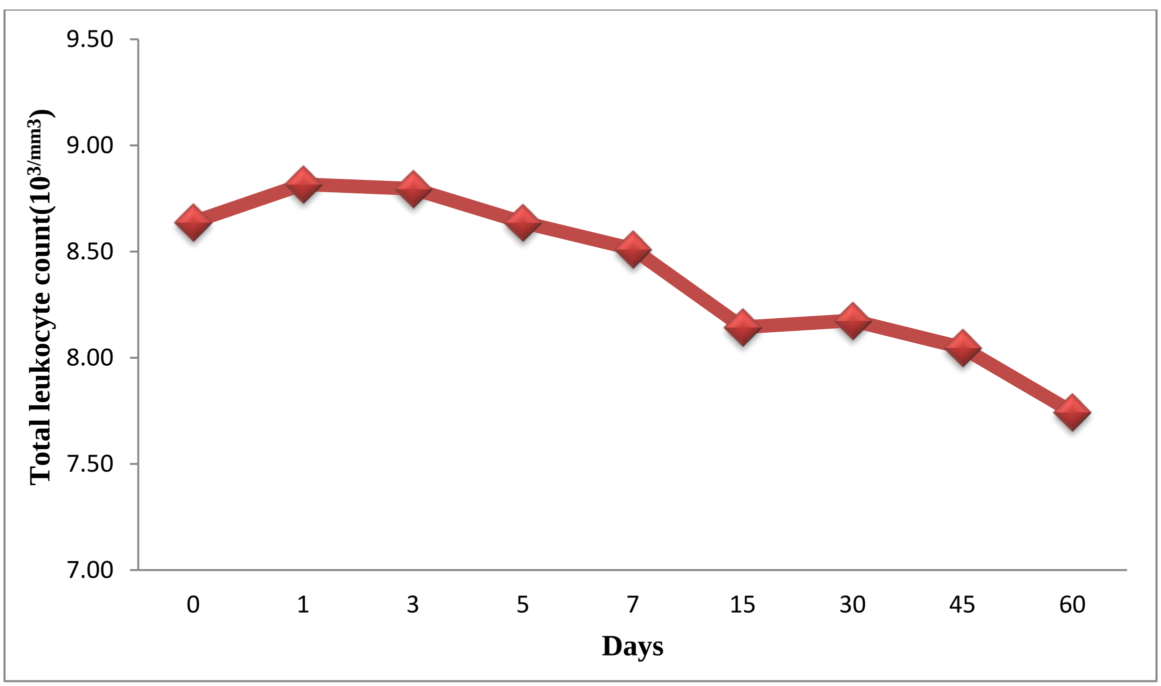

Fig. 11: Mean ± SE values of Total leukocyte count (10^3/mm) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

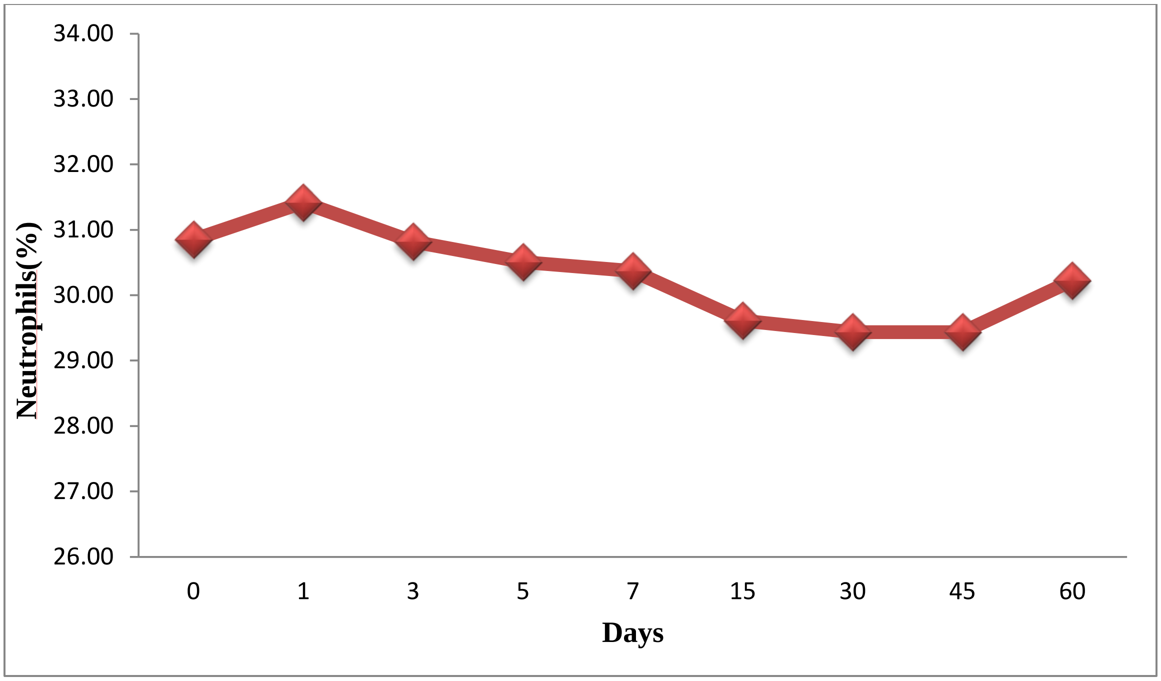

Fig. 12: Mean ± SE values of Neutrophil (%) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

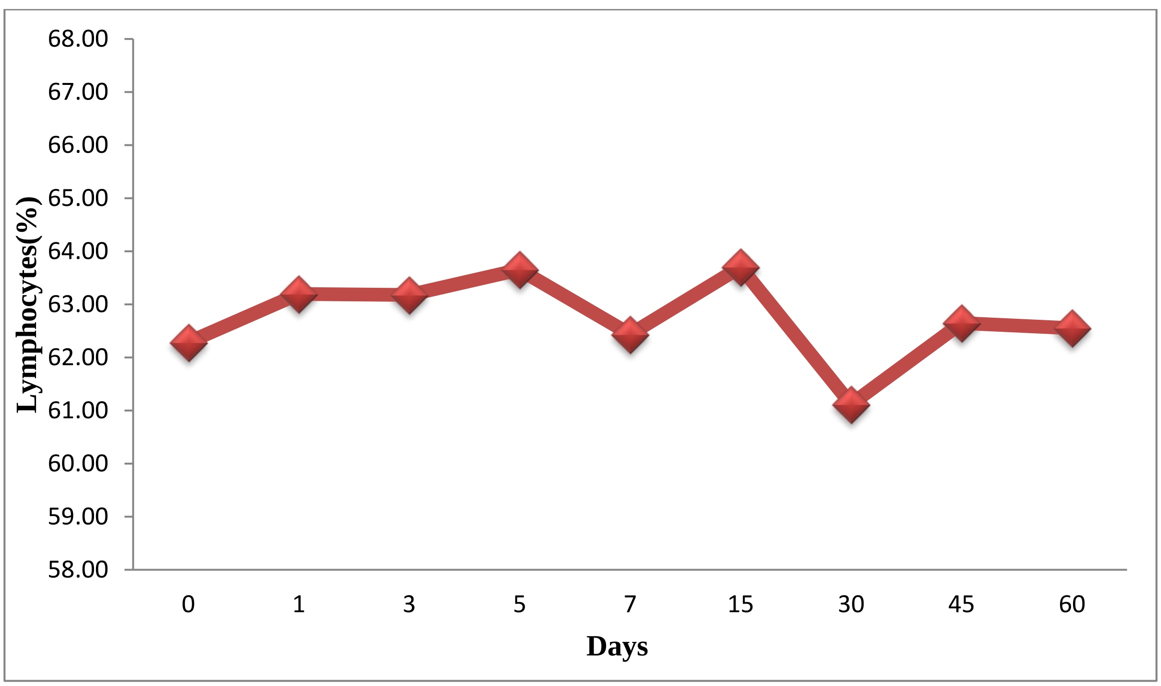

Fig. 13: Mean ± SE values of Lymphocytes (%) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

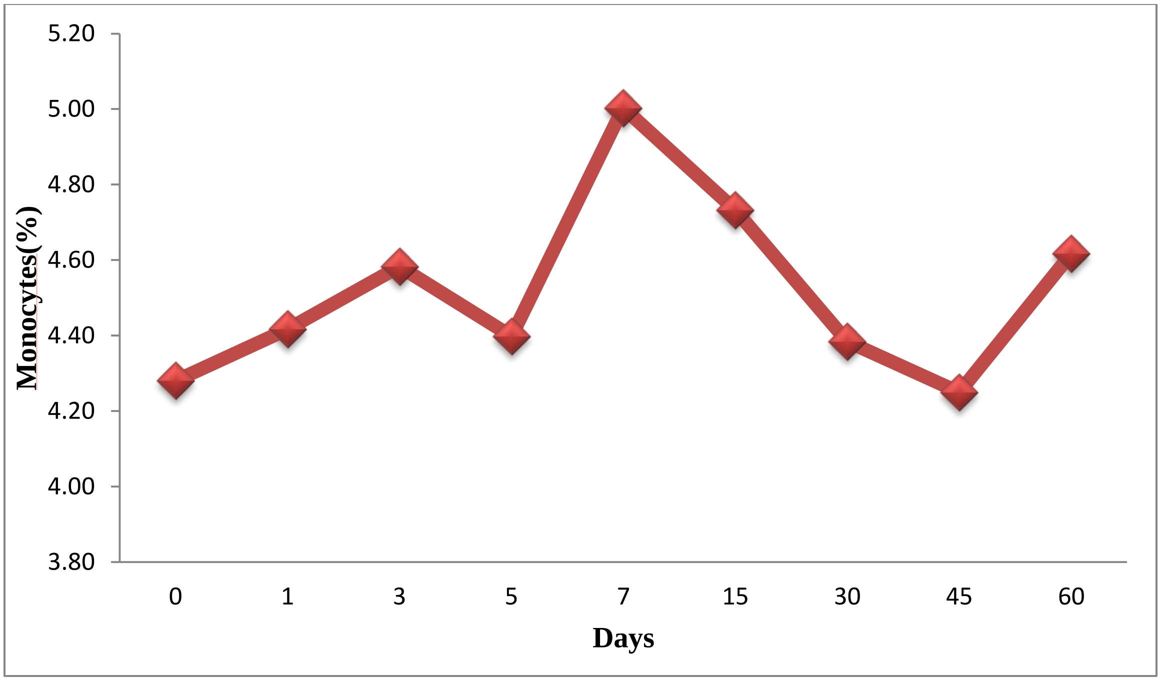

Fig. 14: Mean ± SE values of Monocytes (%) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

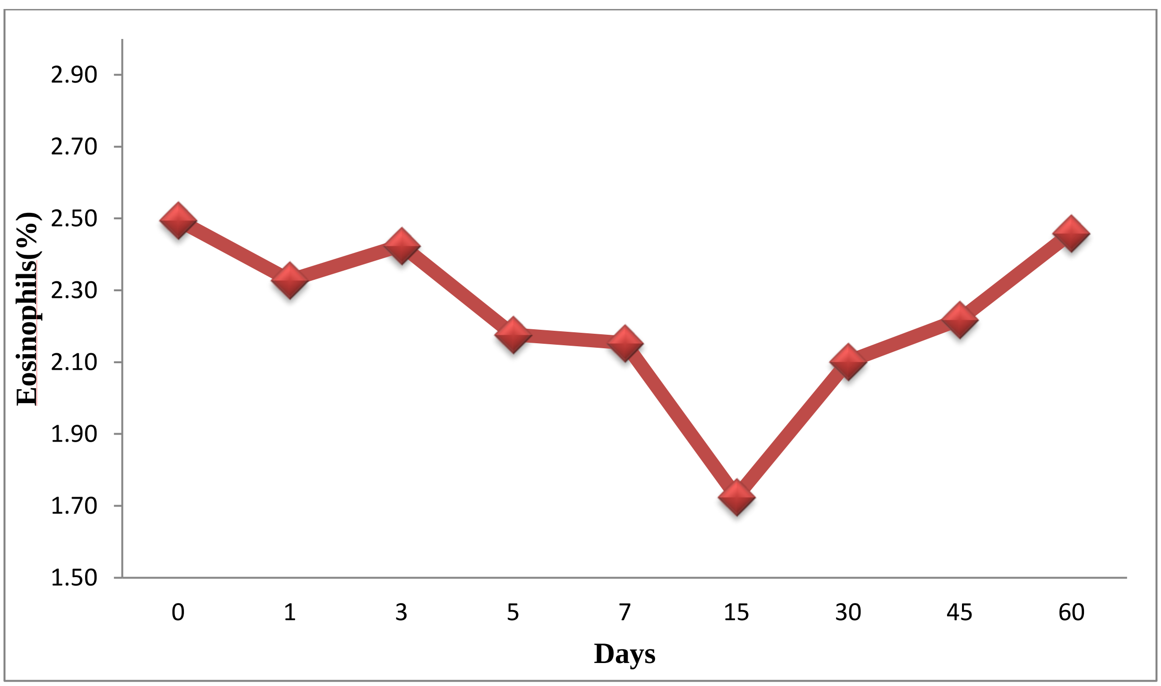

Fig. 15: Mean ± SE values of Eosinophil (%) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

4.8 Biochemical parameters

4.8.1 Serum calcium

The mean value of pre-operative calcium level was 8.47±0.01 and post operatively it ranged from 8.19±0.01 to 9.64±0.08 .There was a non-significant variation in serum calcium level . The variations were found to be within the normal range as depicted in Fig. 16

4.8.2 Serum phosphorus

The mean value of pre-operative phosphorous level was 4.36±0.03 and post operatively it ranged from 4.2±0.03 to 4.63±0.05. There was a non-significant variation in serum phosphorous level. The variations were within the normal range as depicted in Fig. 17

4.8.3 Serum alkaline phosphatase

The mean value of the pre-operative serum alkaline phosphatase level was 44.26±0.01 and post operatively it ranged from 44.10±0.16 to 51.16± 0.09. There was a non-significant increase in mean serum alkaline phosphatase level on first postoperative day followed by steady increase up to 15th postoperative day. There was subsequent decrease in serum alkaline phosphatase level between 30th to 60th postoperative days as depicted in Fig. 18.

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Table 9: Calcium, Phosphorous, Alkaline phosphatase in bovines (Mean ± SE) subjected to modified type II external skeletal fixation for tibial fracture repair

Days	Mean ± SE of Calcium (mg/dl)	Mean ± SE of Phosphorous (mg/dl)	Mean ± SE of Alkaline phosphatase (U/L)
0	8.47 ± 0.01	4.36 ± 0.03	44.26 ± 0.01
1	8.19 ± 0.01	4.50 ± 0.05	44.56 ± 0.17
3	8.25 ± 0.01	4.50 ± 0.01	45.55 ± 0.04
5	8.33 ± 0.01	4.31 ± 0.026	47.55 ± 0.14
7	8.49 ± 0.01	4.2 ± 0.03	48.97 ± 0.07
15	8.86 ± 0.01	4.24 ± 0.01	51.16 ± 0.09
30	8.97 ± 0.03	4.24 ± 0.01	47.24 ± 0.15
45	9.31 ± 0.02	4.63 ± 0.05	45.90 ± 0.09
60	9.64 ± 0.08	4.55 ± 0.01	44.10 ± 0.16

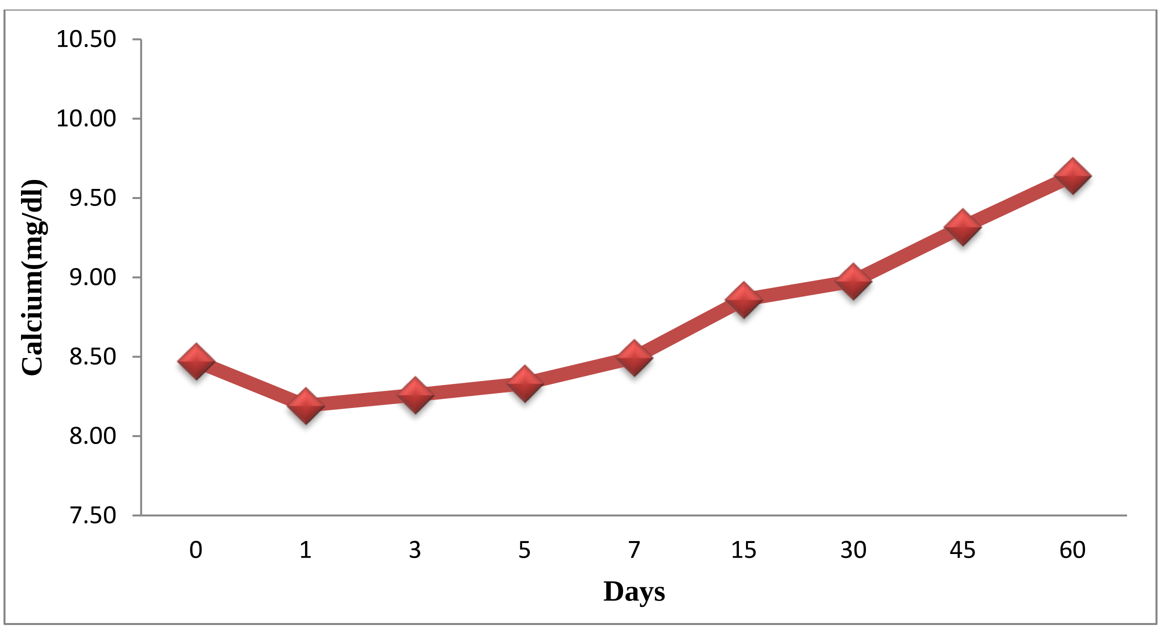


Fig. 16: Mean ± SE values of Calcium (mg/dl) levels in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

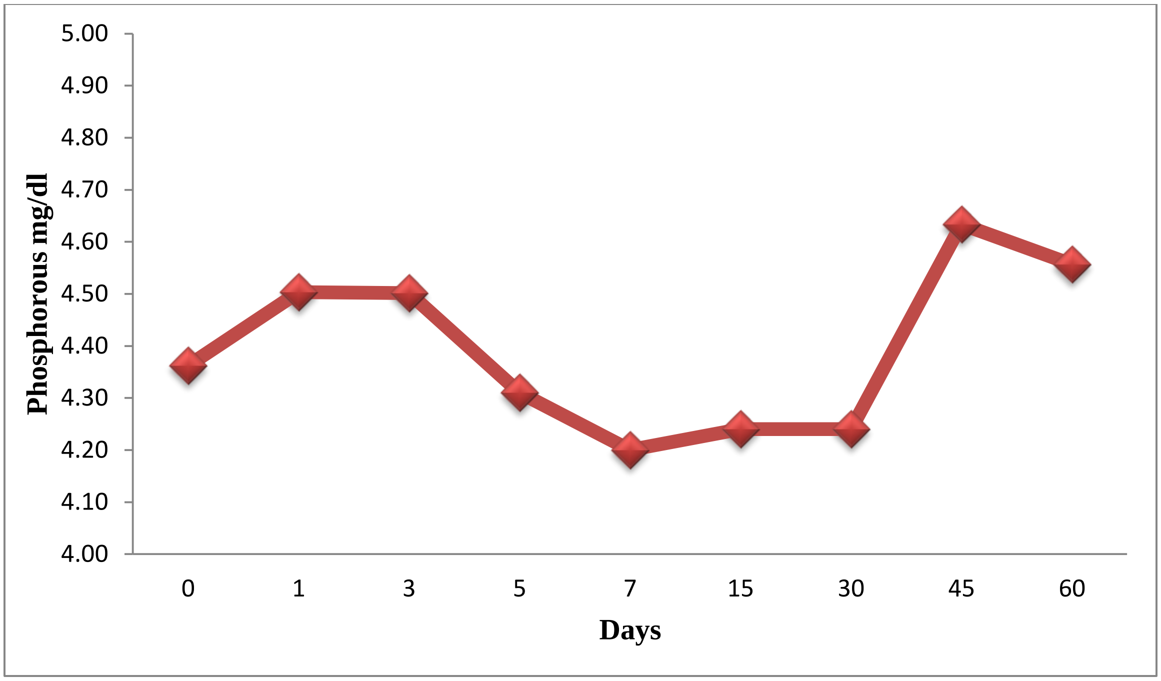


Fig. 17: Mean ± SE values of Phosphorous (mg/dl) levels in bovines subjected to modified type II External skeletal fixation for tibial fracture repair

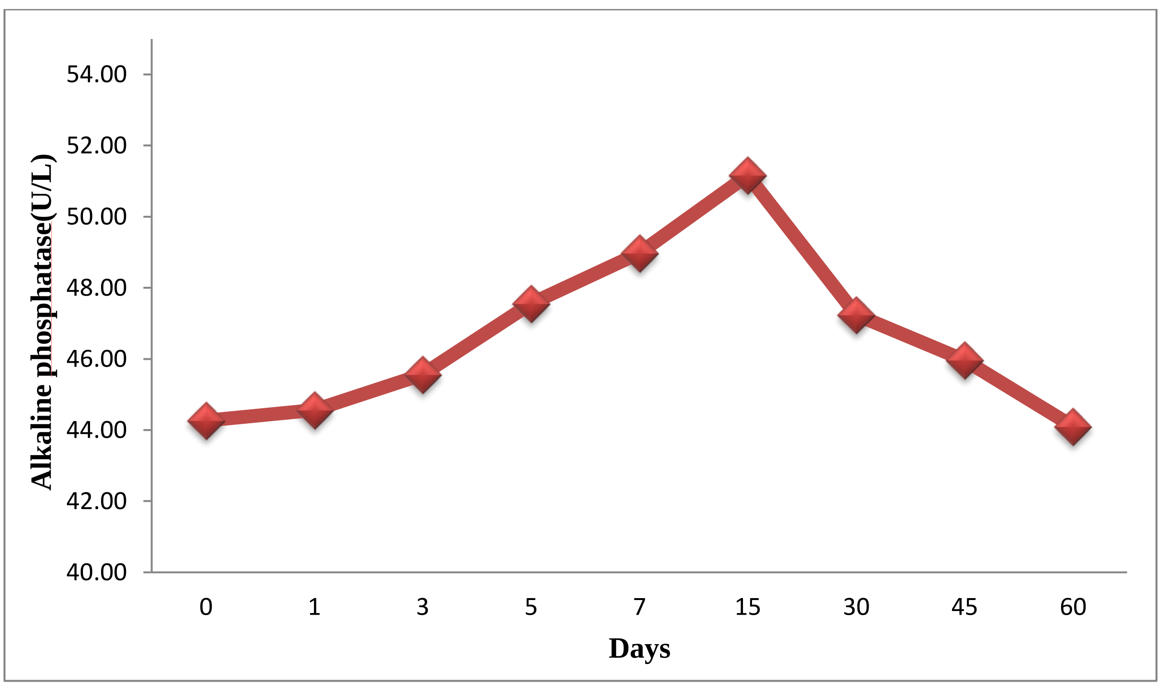


Fig. 18: Mean ± SE values of Alkaline phospatase (U/L) in bovines subjected to modified type II external skeletal fixation for tibial fracture repair

4.9 Clinical observations

4.9.1 Weight bearing pattern

Pre operatively four animals showed non-weight bearing and other animals showed partial weight bearing. Immediately after fracture repair none of the animals showed complete weight bearing but four animals showed partial weight bearing and two animals showed moderate weight bearing.

On 1st post-operative day, none of the animals showed complete weight bearing, two animals showed moderate weight bearing, four animals showed partial weight bearing

On 3rd post-operative day, two animals showed moderate weight bearing, four animals showed partial weight bearing.

On 5th post-operative day, one animal showed non-weight bearing, four animals showed partial weight bearing and one animal showed moderate weight bearing.

On 7th post-operative day, none of the animals showed complete weight bearing, four animals showed partial weight bearing, two animals showed moderate weight bearing.

On 15th post-operative day, none of the animals showed complete weight bearing, three animals showed partial weight bearing and three animals showed moderate weight bearing.

Table 10: The weight bearing pattern in bovine cases subjected to Modified type II external fixation on different days

Days	Non-weight bearing	Partial weight bearing	Moderate weight bearing	Complete weight bearing
0	3	3	-	-
1	-	4	2	-
3	-	4	2	-
5	1	4	1	-
7	-	4	2	-
15	-	3	3	-
30	-	1	5	-
45	-	1	5	-
60	-	-	-	6

Plate 14: Photograph showing partial weight bearing on 0 day

Plate 15: Photograph showing partial weight bearing on 1st postoperative day

Plate 16: Photograph showing partial weight bearing on 3rd postoperative day

Plate 17: Photograph showing partial weight bearing on 5th post-operative day

Plate 18: Photograph showing partial weight bearing on 7th post-operative day

Plate 19: Photograph showing moderate weight bearing on 15th post-operative day

Plate 20: Photograph showing moderate weight bearing on 30th post-operative day

Plate 21: Complete weight bearing on 45th post-operative day

Plate 22: Photograph showing complete weight bearing on 60th post-operative day.

On 30th and 45th post-operative day, one animal showed partial weight bearing this is because of the pin tract infection in the transfixed pins, five animals showed moderate weight bearing.

On 60th post-operative day all the animals had complete weight bearing. In general 100% normal weight bearing is observed in treated animals on 60th post-operative day.

4.10 Radiological observations

Radiological evaluation of fracture repair was done in all the six treated animals, which were subjected to Modified type II External skeletal fixation. Radiographs taken on 0th day before surgery (plate 21) helped to assess location and type of tibial fracture before the application of external skeletal fixators. Radiological observations at different intervals revealed near normal alignment of fractured fragments. The radiographs taken immediately after fixation of tibial fracture with modified type II external skeletal fixation revealed good apposition and alignment of fracture ends. The transfixation pins were properly placed with penetration of both cortices. No malalignment was noticed in any of the treated cases.

Day- 1

On 1st post-operative day, the fracture reduction was observed in all the six animals and considerable changes were not observed in any of the treated cases (plate 21).

Day-7

A slight change in the alignment of reduced fractured fragments was observed in two cases which may be due to the heavy weight of the animal and in rest of the treated cases fractured fragments were in good apposition. Periosteal reaction was seen in four among the six treated cases, this early sign of periosteal reaction revealed improved blood supply to the periosteum. The Callus was not visible in any case (Plate 22).

Day-30

In the entire cases fixator frame was in position. The fractured fragments were in good apposition and the fracture line was reduced compared to seventh day radiograph, moderate intensity of callus formation was seen in all the cases (Plate 23).

Day-45

In all the cases external skeletal fixator frames were in position. Fractured fragments were indistinctly visible. Periosteal reaction was seen at the fractured segments with good callus formation between the fractured segments (Plates 24).

Day-60

There was dense irregular callus surrounding the fracture site and excess periosteal reactions at the pin-bone interface were observed (Plates 25). Throughout the period of the study complications like pin osteolysis, pin breakage/ bending and osteoporosis was not noticed in any of the cases.

Plate 23: Pre-operative radiograph showing splintered fracture of tibia

Plate 24: 1st day post operative day radiograph showing fractured fragments are in alignment

POSTERIOANTERIOR VIEW

LATERO-MEDIAL VIEW

Plate 25: 7th day post operative day radiograph showing fracture fragments are in alignment

POSTERIOANTERIOR VIEW

LATERO-MEDIAL VIEW

Plate 26: In 15th day post-operative radiograph, small amounts of periosteal callus was observed in fracture site and implants are in situ.

POSTERIOANTERIOR VIEW

LATERO-MEDIAL VIEW

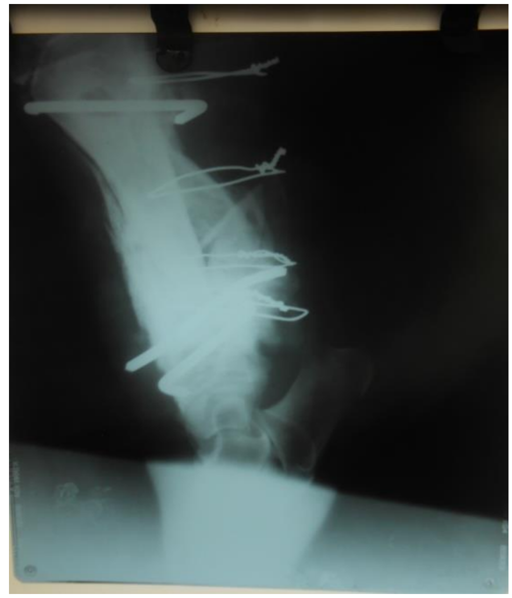
Plate 27: One month follow-up radiographs showing excellent progressive healing

POSTERIOANTERIOR VIEW

LATERO-MEDIAL VIEW

Plate 28: 45th day radiographic views showing clear bridging between fractured fragments

POSTERIOANTERIOR VIEW



LATERO-MEDIAL VIEW

Plate 29: 60th Post-operative radiographic views before fixator removal showing complete union of fracture with cortical continuity.

POSTERIOANTERIOR VIEW

LATERO-MEDIAL VIEW

Plate 30: 60th Post-operative radiographic views after removing the fixator showing complete union of fracture with cortical continuity with radiolucent pin tracts

4.11 Peri and post-operative complications:

4.11.1 Apparatus stability

The fixators were evaluated during the post-operative period and the results were recorded. The external skeletal fixator was found to be stable in all the treated cases. Post-operative complications like pin loosening was not observed in any cases.

4.11.2 Patient acceptance

Modified type II External skeletal fixator applied to fractured tibial bone was well tolerated, and the animals could lie down, stand and walk freely with the fixator without any problems and the fixator's maintained rigid stability.

4.11.3 Infection and Pin tract drainage

The Infection and pin tract drainage at the emergence of the pin was seen in two cases treated during the 15th post-operative day, which later subsided after flushing with sterile saline mixed with povidone iodine solution.

4.12 Removal of fixator frame

The fixator frame was removed based on the radiographic evaluation of the clinical union of fracture evident by the presence of callus at fracture site. In all the animals, staged disassembly of the fixator frame was done on 60th day based on radiographic evaluation. This technique allowed satisfactory limb usage after removal of fixator frame.

Discussion

V. DISCUSSION

The present study was carried out to study the occurrence of tibial fracture in bovines and to standardize the technique of modified type II external skeletal fixation for the treatment of tibial fracture in bovines.

5.1 Occurrence

In the present study the total number of cases presented to the Veterinary College Hospital, Bangalore was 10743 during the period from April 2013 to March 2014. Out of these, 469 (4.36%) were bovine cases and among these 469 bovine cases, 30 (6.4%) were bovine fracture cases and out of 30 bovine fracture cases 8 (26.6%) were tibial fractured cases. The present study revealed that the occurrence of tibial fracture were 8 (26.6%) out of 30 bovine fractured cases. The results were in accordance with the Camara *et al*. (2014), Kushwah *et al.* (2011). In cattle, maximum fractures were recorded in tibia, followed by metatarsus. Ahmed and Al-sobayil (2012) have recorded more incidences of tibial fractures in young camels, Singh and Nigham (1983) and Aithal and Singh (1999) have also recorded a high incidence of tibial fractures followed by metatarsal and femur fractures. There was high incidence of fracture of tibia (27.3%) followed by metacarpal (16.4%) in bovines (Adams and Fessler, 1983). This may be due to an increase in the road traffic in recent years might have contributed to a high incidence of fractures due to vehicular accidents (Kumar *et al*., 2013). In vehicular accident, more animals are likely to get hit from behind and animals probably are too slow to react so that their rear parts are likely to be hit by vehicles hence there may be more chances of tibial fractures in bovines.

In the present study relatively more tibial fracture were recorded in female bovine cases5 (62%) than males 3 (38%). This may be attributed to the larger population of female large animals being reared in this locality for milk production. Similar findings were also reported by (Kumar *et al*. 2013)

In the present study highest occurrence of tibial fracture was seen in 5 cases of less than 1year of age (62%), 2 cases of one to two years of age (25%) and 1 case of above two years of age (13%). More incidence of tibial fracture was seen in bovine cases up to 2 years of age. Singh *et al*. (1983) have reported majority of fractures in the age group 1-3 years both in bovines and sheep/goats. Similar observations were also reported by Dass *et al*. (1985) and Ramdan *et al*. (1991) in goats. Higher incidence of fractures in younger animals may be related to their agile temperament (Kumar *et al*., 2013).

5.2 Aetiology and type of tibial fractures in bovines.

In the present study, highest occurrence of tibial fractures in bovines recorded was due to automobile accidents. Similar findings were recorded earlier by several workers (Aithal and Singh. 1999; Aithal *et al*., 2007; Shivaprakash, 2012; Kumar *et al*., 2013). Majority of the fracture recorded were simple fracture 7 out of 8 clinical cases of tibial fracture and one compound tibial fracture was recorded. This could be due to early presentation of cases to veterinary hospital and increased awareness about veterinary service. And open fracture are less common in cattle than in horses because cattle have a thicker skin and are more likely to protect a fractured limb from additional trauma (Adams, 1985).

5.3 Material for external skeletal fixation

The art of stabilizing fracture fragments is essential for modern surgery and orthopaedic surgery has increased in complexity in terms of stabilizing materials or implants. The choice of implant materials and the techniques of using them are prime factors in the restoration of continuity and functional strength to the fractured bone during healing process (Alam *et al.*, 2014)

External fixation is an excellent way to manage fractures in cattle. Two to three transcortical pins are inserted proximally and distally to the fracture and connected with sidebars stated by Mulon (2013). Closed stabilization with external skeletal fixation using transfixation pin cast resulted in similar time to clinical union when compared with plate fixation stated by Brounts *et al*. (2011).

In the present study Steinmann pins of appropriate length and diameter were drived at each fractured fragment for stabilizing tibial fracture in bovines. Shivaprakash (2012) stabilized tibial fracture in two heifers using transfixation pinning and reinforcement with plaster cast and methyl methacrylate rod and he reported treated heifers could bear weight and showed complete improvement. Brounts *et al*., (2011) stabilized long bone fractures in Llamas and alpacas by means of transfixation pin cast. George *et al*. (2014) stabilized open dislocated metacarpo-phalangeal joint in a calf using external skeletal fixation where they inserted two pins on each proximal and distal fragments..

Verschooten *et al*. (1972), St-Jean and Debowe’s, (1992) and Anderson and St-Jean (1993) used two pins in each fragment of tibial fracture in cattle, radial fracture of calves and radial fracture of Suffolk ewe respectively. However, Verschooten *et al*. (1972) found that perfect and rigid immobilization of the bone fragment was seldom achieved. The use of external fixation technique depends on tibial fracture configuration, injury of soft tissue and the presence of open fractures (Adams, 1985; Anderson *et al.*, 1994). It has been applied successfully in the long bones of cattle, sheep, goats, llamas as quoted by Anderson & Saint-Jean (1996) and small animals Verschooten *et al.* (1972).

Transfixation pinning had several advantages in management of tibial fractures in bovines, which include flexibility in pin positioning, adequate reduction, early return to weight-bearing status, joint mobility, and ease of ambulation (St- Jean *et al*., 1991).

5.4 Fracture repair in animals

5.4.1 Preoperative procedure

All fractures results from external forces applied to the bone exceeding the mechanical strength of the bone. Evaluation of the patient necessitates its cooperation; pharmacological restraint with a α_2-agonist will provide immediate pain relief and a sufficient alteration of animal's mental status to allow complete physical examination (Mulon, 2013).

Preoperative radiograph helped in assessment of fracture type and nature for reduction and immobilization and in selection of size of the pins. Preoperative chemotherapy controlled swelling and infection. Similar observations were made by Martins *et al*. (1981) and Guzel *et al*. (2013).

5.4.2 Anaesthetic procedure

The Intravenous regional analgesia with 2% Lignocaine hydrochloride reduced the pain to the animal during insertion of the pins and ease of handling of animal during surgery was observed in all the treated cases. Similar observations were made by Ramanathan (1996).

5.4.3 Surgical procedure

Conservative treatment of tibial fractures usually does not result in acceptable fracture healing. A full limb cast cannot immobilize the stifle joint and does not stabilize tibial fractures adequately (Adams and Fessler, 1983; Tulleners, 1986b).

The surgical repair of tibial fractures in cattle can provide sufficient immobilisation and gives the animal freedom of movement in the adjacent joints stated by Martens *et al*. (1998). Internal fixation with bone plates or intramedullary pinning is suitable for the repair of mid-diaphyseal fractures but is relatively expensive (Vijaykumar *et al*., 1982). Transfixation with Steinmann pins and external methyl methacrylate bridges is a valuable and cheap alternative stated by Martens *et al*. (1998). In the present study the tibial fracture in bovines was fixed using Steinmann pins of appropriate length and diameter were inserted transversely to the proximal and distal fragments of fractured tibia and pins were held in position by fixing them to the wooden planks externally on both medial and lateral sides, which proved to be very good external support providing rigid fixation at the fracture site. The external transfixation technique used in this study was simple, cheap and effective in treating tibial fractures in bovines.

In the present study cold sterile normal saline was flown on each transfixation pins while driving them in to the bone using power drill, which prevented excess heat production during pin insertion. Similar method was followed by other workers earlier like Aithal *et al*. (2007), Rossignol *et al*. (2014). Anderson and Saint Jean (1996) reported the use of saline for the drill during drilling bone, reducing bone thermo necrosis and conferring improved stability in the cortical pin path.

The whole external transfixation device was covered with thick cotton bandaging in order to prevent injury to the contra lateral limb and to prevent contamination of the pin holes. Proper reduction and alignment of fracture ends were noticed in all the treated animals immediately after the fracture stabilization. Most of the treated animals showed good weight bearing in the immediate post-operative period and could lie down, stand and walk freely with the fixator without any problems after 15 days.

5.5 Clinical observations

Proper reduction and alignment of fracture ends were noticed in all the calves immediately after the fracture stabilization. Most of the treated animals showed good weight bearing in the immediate post-operative period and could lie down, stand and walk freely with the fixator without any problems after 15 days. Closed stabilisation with transfixation pin cast resulted in early weight bearing and better fracture healing by 60 post-operative days.

5.5.1 Weight bearing

Transfixation pinning had several advantages in management of tibial fractures in bovines, which include flexibility in pin positioning, adequate reduction, early return to weight-bearing status, joint mobility, and ease of ambulation (St-Jean *et al*., 1991).

In the present study two animals showed moderate weight bearing immediately after the surgery and four animals showed partial weight bearing soon after the surgery indicating rigid fixation of the fractured fragments. Similar observations were recorded by St-Jean *et al*. (1991), Aithal *et al*. (2004), Aithal *et al*. (2007) and Patel *et al*. (2012).

On 3rd day two animals showed moderate weight bearing and four animals showed partial weight bearing indicating rigid stability of the fracture fixation.

On 5th and 7th post-operative days one animal with compound fracture showed non-weight bearing because of inflammatory swelling and four animals showed partial weight bearing and one animal showed moderate weight bearing.

On 15th post-operative day three animals showed partial weight bearing and three animals showed moderate weight bearing. In a study where tibial fractures in sheep treated with the use of a type I external fixation, Klein *et al*. (2003) observed that non-weight bearing lasted for two weeks after surgery, after which weight was gradually applied on the treated limb. Bilgili *et al*. (2008) reported full usage of treated limb by calves started after between15 and 27 days.

On 30th and 45th post-operative day one animal with compound fracture showed partial weight bearing and all five animals showed moderate weight bearing. The results were in accordance with the results of the study conducted by Pattanaik *et al*. (1996) and Aithal *et al*. (2004)

On 60th post-operative day all the animal showed complete weight bearing with nearing to normal gait. Similarly St-jean *et al*. (1991) reported complete weight bearing in treated animals was observed 8 weeks post operatively.

5.5.2 Complications

One animal with compound fracture developed pin tract infection which gradually subsided with regular dressing and flushing with sterile saline solution containing povidone iodine. Similar complication were observed and treated in the same manner earlier by Richardson *et al*. (1987), Aithal *et al*. (2007) and Shivaprakash (2012).

St-Jean *et al*. (1991) stabilised tibial fracture in 5 calves using transfixation pinning and casting without any complications. Similarly Bilgili *et al*. (2008) reported successful stabilization of tibial fractures in three calves without any complications.

5.5.3 Removal of fixator frame

The fixator frame was removed based on the radiographic evaluation of the clinical union of fracture evident by the presence of callus at fracture site. In all the animals, staged disassembly of the fixator frame was done. On 60th day based on radiographic evaluation fixator frame was removed. The technique allowed satisfactory limb usage after removal of fixator frame. The results were in concurrence with Baxter and Wallace (1991), Martins *et al*. (2001), Ramanathan *et al*. (2006) and Mulon (2009).

Aithal *et al*. (2007) used circular fixator for metacarpal fracture and found that it provided rigid stability and the fixator was removed 50-60 days post operatively. St-jean *et al*. (1991) stabilised tibial fracture in five calves using transfixation pinning and casting where pins and cast was removed 8 weeks post operatively after obtaining good radiographic and clinical evidence of fracture stability. Hamilton and Tullener (1980) stabilised tibial fractures in calves where they observed good radiographic and clinical evidence of stability 4-6 weeks post operatively, at that time the fixator was removed.

5.6 Physiological observations

5.6.1 Rectal temperature

There was no significant change in the rectal temperature during the period of study. This indicated that there was no systemic infection and animals were maintained in normal condition during period of the study. Similar observations were made by Ramanathan (1996), Pattanaik *et al*. (1996), Ramesh (2000) and Patel *et al*. (2012).

5.6.2 Heart rate

Variances of analysis showed that there was non-significant decrease in the heart rate on 15th and 30th post-operative day; this could be due to surgical stress of the operated animals. However, there was gradual increase in the heart rate on 45th day and 60th day postoperatively. The results were in concurrence with Ramanathan (1996), Mulon (2009) and Patel *et al*. (2012).

5.6.3 Respiration rate

There was non-significant increase but within the normal physiological limit in respiration rate on 1st postoperative day. However, the values were within the normal limit throughout the study period. Similar observations were also reported by Martins *et al*. (2001).

5.7 Haematological and biochemical observations.

5.7.1 Haematological Studies

5.7.1.1 Haemoglobin

The variations observed were within the normal range and were non-significant. The reason for this might be because of minimum blood loss during the surgical procedure Oehme and Prier, (1974) and Ramanathan *et al*. (2006). The results were in concurrence with Oehme and Prier, (1974) and Ramanathan (1996).

5.7.1.2 Total erythrocyte count

A non-significant variation was observed and the variations were within the normal range. This might be due to the reason of minimum blood loss during the surgical procedure. A similar observation was also reported by Martins *et al*., (2001) and Patel *et al*. (2012).

5.7.1.3 Total leukocyte count

There was non-significant variation observed and all the variations were within the normal range. And this variation could be due to inflammation (Mulon, 2009), and surgical stress (Patel *et al*. 2012).

5.7.1.4 Differential leukocyte count

There was a non-significant increase in neutrophil percentage observed between 1st to 7th postoperative day, there after returned back to normal value and this transient increase initially could be attributed to trauma, surgical stress and subsequent acute inflammation as stated by Ramesh (2000). Non-significant variation observed in mean value of lymphocyte, monocytes, eosinophils and basophils per cent. The results were in concurrence with Ferguson (1982) and Ramanathan (1996).

5.8 Radiological Observations

Early restoration of limb function has a positive effect on the further course of treatment. Functional weight bearing on affected limb speeds up osteosynthesis and increases the strength of the bone callus stated by O' Sullivan (1994) and Sarmiento *et al*. (1997).

Radiograms taken during the observation period of 60 days on different interval revealed gradual hyperplasia and progressive mineralisation of bone callus at different stages of healing. The radiograms obtained immediately after the surgery revealed fracture fragments were in good alignment, images obtained on 7th post-operative day revealed clear contour of fracture groove and transfixed pins were in position. Images obtained on 15th post-operative day revealed formation of periosteal callus. Images obtained on 30th day revealed formation of callus cuff, radiograms obtained after 45th day revealed clear bridging between fractured fragments. The radiograms obtained on 60th post-operative day revealed intensified callus formation at fracture site and fracture groove was almost disappeared, at this stage the external skeletal fixator was removed by staged disassembly. The results were in concurrence with the results obtained by earlier workers like Hamilton and Tulleners (1980), St-jean *et al*. (1991), Piorek *et al*. (2012), Guzel *et al*. (2013), Alam *et al*. (2014) and George *et al*. (2014).

Summary

VI. SUMMARY

The study was conducted over a period of one year to evaluate the efficacy of modified type II external skeletal fixation for the repair of tibial fractures in six clinical bovine cases belonging to different age, sex, breed and body weight.

1. Totally 10743 cases were presented to Veterinary College Hospital during April 2013 to March 2014. Among them 469 (4.36%) cases were bovine cases.

2. Among these 469 bovine cases, 30 (6.4%) were bovine fracture cases and among them 8 (26.6%) were tibial fractured cases.

3. Among 8 tibial fractured cases 5 females (62%) and 3 males (38%).

4. A total of 4 breeds of bovine were recorded from 8 tibial fractured cases, 5 Holstein Friesian cross (62%), 1 Amrithmahal (13%), 1 Deoni (13%), 1 Hallikar (13%).

5. The age wise occurrence of bovine tibial fracture was 5 cases of less than 1year of age (62%), 2 cases of one to two years of age (25%) and 1 case of above two years of age (13%).

6. Occurrence of tibial fractures in bovines studied were mainly due to vehicle accident 100%.

7. Clinical examination, posterioanterior and lateromedial views of radiograph were adequate to diagnose tibial fracture.

8. Pharmacological restraint with α_2-agonist xylazine and local anaesthetic 2% lignocain hydrochloride provided sufficient analgesic effect until the completion of transfixation procedure.

9. External skeletal fixation for tibial fracture repair in bovines was performed without any difficulty in all the bovine cases.

10. Post-operative radiography revealed proper alignment of bone fragments and no pin loosening was observed up to 60^{th} day postoperatively.

11. Variations in levels of clinical, haematological and biochemical parameters like haemoglobin, total erythrocyte count, total leukocyte count, differential leukocyte count, serum calcium, serum phosphorous, serum alkaline phosphatase were found to be within the normal physiological range in all treated bovine cases during the study period.

12. Excellent and complete recovery was seen in 6 treated bovine cases (100%) in the present study.

In conclusion, modified type II external skeletal fixation technique for tibial fracture repair in bovines provided good pin longevity, excellent fracture healing and early restoration of normal limb function in treated animals with negligible complications. The technique is simple in its application with least efforts to surgeon, minimal invasiveness to animal, less expensive and feasible to be adopted in field.

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Abstract

VIII. ABSTRACT

Various reduction and stabilization techniques have been introduced for the treatment of different types of fracture but external skeletal fixation is one of the novel techniques used for the fracture management in animals. Transfixation pinning is accomplished by placing two or more pins transversely through the proximal and distal bone fragments, and fixing the protruding ends with external support like metal bars or to the hard wooden blocks. In the present study transversely placed Steinmann pins were connected to the wooden blocks externally on both medial and lateral side of the treated limb, which provided satisfactory results in keeping the transfixed pins in position and providing rigid fixation throughout the fracture healing period. This modified type II external skeletal fixation technique can easily practiced by any orthopaedic surgeon and can stabilize long bone fractures like radius, metacarpal, metatarsal and tibial bones of large ruminants and small ruminants with least effort to surgeon. This technique can be applied to simple, compound and communited fractures of long bone in bovines.

This modified type II external fixation technique showed effective immobilization of the fracture, less expensive, minimal invasive and feasible to be done in the field.