FEMUR SHAFT FRACTURE STABILISATION USING INTRAMEDULLARY PINNING AND STACK PINNING IN DOGS

BY

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No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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LIST OF ABBREVIATIONS

@	at the dose rate of
%	Per Cent
ALP	Alkaline phosphatase
AO/ASIF	Arbeitsgemeinschaft fuer Osteosynthefragen
	Association for the Study of Internal fixation
b.i.d	Twice a day
b.wt.	body weight
Ca	Calcium
DCP	Dynamic Compression Plate
et. al.	and others
Fig.	Figure
ESF	External Skeletal Fixation
ILN	Inter Locking Nailing
i.m.	Intramuscular
IMP	Intramedullary pinning
IM Pin	Intramedullary Pin
i.v.	Intra-venous
Inj.	Injection
K-wire	Kirschner wire
LC-DCP	Limited Contact - Dynamic Compression Plate
LCP	Locking Compression Plate
mg/kg	Milligram per kilogram
mm	Millimeter
P	Phosphorus
s.i.d	Once a day
Syp.	Syrup
Tab.	Tablet

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Date: **(T. S. Ramesh Chandra.)**

DECLARATION

I, **Dr. T. S. RAMESH CHANDRA,** ID. No: **GVM/2013-021** hereby declare that the thesis entitled **“FEMUR SHAFT FRACTURE STABILISATION USING INTRAMEDULLARY PINNING AND STACK PINNING IN DOGS”** submitted to **SRI VENKATESWARA VETERINARY UNIVERSITY** for the degree of **MASTER OF VETERINARY SCIENCE** is the result of original research work done by me. I also declare that the materials contained in this thesis have not been published earlier.

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ABSRACT

The present study was conducted on clinical cases with femur fractures presented to the department clinics. In the present study, highest incidence was observed in femur (33.92%) out of total fracture cases and in femur 52.50% were diaphyseal. The cases selected were grouped into two groups of six each. In group I, the fracture was stabilised with IM pin and in group II with “stack pinning” using two IM pins, filling only 70-80 % of medullary cavity. Cerclage wires were used as ancillary fixation in required cases. Lateral and cranio-caudal radiographs of the fractured bone were taken for confirmatory diagnosis, implant selection and surgical approach. Craniolateral approach was used to expose the fracture fragments and reduction under isoflurane anaesthesia. Retrograde technique followed in both the groups was satisfactory. The dogs were evaluated by radiography, serum biochemistry and lameness grading on 0, 15th, 30th and 60th post-operative days. The fracture healed by secondary healing in both the groups with development of bridging periosteal callus. There was no significant difference between the groups and intervals with regard to serum calcium and phosphorus. Elevation of ALP from 0 to 60th post-operative day was observed in both the groups. All the animals regained normal return to weight bearing early (within one month). The IM pin was removed on 60th post-operative day. Seroma and pin migration were observed in three cases. To conclude, intramedullary pinning was an easy, most economic, less time consuming and least traumatic technique for the stabilisation of femur fracture in dogs with good outcome. However, stack pinning provided no advantage of increased torsional stability. The technique resulted in early weight bearing and good functional limb out come.

CHAPTER I

1. INTRODUCTION

Femur fracture is one of the most common orthopaedic affection in dogs (Kumar and Gahlot, 2013) with highest incidence of about 52.5 % among all long bone fractures (Hansda *et. al*., 2012). Femur fractures due to high velocity injuries are the most common type of trauma that causes femur fractures in veterinary patients and most injuries result from automobile accidents (Fossum, 1997). Types of femoral diaphyseal fractures include transverse, short oblique, long oblique, spiral, segmental and comminuted multiple fractures. Most of the femur fractures are unstable and closed fractures because of the abundant overlying muscle, unless caused by penetrating injury such as a gunshot wound (Beale, 2004).

Treatment of femur fractures is often a challenging task for orthopaedic surgeons because fracture fragments do not lend themselves to anatomic reduction and therefore, cannot support load associated with the ability to bear weight after fixation, causing maximal stress on implants. Use of a conventional cast or splint as treatment for the femoral or humeral fractures is contraindicated.

The intramedullary pinning is a simple and economic method of immobilization of the diaphyseal femur fractures (Kumar and Gahlot, 2013).

Intramedullary pinning still remains the most commonly used method for diaphyseal fractures of femur in small animals. In contrast to other implants like bone plates and external skeletal fixators, intramedullary pins have unique biomechanical advantage of resisting bending forces applied from any direction because of their round structure (McLaughlin, 1999) and due to their position close to neutral axis of the bone while they could not neutralize tension, torsional and compression forces (Shales, 2008b).

De Young and Probst (1993) stated that rotation at fracture site might cause delay in fracture healing and could be effectively neutralized by use of multiple intramedullary pins. Stack pinning using two Steinmann pins placed in the medullary cavity of the femur provide stability in fractured fragments and cerclage wires used to stabilize oblique fractures provide stability by inter fragmentary compression in dogs (McLaughlin, 1999). Hence, theoretically, stack pinning is considered to be a better method of stabilisation of femur fracture as it provides some additional stability against rotational forces.

Other methods of femur fracture stabilisation in Dogs viz. Dynamic Compression Plating, Limited Contact Dynamic Compression Plating, Locking Compression Plating, Interlocking nailing, IM pin with ESF and External Skeletal Fixation are more costlier than IMP and stack pinning and they require further surgical procedure for removal of implants whereas IM pins can be removed easily without surgery.

Review of literature revealed scanty reports regarding the comparative evaluation of intramedullary pinning and stack pinning for stabilisation of femur fracture. Hence, the present study was undertaken with following objectives:

1) To study the types of femur fractures encountered in the study
2) To study the gross, clinical and biochemical changes in pre and post-operative period at 0, 15^{th}, 30^{th} and 60^{th} days
3) To study the radiographic changes of fracture healing on 0, 15^{th}, 30^{th} and 60^{th} days
4) To compare the effectiveness of intramedullary pinning and stack pinning in canine metaphyseal and diaphyseal femur fractures

CHAPTER II

2. REVIEW OF LITERATURE

2.1 ANATOMY

Whitehair and Vasseur (1992) stated that the femur was a typical long bone with a cylindrical shaft and expanded extremities and the proximal end consists of the femoral head and neck and the greater, lesser, and third trochanters. The proximal femur tapers to the femoral isthmus located at the level of the proximal diaphysis and then flares distally toward the metaphysis. The isthmus is the narrowest portion of the medullary canal. The shaft of the canine femur is slightly convex cranially. The mid shaft of the femur is covered laterally and cranially by the bellies of the biceps femoris and quadriceps muscles, respectively. The adductor magnus attaches to the caudal aspect of the femoral diaphysis. The distal aspect of the femur consists of the trochlea and condyles. The major blood supply to the diaphyseal region of the femur enters the bone at the nutrient foramen located at the caudal aspect of the proximal third of the diaphysis

Fossum (1997) stated that the femoral diaphysis is the mid portion of bone that curves craniocaudally in dogs and lies between the articular extremities.

2.2 INCIDENCE

2.2.1. Etiology of Fracture

Singh *et. al.* (1983) reported that femur was the most commonly fractured bone accounting for 36.6 % in dogs and usually the result of traumatic injuries, with majority of them being diaphyseal oblique fractures

Braden *et. al.* (1995) found that 28 % of long bone fractures occurred in the femoral diaphysis. They also stated that 60 % of these fractures were simple transverse or oblique or had only one reducible wedge fragment and 40 % were comminuted.

Fossum (1997) opined that high velocity injuries were the most common type of trauma that causes femur fractures in veterinary patients and most injuries result from automobile accidents.

Thilagar and Balasubramanian (1988) and Hansda *et. al.* (2012) stated that among long bone fractures incidence was highest in femur (52.5%) followed by tibia (18.8%) humerus (9.6%) and radius-ulna (8.2%) in dogs.

Harasen (2003) reported that the most commonly fractured long bone in dogs and cats was the femur followed by tibia representing 45 % and 26% respectively. He further stated that the hind limbs were affected more than the fore limbs as the dogs expose their hind quarters to the major force of impact.

Beale (2004) opined that most of the femur fractures were closed and were not generally amenable to conservative repair, and some kind of internal fixation was generally required.

Rani *et. al.* (2007) stated that 88.88% were oblique fractures and 22.22 % were transverse fractures while describing about fracture pattern of femur in canines. They further stated that occurrence of right femur fracture was higher (55.55%) compared to that of left femur (44.44%).

Atri (2009) observed higher incidence of fractures in males than in females due to their higher population and aggressive temperament, which makes them more prone to trauma.

Tercanlioglu and Sarierler (2009) stated that road traffic accident was the major cause of the fracture in animals. They further reported that the most common site of the fracture was the shaft of the femur (73.21%) followed by the growth plates and left leg was fractured slightly more than the right, 53.38% to 46.42%.

Shiju *et. al.* (2010a) observed that the incidence of fracture was highest in femur followed by tibia and fibula in a study about prevalence of fractures of pelvic limb in India

Tambe *et. al.* (2012) and Kushwaha *et. al.* (2012) stated that femur was the most commonly fractured bone in dogs.

Hansda *et. al.* (2012) observed highest incidence of fractures in the mid shaft (50%) followed by distal third (33.33 %) proximal third of diaphysis (11.11%) and supracondylar (5.55%) fractures in a study involving 18 cases of femur fractures.

Ali (2013) reported that most of the fractured dogs and cats were ‘entire’ males and females. This could reflect that neutering under our circumstances was not a routine approach, consequently, intact pet animals wandering outdoors in mating season, resulting in traumatic fractures.

Hari Krishna (2013) stated that the most common cause of fracture was fall from height followed by miscellaneous cause and direct injury to bone in dogs.

Hari Krishna *et. al.* (2013) stated that femur was often fractured bone in the dogs which comprised almost half of the long bone fractures.

Shrestha and Thapa (2013) reported that the femur was the most commonly fractured bone in the dog and cat, comprising almost half of all long bone fractures (45% femoral and 26% tibial fracture).

Jani *et. al.* (2014) reported that road traffic accident (35.16%) was the major etiological factor for fracture incidence followed by fall from height (30.77%) and hit injury (20.88%).

2.2.2 Breed wise Incidence

Aithal *et. al.* (1999) opined that most of the fractures were due to road traffic accident and non-descript dogs were more prone for automobile accident due to their wandering habit.

Hansda *et. al.* (2012) reported that in a study involving 18 femoral fractures in dogs highest incidence of femur fracture was noticed in non-descript dogs (50%) followed by Pomeranian (16.6%) Labrador Retriever (11.11%) and Great Dane, German Shepherd Dog, Rottweiler and Doberman Pinscher (5.55% each) breeds.

Ali (2013) stated that German Shepherds were the most common breed exposed to long bone fractures.

Bishnoi *et. al.* (2013) observed that comminuted long bone fractures were more common in German Shepherds (26.83%) followed by Labrador Retriver

(19.51%) Saint Bernard (12.20%) Rottweiler (9.76%) Sheep Dog and Hound (7.32% each) Pakistani bully (4.88%) and Dalmatian, Doberman, French mastiff, Great Dane and Mongrel (2.44% each).

Jani *et. al.* (2014) recorded high incidence of fractures in Non-Descript dogs (32.97%) followed by German Shepherd Dog (25.27%) Spitz (19.78%) Labrador Retriever (14.29%) Pomeranian (3.29%) Boxer (2.2%) Cocker Spaniel (1.1%) and Pug (1.1%).

2.2.3 Age and Sex wise Incidence

Kolata *et. al.* (1974) reported that young dogs are more active, agile and were not learnt to cope with hazards, unlike their older counter parts.

Tercanlioglu and Sarierler (2009) and Singh and Saha (2012) stated that femoral metaphyseal and diaphyseal fractures were more common in mature dogs and proximal or distal physeal fractures were more common in puppies.

Hansda *et. al.* (2012) observed that femur fractures were highest in younger dogs of 2-4 months age (55.55%) followed by 6-9 months (27.77%) and 5.55% in 2 to 4 years and 12 years old dogs each in a study involving18 dogs. He further stated that males were affected more than females.

Bishnoi *et. al.* (2013) reported that occurrence of fractures was more in males (68%) than in fale dogs (32 %). He further stated that the occurrence of fractures was recorded in all age groups of dogs ranging from 3 months to 9 years but majority were below 2 years of age (70.73%)

Jani *et. al.* (2014) found that fracture incidence was highest in dogs of 3-6 months (27.47%) followed by 1-3years (16.48%) 6-9 months (13.19%) 6 years

(13.19%) 3-6 years (10.99%) 0-3 months (8.79%) unknown age group (6.59%) and 9-12 years (3.30%). He further stated that occurrence of fractures in male dogs was significantly higher (75.83%) than the female dogs (24.17%) with male: female ratio of 3.14:1.

2.3 CLASSIFICATION OF FRACTURES

Miller *et. al.* (1998) radiographed the fractured bone in cranio-caudal and mediolateral views to determine the fracture location and configuration and fractures were classified using Winquist-Hansen (W-H) and AO (ASIF) classification. They further reported that the code used for fracture morphology and its complexity of the distal and proximal extra articular fracture was different from that of diaphyseal fractures.

In Winquist-Hansen (W-H) classification, grading of fracture was done according to degree of comminution:

Grade 0 - No comminution, two piece fracture.

Grade I - One small unimportant bone chip.

Grade II - Greater than 50 % contact between major proximal and distal fracture fragments.

Grade III- Less than 50 % contact between major proximal and distal fracture fragments.

Grade IV - No contact between major proximal and distal fracture fragments.

Grade V- Segmental fractures no contact between major proximal and distal fracture fragments.

According to AO/ASIF classification each fracture was described using alpha-numeric code which designated the bone involved, fracture location, fracture morphology and its severity. In this code, the first digit identifies the bone (1-Humerus, 2-Radius, 3-Femur, 4-Tibia and Fibula). The second digit identifies the location of the fracture in the bone (1-Proximal, 2-Diaphyseal, 3-Distal). The fracture morphology was described using a letter A,B,C as A-simple, B-wedge fractures, and C-complex fractures Each grade was further grouped into three degrees of complexity (viz., C1, C2, C3) depending upon the type and extent of bone fragmentation. The code used for the fracture morphology and its complexity of the distal and proximal extra-articular fractures is different from that of diaphyseal fractures.

Kumar *et. al.* (2007) recorded higher percentage of femoral fractures in middle/ distal diaphyseal region (57%) followed by distal metaphyseal/epiphyseal (20 %), proximal diaphyseal (12%) and proximal metaphyseal/epiphyseal (11%) regions in dogs

2.4 BONE HEALING

Slatter (2003) stated that successful femoral shaft fracture healing outcome depends on a comprehensive preoperative assessment and knowledge of the surgical anatomy.

Beale (2004) reported that duration of fracture healing may vary from 4 to 16 weeks, depending on the age of the patient, type of fracture, method of repair, surgical approach used, compliance of the owner and compliance of the patient.

Vertenten *et. al.* (2010) stated that in fracture repair, proper reduction and immobilisation were essential to achieve optimal bone healing which could be accomplished through the use of specific reduction technique, adequate blood supply allowing the bone to counteract possible infection and to receive the needed circulating factors and nutrients.

Hansda *et. al.* (2012) found callus formation by day 20 following femur fracture repair using steinmann pin, Kuntscher nail and interlocking nailing. Steinmann pin group showed moderate quantity of periosteal callus. On 40th day, radiograph revealed resorption of excessive callus, reduced periosteal reaction and remodeling of bone.

Tiwari *et. al.* (2012) found bony union on a radiograph at 5 to 7 weeks post-operatively following femur fracture stabilization using intramedullary pinning in a dog. They further stated that the radiograph revealed relatively denser bridging periosteal callus indicating mineralization of the callus with delineated fracture line.

Awad *et. al.* (2013) found dense periosteal reaction at 3rd week, at 6th week the periosteal reactions were getting denser between the two fracture ends at 9th week the callus was declined in the size and healed bones were noticed at 12th week in an experimental study of femoral fracture stabilization with Ender's Nail with autogenous cancellous bone graft.

Hari Krishna *et. al.* (2013) stated that fracture healing progressed well with secondary healing and ambulation following repair of distal femoral fracture using locking reconstruction plating in a dog.

Kumar and Gahlot (2013) recorded a bridging callus at 3rd post-operative week in a radiograph after intramedullary pinning for femur fracture repair in a dog. They observed malunion due to rotation of fracture fragments.

2.4.1 Inflammatory Phase

Remedios (1999) stated that the inflammatory phase began immediately after fracture and continued for the first two to three weeks after injury.

2.4.2 Repair Phase

Remedios (1999) observed that the hematoma was formed by platelet plug and fibrin deposition at the fracture site. Macrophages initiated fibro osteoprogenitor cells migration into the fracture site from the endosteum, medullary cavity and cambium layer of the periosteum. Endothelium also served as source of osteoprogenitor cells. Endothelial cells released endothelial cell derived growth factors, which caused bone cell proliferation. Together with fibroblasts, macrophages and capillaries these pluripotential mesenchymal cells form the external periosteal callus. New blood vessels, representing an extra osseous blood supply, originated from the surrounding soft tissues and feed the periosteal callus and any detached cortical fragments, reaching a maximum blood flow by the day 10 post injury. As healing progresses, the contribution of extra osseous blood to further bone healing also diminishes.

2.4.3 Remodelling Phase

Langley-Hobbs (2003) reported that remodeling could continue for years.

2.4.4 Primary Bone Healing

Langley-Hobbs (2003) reported that direct/primary healing occurs when a fracture has been stabilized by rigid internal fixation and compression with little or no gap present at the fracture site and bone will form directly between cortices as a result of osteoclasts (cutting cones) initially crossing the fracture to recreate the blood supply, followed closely by bone building osteoblasts (closing cones).

Gemmill (2007) reported that careful preservation of the natural biology of the fracture site can lead to rigid healing.

Shales (2008a) opined that primary bone healing rapidly stabilises fracture fragments with direct contact between fracture fragments and heal by migration of ‘cutting cones’ (comprising osteoclasts and osteoblasts) from one fragment to the other, resulting in reformation of lamellar bone (Haversian remodeling) without any requirement for precursor tissue or callus and the lack of callus phase could be very important in some cases, particularly when joints are affected.

He further stated that ‘Gap healing’ in which rigidly stabilized fragments were separated by a gap of up to 1mm was a slight variation of this mechanism and the space was initially filled by lamellar bone oriented at 90^{o} to the long axis of the bone, which enable the cutting cones to migrate across the gap and reorientate the lamellar bone. Fracture fragments separated by a gap of more than 1mm or with an interfragmentary strain greater than 2 % will undergo secondary bone healing.

2.4.5 Secondary Bone Healing

Goodship and Kenwright (1985) noted that weight bearing can lead to micro motion at fracture site, which acts as a mechanical stimulus to secondary bone healing.

Langley-Hobbs (2003) opined that spontaneous healing (secondary) relies on adequate ‘biological tissue’ as well as appropriate mechanical stability and she further stated that it was influenced by the amount and condition of the surrounding soft or mesenchymal tissue and a patent blood supply.

Shales (2008a) stated that fragments separated by a gap of more than 1m.m or with an interfragmentary strain greater than 2% will undergo secondary bone healing and this involves the formation of tissue (i.e. callus) that could cope with the strain occurring at the fracture site. He further stated that the callus tissue progression during healing was as follows: granulation tissue → connective tissue → cartilage → mineralised cartilage → Bone.

2.5 CLINICAL SIGNS

Piermattei and Flo (1997) stated that the visible signs in fracture include one or more of following viz., pain or localized tenderness, deformity or change in angulations, abnormal mobility, local swelling, loss of function and crepitus.

Mohindroo *et. al.* (2006) observed not putting weight on both hind limbs and recumbency for six days, swelling in the inguinal region, crepitation of both femurs and inflamatory swelling at the inguinal region without any hernial ring in two years and nine months old Spitz dog with bilateral femoral fracture.

Sharma *et. al.* (2011) noticed that non-weight bearing on the right hind limb since last seven days and physical examination revealed swelling and stiffness with no crepitation on manipulation of joint in a two year old Alsatian dog with right femur fracture.

Gazi and Makhdoomi (2012) found swelling on right hind limb with pain on palpation and inability to bear weight properly with massive multiple bruises and grinding sensation in a traumatized dog with right femur fracture.

Singh and Saha (2012) recorded non weight bearing lameness of right hind limb and pain, swelling and crepitus on palpation of right thigh region following femur fracture in a one year old non-descript male dog.

Tiwari *et. al.* (2012) found that physical examination of thigh in a dog with femur fracture revealed pain, swelling, abnormal motion, deformity with easily palpable fractured ends just above the stifle joint.

Shrestha and Thapa (2013) observed non-weight bearing lameness of right hind limb since one day with pain and disruption in the alignment of the bone during palpation in two year old German Shepherd dog.

2.6 DIAGNOSIS

Langley-Hobbs (2003) opined that before attempting fracture repair one should obtain orthogonal radio graphic views (i.e. taken at 90^o to each other) including the joints proximal and distal to the fracture and radiographic views of the normal contralateral bone were also useful for comparative purpose, particularly when dealing with severely comminuted fractures as they give information about the original dimensions and shape of the bone. She further stated that immediate post-operative radiographs were essential after a fracture repair, even when the injury has been managed with external cooptation and a thorough assessment of the radiographs can be aided by considering the 'Four A s' apposition, alignment, angulation and apparatus. She also mentioned that follow up post-operative radiographs should be taken every two to three weeks for immature animals and every four to six weeks for mature cases.

Shales (2008a) stated that the fracture should be radio graphed, with two orthogonal view's of the affected limb taken as a minimum. He further stated that the quality of the images should be good enough to spot potential fissures that could extend into major fragments and significantly complicate the repair.

2.7 TREATMENT

Newton and Nunamaker (1985) reported that intramedullary pins were best when used in combination with other implants for adequate stabilization of fractured site.

Braden *et. al.* (1995) and Harasen (2003) reported that simple femoral fractures with significant obliquity could be well managed with an intramedullary pin and full cerclage wires.

McLaughlin (1999) stated that stack pinning using two Steinmann pins placed in the medullary cavity of the femur provided good stability and cerclage wires used to stabilize oblique fractures which provided stability by inter fragmentary compression in dogs.

Beale (2004) stated that femur fractures were generally not amenable to conservative repair and some kinds of internal fixation is generally required. He further stated that intramedullary pin provides excellent bending stability, but poor rotational and axial stability. Rotational and axial stability of long oblique and spiral femur diaphyseal fractures could be obtained by appropriate placement of cerclage wires, lag screws or an adjunct external fixator.

Rani *et. al.* (2007) explained that the intramedullary pinning with cerclage wiring were the commonest treatment for diaphyseal femur fractures in dogs and double intramedullary pinning with cerclage wiring was an excellent technique for femoral diaphyseal oblique fracture in dogs, since they provided alignment and by their tight fit at the fracture site provided rotational stability. They further stated that double intramedullary pins and cerclage wires were relatively inexpensive and often easier to implant than other forms of fixation and relatively easy to remove once the fracture was healed.

Shales (2008a) opined that intramedullary pins were good at resisting bending forces due to their position close to neutral axis of the bone while they could not neutralize tension, torsional and compression forces. He further stated that cerclage wires were always used in groups of atleast two and could counter shear forces in oblique fractures.

Kumar and Gahlot (2013) stated that intramedullary pinning was a simple and economic method of immobilization of the diaphyseal femoral fractures.

Shrestha and Thapa (2013) reported that the retrograde intramedullary pinning was performed from the central depression till its exit from the trochantric fossa with further distal progression of the pin into the epiphysis with the fracture in reduction.

2.7.1 Anaesthesia

2.7.1.1 Premedication

Roon *et. al.* (2007) observed that acepromazine as premedicant provided profound sedation.

Ranpariya *et. al.* (2013) conducted a study on safety and efficacy of butorphanol- acepromazine- glycopyrrolate as premedication combination to midazolam- ketamine induction and isoflurane maintenance in canine orthopedic surgeries and they concluded that the use of butorphanol acepromazine and glycopyrrolate (BAG) 15 minutes prior to induction of general anaesthesia provided (moderate to profound sedation) excellent analgesic, sedative and anti-sialogogue effects and ketamine-midazolam induction was smooth with fast, uneventful recovery free of any excitement.

Nithin (2016) observed that butorphanol-acepromazine-atropine and tramadol-acepromazine-atropine premedication provided good sedation in clinical orthopaedic cases induced with ketamine-diazepam and maintained with isofluorane. He further stated that, however, quality of sedation and induction were better in butorphanol group with better anaesthetic sparing effect.

2.7.1.2 Induction

Hellyer *et. al.* (1991) stated that induction was reported to be smooth and free from excitement with ketamine-midazolam combination in dogs.

Ranpariya *et. al.* (2013) reported that induction with ketamine-midazolam was smooth and satisfactory for orthopaedic procedures viz., intramedullary pinning, limb amputation, Ilizarov circular external fixator and type II external fixator in dogs.

2.7.1.3 General Anaesthesia

Ranpariya *et. al.* (2013) opined that isoflurane anaesthesia provided stable maintenance for orthopaedic procedures.

2.7.2 Surgical Approach

Piermattei *et. al.* (2006) stated that with few exceptions a lateral approach is used to expose the femoral shaft for reduction and internal fixation. They further stated that open approach to expose the femoral shaft, the belly of the biceps femoris muscle is reflected caudally and the vastus lateralis muscle and fascia lata are reflected cranially exposing most of the femoral shaft.

Mohindroo *et. al.* (2006) approached the right femur through cranio- lateral site.

Das *et. al.* (2012) used lateral approach to expose fractured femoral diaphysis by incising the skin and fascia lata along the cranial boarder of the biceps femoris muscle, then cranial retraction of the vastus lateralis and caudal retraction of the biceps femoris muscle was carried out.

Rani *et. al.* (2012) in a study of immobilization and treatment of femoral diaphyseal oblique fractures in dogs using double intramedullary pinning and cerclage wiring in twelve dogs approached the femur through a linear skin incision of about 10-12 cm made laterally from below the trochanter major up to the point above lateral condyle of femur.

Singh and Saha (2012) approached femur through a skin incision made along the cranio-lateral boarder of the thigh.

Johnson (2014) described the approaches to the shaft of the femur in dog and stated that the skin incision was made along the craniolateral boarder of the shaft of the bone from the level of the greater trochanter to the level of the patella. The sub cutaneous fat and superficial fascia were incised directly under the skin incision. The skin margins were undermined and retracted. The superficial leaf of the fascia lata was incised along the cranial boarder of the biceps femoris muscle, this incision extends the entire length of the skin incision. If muscle fibres are encountered the incision should be directed more cranially. Caudal retraction of the biceps femoris exposes the shaft of the femur. They further stated that it is necessary to incise the fasial aponeurotic septum on the lateral shaft of the bone to adequately retract the vastus lateralis. The vastus lateralis and intermediate muscles on the cranial surface of the shaft were retracted by freeing the loose fascia between the muscle and the bone.

2.7.3. Surgical Technique

Slatter (2003) opined that successful outcome in fracture repair depends on a comprehensive pre-operative assessment and knowledge of surgical anatomy.

2.7.3.1 Intramedullary pinning

Newton and Nunamaker (1985) opined that intramedullary pins were best when used in combination with other implants for adequate stabilization of fractures. They further stated that orthopaedic wire, hemicerclage or full cerclage wire, provided interfragmentary compression between oblique, spiral or comminuted fracture fragments and the use of hemicerclage or full cerclage wires alone without an intramedullary device was contraindicated and resulted in fixation failure.

Whitehair and Vasseur (1992) stated that the isthmus was the narrowest portion of the medullary canal and was therefore the limiting factor when choosing the diameter of an IM pin for fracture fixation. The placement of a single, large IM pin in an attempt to "fill the medullary canal" was an ineffective method for preventing rotation in transverse fractures because of the limited IM pin-bone contact and the smooth surface of Steinmann pins.

McLaughlin (1999) concluded that the intramedullary pins should fill at least 60-70 % of the medullary cavity at the isthmus of the diaphysis.

Beale (2004) explained that intramedullary pinning (IMP) was the most readily used system of internal fixation in small animal . He also stated that IMP acts primarily as an internal splint for medullary canal of long bone that shares loading with bones, maintains axial alignment of the fracture and resists bending forces in all directions applied to the bone.

Stiffler (2004) opined that IMPs were minimally traumatic as they interfere with endosteal and not periosteal callus formation. He further stated that Orthopaedic pins were used for internal fixation as a primary method of stabilization and were used frequently in combination with wires, bone plating or ESF. The use of multiple pins in combination with wires or pins locked with screws such as interlocking nail increases their resistance to fracture forces. Pins placed in the medullary canal neutralize bending forces in all directions, but alone they do not resist compressive, torsional or shearing forces. To decrease potential, IM pin should engage the proximal and distal cortical surfaces without penetrating the joint surface. Pins can be inserted a normograde or retrograde fashion and should fill at least 70 % of the diameter of the bones at its diaphysis. Intramedullary pins are best used for diaphyseal fractures of humerus, femur, and tibia. Normograde pin placement is recommended in the femur, with the tip being inserted in the craniolateral portion of the trochantric fossa extending as far distally as possible, and this method allows the pin to be seated at the greatest distance from the sciatic nerve

Mohindroo *et. al.* (2006) surgically treated a case of bilateral femur fracture in a female Spitz dog. The right femur having distal third oblique fracture with a split in the proximal fragment was stabilized with stack pinning and full cerclage wire using no.1 vicryl. The left femur was stabilized with retrograde intramedullary pinning and observed early return to weight bearing due to good stability provided by the reduction technique.

Das *et. al.* (2012) surgically managed a case of bilateral femur and tibia fracture by intramedullary pinning and bilateral modified Thomas splints in a 4 months old Labrador pup.

Gazi and Makhdoomi (2012) treated a case of old comminuted femur fracture using an intramedullary pinning in a dog. They passed the pin in normograde fashion through the articular surface, cranial to origin of caudal cruciate ligament, as it provides rotational stability. They further stated that the limb should be extended and adducted while driving the intramedullary pin through the trochantric fossa to avoid the sciatic nerve.

Singh and Saha (2012) treated an unstable comminuted diaphyseal right femur fracture in a one year old non-descript dog by retrograde intramedullary pinning and cerclage wire following the concept of biological fracture fixation which resulted in successful and adequate healing.

2.7.3.2 Stack Pinning

Piermattei *et. al.* (2006) mentioned that the method of stack pinning involves the use of several pins rather than one pin to fill the cavity as a general rule stack pinning was necessary only for the humerus or femur.

Lewis *et. al.* (2009) mentioned that a single intra medullary pin offers little resistance to torsional forces. Stack pinning was an useful technique to improve torsional stability. More smaller pins were selected which fill the medullary canal at the isthmus. In one in vivo study, multiple intramedullary pins provided approximately twice the rotational resistance as that of a single intramedullary pin.

Singh and Saha (2012) opined that in retrograde placement the intramedullary Steinmann pins of appropriate size was introduced into the femoral medullary cavity from the fracture site and out the proximal femur through the trochanteric fossa. They also used three full cerclage wires as an ancillary technique to hold the bony fragments around the intramedullary pin.

Das *et. al.* (2012) stated that retrograde pinning was done through the proximal femoral metaphysis and the pin was directed to emerge from the craniolateral aspect of trochantric fossa, then the pin was fixed at the distal fractured fragment under c-arm guidance and the extra portion of pin was cut.

Rani *et. al.* (2012) performed stack pinning to stabilise femur fracture and explained that the proximal fragment was held by bone holding forceps and the pointed end of Steinmann pin (3.0 or 3.5mm) was introduced into the medullary canal in retrograde fashion with a hand drill and Jacob chuck. The pin was driven proximally with an effort to direct it along the cranio-lateral surface of the medullary cavity. The proximal bone fragment was adducted until it was parallel to surface of table and held in rotation and angulation of normal standing position. As the pin penetrated the proximal bone and soft tissue, a nick was made on the skin to facilitate the migration of the pin from the bone. The second steinmann pin ranging from 3.0 to 4.0 mm diameter was selected so as to completely occupy the medullary cavity at the fracture site was introduced in a similar manner. The reference pin positioned external to the leg was then compared to the pin placed in the marrow cavity to verify the depth of insertion. The proper placements of pins were near the level of the proximal pole of the patella. Two cerclage wires of 20 gauge were applied 1.0 cm apart and 0.5 cm away from the fracture line. Radiographs were taken to confirm the proper placement of the intramedullary pins and excess length of pins was cut close to skin with pin cutter. The cut ends were made smooth by rasping in order to avoid damage to soft tissue. Fascia lata and biceps femoris muscle were sutured with chromic cat gut size 0 in continuous lock suture pattern. A continuous sub cutaneous suture was applied with chromic cat gut size 0. The cutaneous wound was sutured with simple interrupted pattern using cotton thread.

2.7.4 Post-operative Care

Whitehair and Vasseur (1992) opined that an Elizabethan collor should remain in place until the sutures were removed. They further stated that some animals may require the collor until the fixator was removed.

Mohindroo *et. al.* (2006) reported that Robert Jones bandage provided an excellent adjunct to support the internal fixation technique applied, by further stabilising the fractured fragments.

2.8 EVALUATION OF FRACTURE HEALING

Chawla *et. al.* (1983) radiographically evaluated tibial fracture healing in sheep and concluded that marked periosteal reaction and bigger callus were seen in fractures immobilized by simple coaptation and IM pin than with plating.

Dubey *et. al.* (1993) observed callus formation and alignment of fracture fragments at 3 weeks following repair of femoral fractures in canine with bovine horn plates. At 6 weeks post-operatively, marked periosteal proliferation at the fracture site lead to a bridging callus. At 9th week the fracture line disappeared with dense callus and at 12th week post-operatively, bony union of the fracture site with smaller, more dense and well organized callus.

Braden *et. al.* (1995) reported that bone plate fixation of femur shaft fractures resulted in better clinical function of the leg than with IM pins or external fixators. IM pins were satisfactory in small dogs and cats, but plates were better in medium and large dogs.

Nagaraja *et. al.* (1997) radiographically evaluated fracture healing following plastic rod implantation in experimental dogs at immediate postoperative, 4th, 8th and 12th week post-operatively. Radiographs were taken immediately after fixation showed anatomic alignment of fractured ends with a clear fracture line between the fracture fragments. Fourth week radiographs showed feathery periosteal callus extended 1 cm above and below the fracture line. Radiographs taken at 8th week revealed a bigger, relatively less dense, well organized and bridging callus and by 12th week a strong periosteal callus with a radiographic density equal to that of normal bone was observed.

Haaland *et. al.* (2009) opined that the mean healing time of the fractures was seven weeks (95 per cent confidence interval 5.8 to 8.3 weeks) in a study of 47 cases of appendicular fracture repair in dogs, which were repaired with the LCP system combined with less invasive surgical techniques. The authors noticed that forty six out of forty seven fractures reached radiographic union.

2.9 LAMENESS GRADING

Tiwari *et. al.* (2012) observed mild weight bearing at one to two weeks post-operatively in a dog after femur fracture repair using intramedullary pinning.

Hansda *et. al.* (2012) conducted comparative evaluation of Steinmann pin, Kuntscher nail and interlocking nail for femur fracture repair in 18 dogs. The animals required 7.00 +_0.36 days and 6.66+_ 0.42 days and 25.66 +_ 0.33 days and 24.66+_ 0.33 days for partial weight bearing and complete weight bearing in Steinmann pin and Kuntscher nail respectively. However, animal treated with interlocking nail required less time i.e., 4.66+_0.42 days and 20.83+_0.74 days for partial and complete weight bearing, respectively.

Kumar and Gahlot (2013) observed partial weight bearing on 25th post-operative day following femur fracture stabilization using intramedullary pinning.

2.10 FUNCTIONAL LIMB OUTCOME

Braden *et. al.* (1973) evaluated fracture healing following transverse mid shaft fractures in dogs based on functional limb usage. Dogs with bone plates regained normal, full function of the injured limb in about 3.5 weeks, whereas dogs with IM pins and ½ K splints averaged 7.5 weeks and dogs with IM pins averaged 9.2 weeks, until full function was restored and concluded that IM pins with or without ½ Kirschners caused decreased function of the limb, increasing chance of fracture disease.

2.11 IMPLANT REMOVAL

Shiju *et. al.* (2010b) in a study with 10 dogs on plate-rod technique for the management of diaphyseal femoral fractures in dogs opined that in all the cases Intramedullary pins were removed at 6 weeks.

Singh and Saha (2012) studied IM pinning and the use of cerclage wires for management of diaphyseal comminuted femoral fracture in dog they opined that the removal of IMP was removed after taking radiograph and clinical evidence of improvements.

Shrestha and Thapa (2013) studied IM pinning for surgical correction of condylar fracture in a dog, and opined that the IM pin was removed after satisfactory radiological evidence of healing by 45th day in terms of relatively early appearance of amount of the bridging callus.

2.12 SERUM BIOCHEMISTRY

2.12.1 Serum calcium

Bush (1991) observed slight elevation of serum calcium on the 5th postoperative day and then increased significantly to reach the peak level on the 15th postoperative day followed by gradual decline to near base value on the 60th postoperative day but it remained always above the normal value throughout the period of study. The gradual decline in the serum calcium level from the 30th postoperative day might be due more rapid calcification at fracture site.

Nagaraja *et al.* (2003) studied serum biochemical variations, following immobilization of experimentally created midshaft femur osteotomies in dog, before and on postoperative days 1, 2, 3, 7, 9, 11, 13, 15, 60 and 90. The levels of calcium and phosphorus increased gradually up to 15th postoperative day and rapidly decline thereafter. The increase in calcium level could be attributed to mineralization process at the osteotomy site and that of phosphorus could be due to necrotic disintegration of cells at the fracture site. No significant variations were noticed in the postoperative serum alkaline phosphatase values from that of preoperative values, however the values declined from 30th postoperative day onwards.

Rani *et. al.* (2012) noticed significant reduction in serum calcium on 3rd post-operative day followed by an elevation up to 60th post-operative day. They further opined that the initial decline in serum calcium was possibly due to increased urinary excavation after traumatic bone injury and followed by an increase might be due to fracture stabilisation.

2.12.2 Serum phosphorous

Siemens (1970) observed that serum inorganic phosphorus level elevated immediately after fracture fixation and significant increase was recorded on the 30th postoperative day and which thereafter decreased to reach normal level on the 60th postoperative day.

Rani *et. al.* (2012) observed significant increase in serum inorganic phasporous level on 3rd post-operative day and there after the values were significantly reduced and reached the non significant variation level on 60th post-operative day. They further opined the early rise in serum phosphorous level could be due to the necrotic disintegration of the cells at the site of fracture.

2.12.3 Serum Alkaline Phosphatase

Guyton (1981) observed an increase in alkaline phosphatase activity during osteoblastic activity and the author also observed a high increase in alkaline phosphatase level in most of the compression methods of internal fixation.

Maiti *et. al.* (1999) recorded a significant increase in serum alkaline phosphatase level from 5th postoperative day which reached its peak value at 15th day and thereafter a declining trend was noticed at the 60th postoperative day but always remained significantly above the base line value. This increased alkaline phosphatase activity might be an indication of increased chondroblastic proliferation to cause bone formation during fracture repair.

Ghosh *et. al.* (2003) found an increase in serum alkaline phosphatase level from base value on 1^{st} week, reaching peak on 3^{rd} week, then declined towards normal level by 6^{th} week post-operatively following repair of compound fractures with autogenous cancellous and homogenous decalcified bone chips in goats.

Komnenou *et. al.* (2005) stated that the detection of specific biochemical markers of bone formation in serum, such as alkaline phosphatase (ALP) activity can be clinically useful in evaluating the progress of the healing process and serves as an additional tool in predicting fractures at risk of developing a non-union.

Umashankar and Ranganath (2008) observed significant increase in serum alkaline phosphatase level from 1^{st} postoperative day to 21^{st} postoperative day during tibial fracture healing in dogs. The marked elevation in early postoperative period could be attributed to adrenal hyperfunction, stress, skin and muscle trauma and the later increase might be due to increased osteogenic activity and deposition of calcium salts at the site of the fracture.

Hansda *et. al.* (2012) observed in a study in 18 femoral fracture repair, the increased serum alkaline phosphorus activity in all groups from 0-20 days of observations indicating osteoblastic activity at the fracture site.

Rani *et. al.* (2012) observed that there was significant elevation of alkaline phosphotase levels up to 15^{th} post-operative day and values started to decline from 30^{th} post-operative day and reached non significant variation on 60^{th} post-operative day. They further opined the increase in level of alkaline phosphatase following bone injury was attributed to exuberant proliferation of fibrous tissue at fracture site, proliferating osteogenic cells maturing and active osteoblast and the formation of bone matrix.

2.12 COMPLICATIONS

Hunt *et. al*. (1980) and Smith (1998) stated that intramedullary pinning presents a popular form of internal fixation for femoral fractures but instability caused after intramedullary pinning can lead to non-union and predisposes to osteomyelitis.

Dallman *et. al.* (1990) did a study on rotational strength of double-pinning technique in repair of transverse fractures of femur in dogs and concluded that the study did not find statistically significant differences in mechanical torsional strength when comparing single, double and multiple pin fixation of femoral fractures.

Gibson (1991) conducted a retrospective study on stack pinning of long bone fractures in dog and concluded that the theoretical advantages include better rotational stability and more point of bone contact. However, clinical results do not bear these out, with a 50% complication rate and generally unsatisfactory results were reported in one study.

De Young and Probst (1993) found that rotation at fracture site might cause delay in fracture healing and could be effectively neutralized by the use of multiple intramedullary pins.

Stiffler (2004) stated that complications associated with the use of IM pins were secondary to instability or inappropriate placement. He further stated that damage to soft tissue could occur if pins protrude excessively from the bone or migrate over time he observed that temporary or permanent damage to sciatic nerve could occur from incorrect placement or migration of a femoral IM pin.

Mohindroo *et. al.* (2006) observed mild post-operative hyperemia and oedema due to surgical trauma and tissue manipulations during surgical procedure.

Ulusan *et. al.* (2011) observed quadriceps muscle contracture in ten dogs and two cats following different treatment techniques for femur fracture stabilisation. They opined quadriceps contracture as a result of improper bandage application or operations due to femoral fractures, long term immobilization as (for 35-45 days) in a bandage and deficiency of rigid fixation with hyperextenstion on stifle joint causes quadriceps contracture, atropy of femoral quadriceps muscle and affected limb genu recurvatum, patella atta, coxofemoral luxations were observed.

Ayyappan (2012) stated that using single intramedullary Steinmann pins without a primary fixation results in insufficient axial stability and no rotational stability leading to fracture collapse, pin loosening and proximal pin migration. He further stated that using too short pins could result in distal pin migration and inability to remove the pin once healing was accomplished. Using smaller diameter pin can lead to inadequate fixation. Using excessively long pin can result in impingement and damage to the articular cartilage and entrapment of the joint capsule. Improper pinning techniques lead to damage to sciatic nerve and subsequent neuropathy.

Rani *et. al.* (2012) observed that seroma might be due to irritation caused by cut ends of intramedullary pins.

Kumar and Gahlot (2013) noticed post-operative complications like proximal migration of pin, seroma formation near the cut end of pin, rotational deformity causing limb shortening.

CHAPTER III

3. MATERIALS AND METHODS

3.1 SELECTION OF CASES

The present study was conducted on clinical cases presented to the Department of Veterinary Surgery and Radiology, N T R College of Veterinary Science, Gannavaram, with a history of lameness and clinical signs suggestive of femur fracture.

3.2 INCIDENCE

Data regarding the incidence of diaphyseal femur fractures in dogs presented to the Department of Veterinary Surgery and Radiology between January 2014 and November 2015 were collected and the breed, sex, age and location and type of fracture were recorded and analyzed.

3.3.ETIOLOGY

A detailed history of the etiology of fractures in the 14 cases in two groups studied were elicited

3.4 DESIGN OF STUDY

After detailed clinical, orthopaedic, neurological and radiological examination of 14 dogs with diaphyseal femur fractures which were free from concurrent neurological, metabolic and other infectious diseases were selected for the study. Based on the technique used for stabilization of the fracture, the 14 dogs were grouped into 2 groups as detailed below.

GROUP	TYPE OF FRACTURE	TECHNIQUE APPLIED	NO. OF CASES TREATED
Group I	Diaphyseal femoral fracture	Intramedullary pinning	8
Group II	Diaphyseal femoral fracture	Stack pinning	6

The details of the cases selected were shown in Table no. 1 and 2.

3.5 DIAGNOSIS

Lateral and cranio-caudal radiographs of the fractured bone were taken at 90^{o} angle (Shales, 2008a) for confirmatory diagnosis, classification of fractures, selection of implants and approach.

3.6 FRACTURE CLASSIFICATION

Fractures were classified according to the fracture configuration in all the animals of Group I and II using Winquist-Hansen (W-H) and AO (ASIF) classification and code used for fracture morphology and its complexity of the distal and proximal extra articular fracture is different from that of diaphyseal fractures (Miller *et. al.,* 1998).

In Winquist-Hansen (W-H) classification, grading of fracture was done according to degree of comminution:

Grade 0 - No comminution, two piece fracture.

Grade I - One small unimportant bone chip.

Grade II - Greater than 50 % contact between major proximal and distal fracture fragments.

Grade III- Less than 50 % contact between major proximal and distal fracture fragments.

Grade IV- No contact between major proximal and distal fracture fragments.

Grade V- Segmental fractures no contact between major proximal and distal fracture fragments.

According to AO/ASIF classification each fracture was described using alpha-numeric code which designated the bone involved, fracture location, fracture morphology and its severity. In this code, the first digit identifies the bone (1-Humerus, 2-Radius, 3-Femur, 4-Tibia and Fibula). The second digit identifies the location of the fracture in the bone (1-Proximal, 2-Diaphyseal, 3-Distal).

The fracture morphology was described using a letter A,B,C as A-simple, B-wedge fractures, and C-complex fractures Each grade was further grouped into three degrees of complexity (viz., C1, C2, C3) depending upon the type and extent of bone fragmentation. The code used for the fracture morphology and its complexity of the distal and proximal extra-articular fractures is different from that of diaphyseal fractures.

Table 1. Details of cases studied in Group I

CASE No.	BREED	AGE	SEX	LIMB INVOLVED	CAUSE	FRACTURE TYPE
1	Spitz	1Year 6 Months	Male	L	Fall from height	Complete, oblique, over-riding
2	Pomeranian	8 Months	Male	R	Automobile accident	Complete, oblique, over-riding
3	Non descript	4 Months	Male	L	Unknown	Complete, spiral, over-riding, midshaft.
4	Pomeranian	2 Years 6 Months	Male	L	Fall from height	Complete, transverse, over-riding, shaft.
5	Labrador Retriver	3Years 6 Months	Male	L	Automobile accident	Complete, oblique, comminuted with large bone fragments
6	Pomeranian	2 Years	Female	L	Automobile accident	Complete, oblique, over-riding fracture of neck and pubicsymphysis
7	Spitz	2 Years	Female	R	Unknown	Complete, long oblique, over-riding
8	Pomeranian	6 Months	Male	L	Automobile accident	Complete, transverse, over-riding

Table 2. Details of cases studied in Group IIs

CASE No.	BREED	AGE	SEX	LIMB INVOLVED	CAUSE	FRACTURE TYPE
9	Pomeranian	1 Year	Male	R	Automobile accident	Complete, transverse, over-riding
10	Doberman Pinscher	5 Months	Female	L	Automobile accident	Complete, over-riding, severely comminuted
11	German Shepherd Dog	4 Years	Male	R	Automobile accident	Transverse, over-riding, Comminuted
12	Non descript	8 Months	Female	R	Fall from height	Complete, oblique, over-riding
13	German Shepherd	4 Months	Female	L	Automobile accident	Transverse, over-riding
14	Doberman Pinscher	3 Month	Male	L	Fall from height	Oblique, over-riding proximal

3.7 INSTRUMENTATION, IMPLANT SELECTION AND PATIENT PREPARATION

3.7.1 Instrumentation

A standard orthopaedic set (Fig. 1) and a general surgical instrumentation set were used in the study.

3.7.2 Intramedullary Pins

Trocar pointed Steinmann pins made of surgical grade 316L stainless steel metal alloy were used. Steinmann pins were selected on the basis of radiographic measurement of the medullary canal. Steinmann pins of thickness sufficient to fill up 70 – 80 per cent of the marrow cavity at the isthmus were used. For stack pinning smaller pins were used so that they fill up 70 – 80 per cent of the marrow cavity at the isthmus.

3.7.3 Cerclage wires

Cerclage wire of appropriate size was used for ancillary fixation in necessary cases (Fig.2)

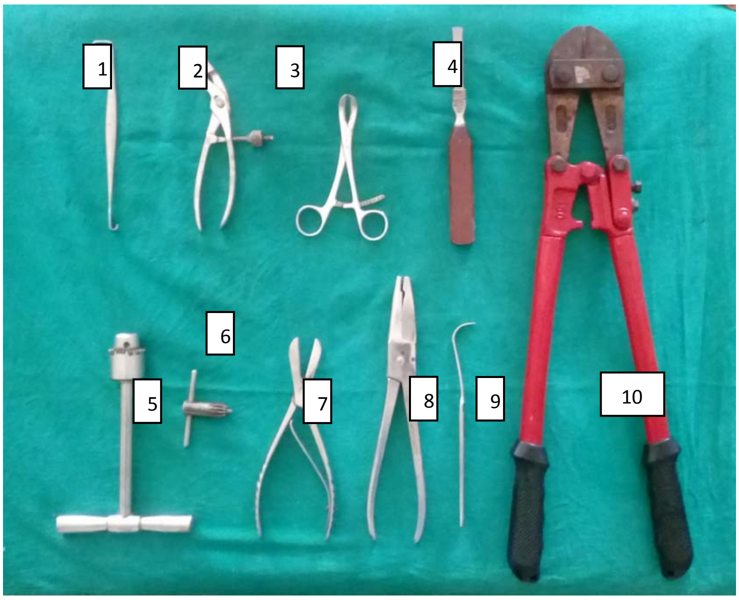

Fig 1: Photograph showing standard orthopaedic set

1 – Senn Retractor	6 – Chuck Key
2 – Self Centring Bone Holding Forceps	7 – Bone Cutter
3 – Serrated Bone Holding Forceps	8 – Wire Twister
4 – Periosteal Elevator	9 – Wire Passer
5 – Hand Chuck	10 – Pin Cutter

Fig 2: Photograph showing Steinmann pins and orthopaedic wires

3.7.4 Patient preparation

The fractures were temporarily stabilized with modified Robert-Jone's bandage with or without the use of splints till the day of surgery. The owners were advised to withheld food for 12 hours and water for about 6 hours prior to surgery. The affected limb was aseptically prepared by clipping the hair from a wide area surrounding the surgical site including the proximal and distal joints. The operative site was shaved and scrubbed using povidone-iodine surgical scrub, followed by application of surgical spirit. Ringer's lactate was intravenously administered throughout the duration of surgery.

3.7.5 Anaesthesia

Atropine[1]-acepromazine[2]-butorphanol[3] @ 0.02 mg, 0.03mg and 0.1 mg/kg b.wt, IM as pre-anaesthetic medication, followed 30 minutes later by Ketamine[4]-Diazepam[5] at the dose rate of 5 mg/kg body weight and 0.3mg/kg body weight respectively IV for induction. Following induction of anaesthesia, the dogs were intubated with endotracheal tubes of suitable size. General anaesthesia was maintained with 1.5 to 2 per cent isoflurane[6']

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1. Atropine sulphate IP- Domesto Pvt. Ltd., Vijayawada – 520 005, A.P., India
2. Ilium acepril-10-Troy laboratories Ltd., Australia.
3. Butrum-2-Aristo laboratories Ltd., Mumbai, India.
4. Ketamax- Troikaa pharmaceuticals Ltd., Dehradun – 248 197, Uttarakhand, India
5. Lori- Neon Laboratories Ltd., Mumbai – 400 093, India
6. Forane- Abbot laboratories Ltd., Engl
7. Lignocaine Hydrochloride IP- Neon Laboratories Ltd., Andheri (East) – 520 005, Mumbai, India

3.8 SURGICAL TECHNIQUE

3.8.1 Positioning of the animal

The animals were placed in lateral recumbency with the affected limb placed uppermost on the operating table (Fig. 3).

3.8.2 Intramedullary Pinning Group I

A skin incision was made on the cranio-lateral aspect of the thigh extending from the trochanter major to the lateral condyle of the femur (Rani *et. al.,* 2012) (Fig. 4). The subcutaneous tissue and fascia were incised directly under the skin incision. Tensor fascialata muscle was incised to the entire length of the skin incision along the cranial border of the biceps femoris muscle (Fig. 5). Biceps femoris and vastus lateralis muscles were separated and retracted to expose the shaft of the femur (Johnson, 2014) (Fig. 6). Blood clots, fibrin mass and sequestered bones, if -any, were removed (Fig. 7). The proximal segment was held in angulation and rotation of the normal standing posture avoiding abduction, excessive rotation and excessive flexion of the hip to prevent sciatic neuropraxia. The proximal fracture fragment was held with bone holding forceps. A Steinmann pin of appropriate length was inserted proximally in the medullary canal in a retrograde manner (Fig. 8) with the help of Jacobson's chuck by quarter turns and constantly applying pressure. The pin was directed along the cranio-lateral surface of the medullary cavity. The pin was driven so as to exit through trochanteric fossa and skin. A nick incision was made on the skin over the pin for its exit. The pin was reversed to ensure that its trocar end was positioned distally. The blunt end of the pin was pushed proximally to exit through trochanteric fossa through the predrilled hole. The chuck was then replaced onto the pin at the proximal end. The fracture was reduced anatomically. The pin with trocar

Fig 3: Photograph showing positioning of the animal for surgery

Fig 4: Photograph showing skin incision

Fig. 5: Photograph showing Tensor fascialata incision

Fig. 6: Photograph showing separation of Biceps femoris and Vastus lateralis to expose the fractured femur

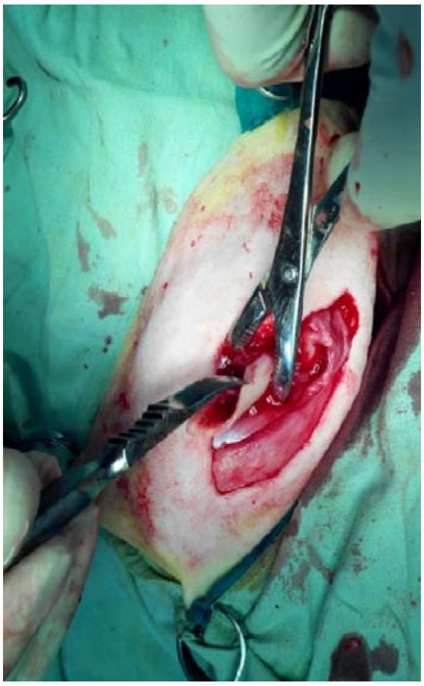


Fig. 7: Photograph showing debridement of fracture ends

Fig. 8. Photograph showing retrograde insertion of Steinmann pin

end in the marrow cavity was driven into distal fragment till it was seated in the trabecular bone of the distal metaphysis (supracondylar region) (Fig. 9). The pin reversal step was eliminated in some cases by the use of Steinmann pin with trocar points at both the ends. Alignment of the fracture fragments was checked. The chuck was removed from the pin. The reference pin of equal length was positioned external to the leg to verify that the distal tip of the reference pin was at the level of the proximal pole of the patella (Fig. 10). Proximal end of the pin was left protruding out from the skin for a length of about 4 to 5 cm. The tensor fascia lata was sutured with 2-0 polyglactin in a continuous pattern (Fig. 11). Subcuticular sutures were placed with 2-0 polyglactin 910 (Fig. 12). The skin incision was sutured in cruciate mattress pattern by using nylon 910 (Fig. 13).

3.8.3 Stack pinning Group II

The procedure was similar to IM pinning except for passing of two Steimann pins of appropriate size.

After exposure of fracture fragments, the proximal fragment was held by bone holding forceps and the pointed end of steinmann pin was introduced in to the medullary canal in retrograde fashion with Jacob son's chuck. The pin was driven proximally with an effort to direct it along the cranio-lateral surface of the medullary cavity. The proximal bone fragment was adducted until it was parallel to surface of table and held in the rotation and angulation of normal standing position as the pin penetrated the proximal bone and soft tissue. A nick was made as the skin to facilitate exit of the pin from the bone. The second steinmann pin of appropriate diameter selected so as to occupy 70-80 % the medullary cavity at fracture site was also introduced in the similar manner.

The fracture reduced and the pins were driven on to distal fragment till seated in trabecular bone of distal metaphysis. The reference pin positioned external to the leg was then compared to the pin placed in the marrow cavity to verify the depth of insertion. The proper placement of pins was near the level of the proximal pole of the patella.

Two to four cerclage wires of appropriate gauges were applied 1.0cm apart and 0.5cm away from the fracture line in both the groups where ever necessary.

Excess length of pin /pins was cut close to skin with a pin cutter. The cut ends were made smooth by rasping in order to avoid damage to soft tissue. The nick incision was closed with single simple interrupted suture with black braided silk. Immediate post-operative radiographs were taken to confirm the proper placement of intramedullary pins.

Fig. 9. Photograph showing Steinmann pin driven into distal fragment after reduction

Fig 10: Photograph showing reference pin placement to ascertain depth
of insertion of IM pin

Fig 11: Photograph showing closure of Tensor fascialata using polyglactin in a continuous suture pattern

Fig 12: Photograph showing subcutaneous suturing with polyglactin 910

Fig 13: Photograph showing closure of skin incision in cross mattress pattern using nylon

3.9 IMPLANT REMOVAL

Implants were removed on 60th postoperative day after evaluating the radiographs for fracture healing.

Implants were removed under 2% Lignocaine Hydrochloride[7] local infiltration analgesia. With the help of thumb and finger palpation near trochanteric fossa, a skin nick was given over the point of pin projection and pin was removed with the help of needle holder. The incision was closed with no. l black braided silk in cruciate pattern.

3.10 PARAMETERS STUDIED

3.10.1 Clinical

Detailed clinical and orthopaedic examinations were performed to identify the fractured area of the affected femur.

3.10.2 Radiological

Preoperative radiological examination, where in the affected limbs were subjected to lateral and craniocaudal projections to confirm and to define the location and type of fracture.

Postoperatively, radiographs of repaired fractures were taken at 0, 15th, 30th, 60th days interval.

3.10.3 Lameness grading

A lameness grade was assigned to all the cases during pre and post treatment period based on the weight bearing nature during stance and while walking. Weight bearing graded as follows (Dymond *et. al.,* 2010)

Grade 0 - No lameness

Grade 1 - Mild lameness – occasional gait abnormality.

Grade 2 – Moderate lameness – obvious gait abnormalities,

Grade 3 - Moderate lameness – obvious gait abnormality and occasional non-weight bearing

Grade 4 – Severe lameness – Consistently non – weight bearing.

The assessment and grading was done on 0, 15^{th}, 30^{th} and 60^{th} postoperative days.

3.10.4 Serum Biochemistry

Blood samples were collected in vaccutainer tubes on day 0, 15, 30 and 60 in all the groups to evaluate the levels of serum calcium, phosphorus and alkaline phosphatase.

3.10.4.1 Serum calcium

Serum calcium (mg/dl) was estimated by Ferro-Hem method

3.10.4.2 Serum phosphorus

Serum inorganic phosphorus (mg/dl) was estimated by Fiske and Subba Rao method

3.10.4.3 Serum alkaline phosphatase

Serum alkaline phosphatase (I U) was estimated by U.V. Kinetic method.

3.10.5 Functional Limb Outcome

Based on the periodical clinical examinations, the functional limb outcome during postoperative period was assessed and the animals were categorized as excellent, good, fair and poor in all the groups of animals (Clark, 1986).

Excellent	:	No lameness, no more than 15° loss of range of motion compared to the dog's opposite limb, no post operative complications
Good	:	Moderate occasional lameness, not required treatment, 20° to 30° loss of range of motion, no postoperative complications
Fair	:	Moderate persistent lameness requiring treatment, 40° to 60° loss of range of motion
Poor	:	Persistent severe lameness with loss of greater than 40° range of motion.

3.11 STATISTICAL ANALYSIS

The data collected were statistically analyzed using S P S S-ANOVA Post Hoc test in Tukey H S D.

CHAPTER IV

4. RESULTS

4.1 INCIDENCE

The total number of fracture cases recorded in dogs during the period of study i. e. January, 2014 to November, 2015 were 338 of which long bone fractures were 230 (68.63 % of total fractures). Among the long bone fractures humerus accounted for 15 (6.52%) radius and ulna 71 (30.86%), femur 78 (33.92%) and tibia and fibula 66 (28.69%) (Fig.14).

Among the 78 femur fractures, 11 (4.10%) were proximal femur fractures, 41 (52.56%) were diaphyseal fractures and 26 (33.33%) were distal femur fractures. The incidence of different femur fractures was shown in Fig. 15.

4.1.1 Breed, Age and Sex wise incidence of femur fracture

Out of the 78 femur fractures recorded, the incidence was highest in Pomerarian (35.89%), followed by Non-descript (34.62%), Labrador Retriever (20.51%), German Shepherd Dog (3.85%), Daschund (2.56%), Cocker Spaniel and Kanni (1.28% each) (Fig.16).

Fig. 14 Graph showing incidence of long bone fractures

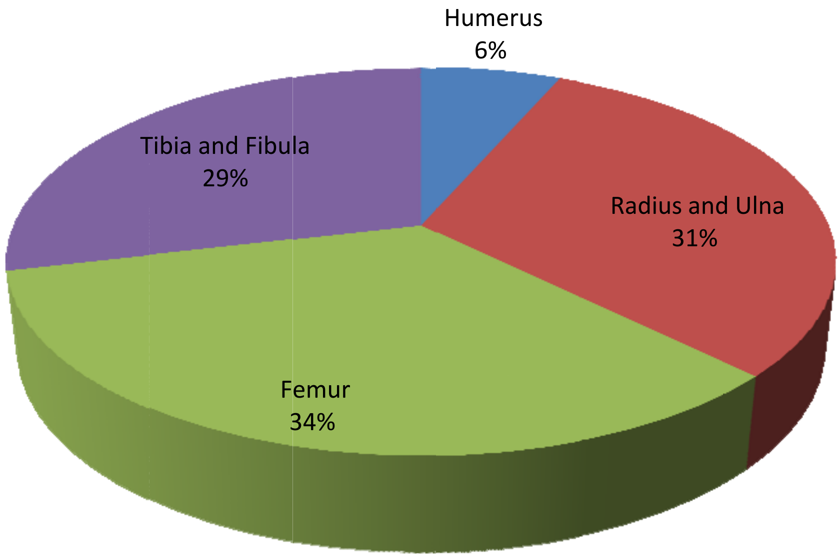


Fig.15. Graph showing incidence of femur fractures

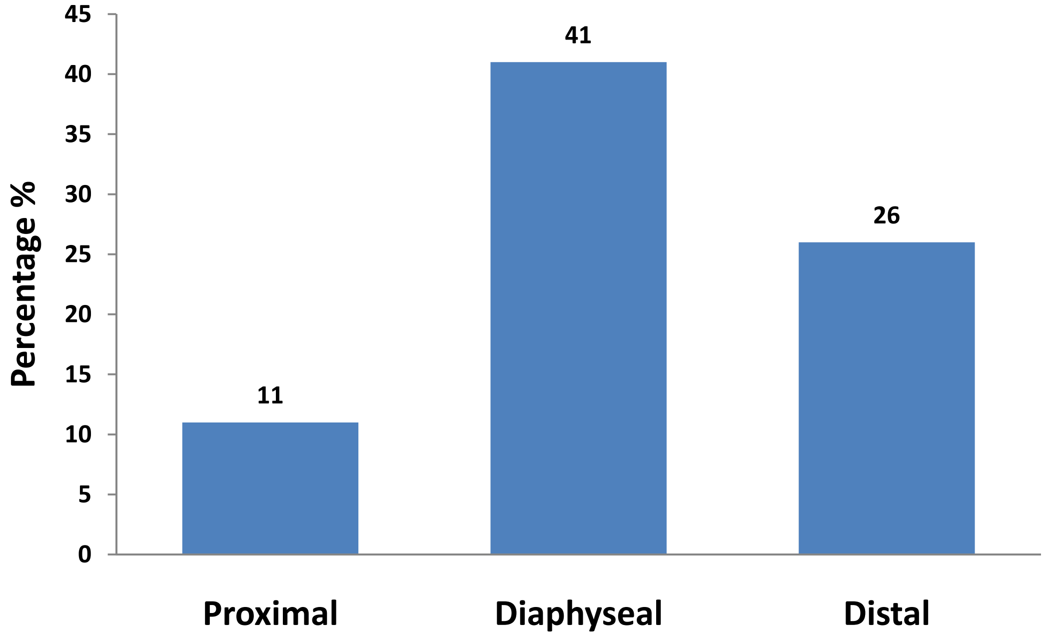


Fig. 16 Graph showing breed wise incidence of femur fractures

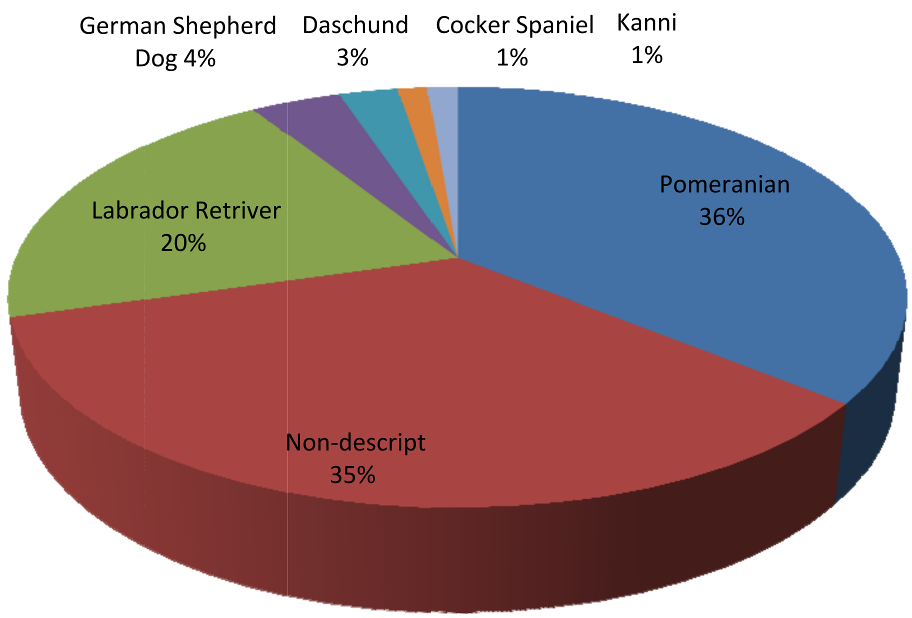
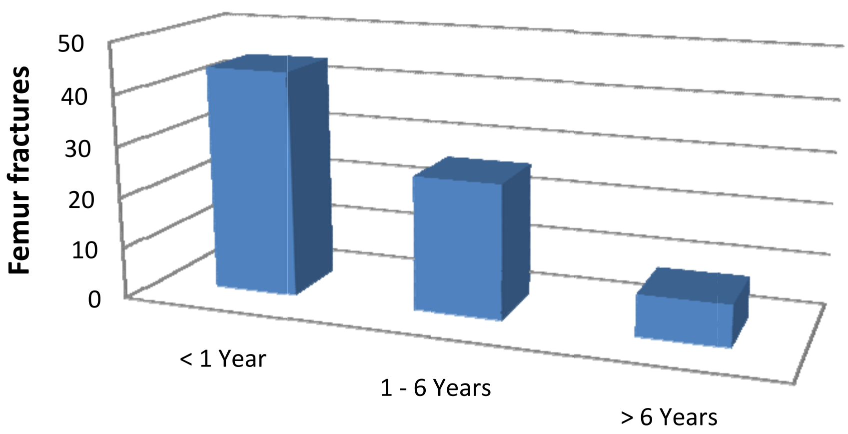


Fig. 17 Graph showing age wise incidence of femur fractures



	< 1 Year	1 - 6 Years	> 6 Years
Series1	44	26	8

Fig. 18 Graph showing gender wise incidence of femur fractures

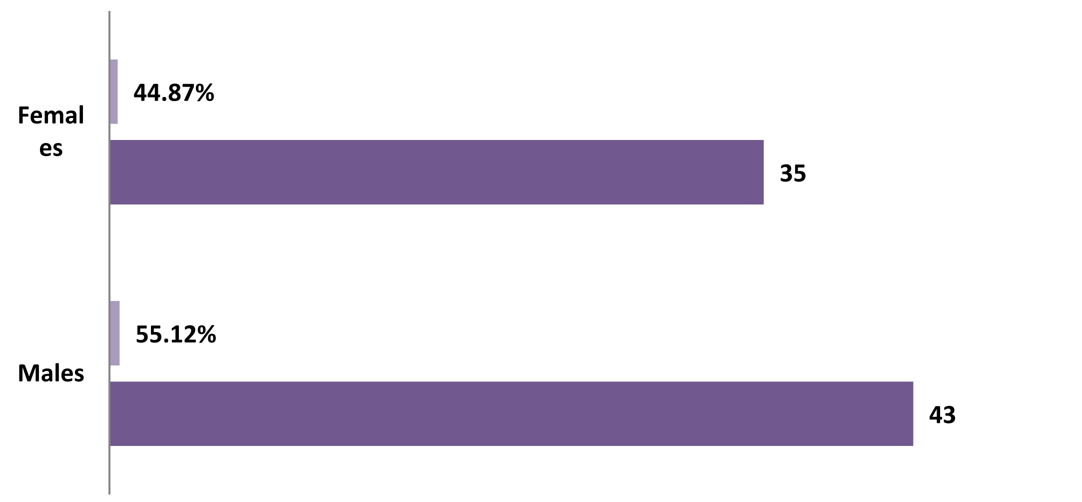
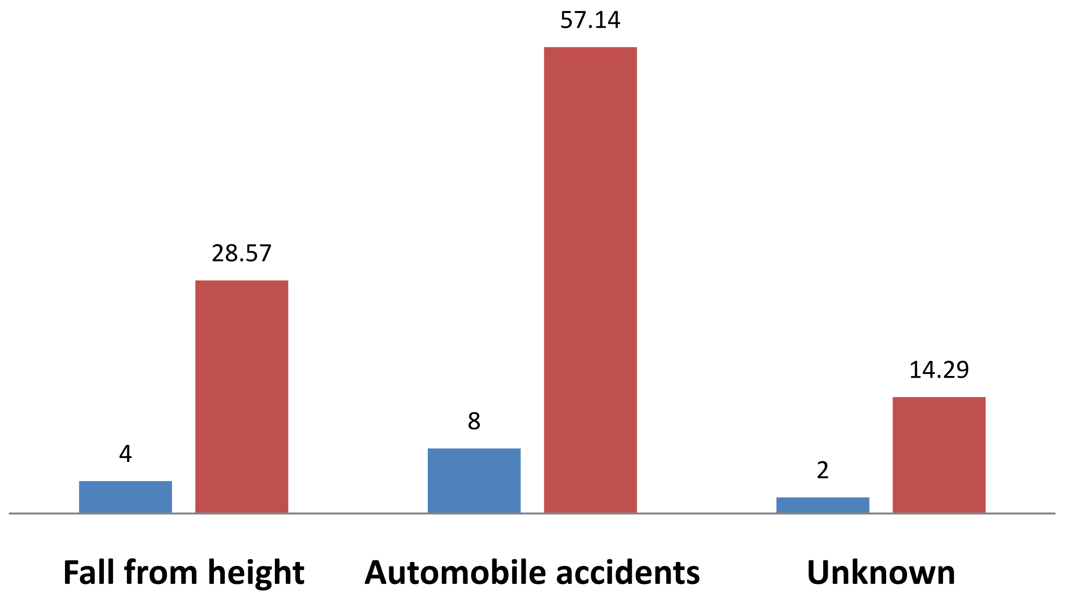


Fig. 19 Graph showing etiology of fractures



The highest incidence of femur fractures were recorded in dogs aged below 1 year with 56.41% followed by 1-6 years age group with 33.33% and above 6 years age group with 10.25% (Fig.17).

Out of 78 femur fractures recorded 43 were in males (55.12%) and 35 were in females (44.87%) (Table 3) (Fig.18)

Table 3. Breed, age and sex wise incidence of femur shaft fractures

S.no	Breed	< 1 Year		1- 6 Year		>6 Year		TOTAL	
		M	F	M	F	M	F	M	F
1	Pomeranian	9	8	4	3	2	2	15	13
2	Non-Descript	9	7	5	4	1	1	15	12
3	Labrador Retriever	4	3	4	3	1	1	9	7
4	German Shepherd Dog	1	1	1	0	0	0	2	1
5	Daschund	1	0	0	1	0	0	1	1
6	Cocker Spaniel	0	0	0	1	0	0	0	1
7	Kanni	1	0	0	0	0	0	1	0
8	Total	25	19	14	12	4	4	43	35

4.2 ETIOLOGY

The cause of femur fracture was determined based on the history for 14 cases included in the study (Table 4). In the present study the main cause was automobile accident (57.14 %) (case no 2, 5, 6, 8, 9, 10, 11, and 13) followed by fall from height (28.57 %) (case no.1, 4, 12, and 14) and unknown causes (14.29 %) (case no. 3 and 7) (Table 4) (Fig.19).

Table 4. Etiology of fractures

S. No.	Causes of fractures	Case number	Total	Per Cent
1	Fall from height	1,4,12 and 14	4	28.57
2	Automobile accident	2,5,6,8,9,10,11 and 13	8	57.14
3	Unknown	3 and 7	2	14.29
	Total		14	100

4.3 CLINICAL EXAMINATION AND DIAGNOSIS

All fourteen dogs presented for treatment of femur fractures exhibited clinical signs like non-weight bearing of the affected limb, soft tissue swelling of the area, tenderness, pain, crepitus and abnormal mobility. Range of stifle joint motion was normal in all the animals except case no.5. None of the dogs had either sciatic or femoral neurological deficit since all of them responded at good or fair levels on pinching of lateral and medial digits. Lateral and cranio-caudal radiographic views of femur were satisfactory and provided confirmatory diagnosis of femur fracture.

4.4 CLASSIFICATION OF FRACTURES

Lateral and craniocaudal radiographic views provided a confirmatory diagnosis, enabled fracture classification and Pre-operative decision making

Fractures were classified as follows based on AO/ASIF classification and Winquist-Hansen (W-H) classification (Table 5).

Out of 14 femoral fractures, 10 were transverse or oblique over-riding fractures and designated as 3 2 A 1, one was oblique over-riding and designated as 3 2 A 2, one was oblique, over-riding, comminuted with large bone fragment and designated as 3 2 C 2, one was transverse over-riding comminuted and designated as 3 2 B 2 and one was over-riding and severely comminuted and designated as 3 2 C 3 (Table 6 and 7).

Table 5. Winquist-Hansen classification of fractures

Group	Case No.	Grade
Group I	1	0
	2	I
	3	0
	4	0
	5	V
	6	0
	7	0
	8	0
Group II	9	I
	10	IV
	11	III
	12	0
	13	0
	14	0

Table 6: Etiology and fracture classification in Group-I

CASE No.	BREED	AGE	SEX	LIMB INVOLVED	CAUSE	FRACTURE TYPE
1	Spitz	1 Year 6 Months	Male	L	Fall from height	Complete, oblique, over-riding, 3 2 A 1
2	Pomeranian	8 Months	Male	R	Automobile accident	Complete, oblique, over-riding, 3 2 A 1
3	Non descript	4 Months	Male	L	Unknown	Complete, spiral, over-riding, shaft, 3 2 A 1
4	Pomeranian	2 Years 6 Months	Male	L	Fall from height	Complete, transverse, over-riding, shaft, 3 2 A 1
5	Labrador Retriver	3 Years 6 Months	Male	L	Automobile accident	Complete, oblique, comminuted with large bone fragments, 3 2 C 2
6	Pomeranian	2 Years	Female	L	Automobile accident	Complete, oblique, over-riding fracture neck and pubic symphysis, 3 2 A 2
7	Spitz	2Years	Female	R	Unknown	Complete, long oblique, over-riding, 3 2 A 1
8	Pomeranian	6 Months	Male	L	Automobile accident	Complete, transverse, over-riding, 3 2 A 1

Table 7: Etiology and fracture classification in Group-II

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CASE No.	BREED	AGE	SEX	LIMB INVOLVED	CAUSE	FRACTURE TYPE
9	Pomeranian	1Year	Male	R	Automobile accident	Complete, transverse, over-riding, 3 2 A 1
10	Doberman Pinscher	5Months	Female	L	Automobile accident	Complete, over-riding, severely comminuted, 3 2 C 3
11	German Shepherd Dog	4 Years	Male	R	Automobile accident	Over-riding, Comminuted, 3 2 B 2
12	Non descript	8 Months	Female	R	Fall from a height	Complete, oblique, over-riding, 3 2 A 1
13	German Shepherd Dog	4 Months	Female	L	Automobile accident	Transverse, over-riding, 3 2 A 1
14	Doberman Pinscher	3Month	Male	L	Fall from a height	Short Oblique, over-riding, 3 2 A1

4.5 PRE OPERATIVE PLAN FOR IMPLANT SELECTION

Pre-operative plan using the lateral and craniocaudal radiographic views of the affected limb and contralateral limb were essential to determine the size and length of the intramedullary pins and measurements taken from the pre-operative radiographs of the affected limb like length of the bone, width of the medullary cavity at isthmus and transcortical diameter at subtrochanteric and supracondylar regions proved vital in selecting the length and thickness of the intramedullary pins.

Lateral and craniocaudal radiographic views provided a confirmatory diagnosis, enabled fracture classification, Pre-operative decision making to determine the size and length of the intramedullary pins.

4.6 PREMEDICATION AND ANAESTHESIA

Atropine-acepromazine-butorphanol as Premedication with ketamine-diazepam anaesthetic induction were satisfactory for intubating the patient in all the cases. Isoflurane anaesthesia at 1.5-2.0% level with oxygen provided satisfactory surgical plane of anaesthesia throughout the surgical procedure without any complications in all the cases.

4.7 SURGICAL TECHNIQUE

4.7.1 Positioning and surgical approach to shaft of femur

The animals were placed in lateral recumbency with the affected limb placed uppermost on the operation table. A skin incision was made on the cranio-lateral aspect of the thigh extending from the trochanter major to the lateral condyle of the femur. The subcutaneous tissue and fascia were incised directly under the skin incision. Tensor fascia lata muscle was incised along the cranial border of the biceps femoris muscle. Biceps femoris and vastus lateralis muscles were retracted caudally and cranially respectively to expose the shaft of the femur.

This approach facilitated adequate exposure of fracture fragments and to achieve normal alignment and fracture reduction.

4.7.2. Group-I: Intramedullary Pinning

The Steinmann pins selected (Table 8) based on the pre-operative plan were found to be appropriate in the present study. Single Steinmann pin used in group-I provided adequate reduction and stability of the fracture with good contact between the fracture fragments. Cerclage wires used as ancillary fixation method in cases of oblique or spiral fractures or to hold the wedge fragments were appropriate and added to the stability of the fracture by providing inter-fragmentary compression. The mean time taken for surgery was 51 minutes (range 39 to 90 minutes).

Table 8: Specification of the implants used – Group I.

Case No.	Breed	Age	Implant specification		
			Steinmann pin Size (m.m)	Primary	Ancillary
1	Spitz	1 Y 6 M	2.5	I M P	2 Cerclage wires
2.	Pomeranian	8 M	3.0	I M P	Nil
3	Non-descript	4 M	4.0	I M P	3 Cerclage wires
4	Pomeranian	2 Y 6 M	3.5	I M P	Nil
5	Labrador Retriever	3 Y 6 M	5.0	I M P	5 Cerclage wires
6.	Pomeranian	2 Y	3.5	I M P	2 Cerclage wires
7	Spitz	2 Y	2.5	I M P	2 Cerclage wires
8	Pomeranian	8 Y 6 M	4.0	I M P	Nil

M: Months, Y: Years

4.7.3. Group-II: Stack Pinning

The Steinmann pins selected (Table 9) were found to be appropriate and two Steinmann pins used in each case as stack pinning to fill approximately 70% of the marrow cavity. Two Steinmann pins used in group-II provided good reduction and stability of the fracture with good contact between the fracture fragments. Cerclage wires used as ancillary fixation in two cases (case no. 10 and 11 respectively) with comminution provided good extra stability for fracture reduction. In case no. 9 tension band wiring using a single K-wire used as additional fixation which has trochanteric major fracture. The mean time taken for surgery in group-II was 60.5 minutes (range 52 to 75 minutes).

Table 9 : Specification of the implants used – Group II.

Case No.	Breed	Age	Implant specification	
			Steinmann pins Size (m.m)	Ancillary
9	Pomeranian	1 Y	2.0 and 2.5	Tension band wiring with single K-wire
10	Doberman Pinscher	5 M	4.5 Threaded and 2.5	4 Cerclage wires
11	German Shepherd Dog	4 Y	3.5 and 2.5	3 Cerclage wires
12	Non descript	8 M	2.5 and 2.5	Nil
13	German Shepherd Dog	4 M	3.5 and 2.0	Nil
14	Doberman Pinscher	3 M	2.0 and 1.8	Nil

4.8 EVALUATION OF PINNING TECHNIUE

4.8.1 Clinical evaluation

Surgical wounds healed without any complication in all the cases of group-I and II , except for formation of seroma at the point of pin projection from trochanteric fossa in case no. 5, 6 and 8 of group-I and case no. 11, 12 and 13 of group-II.

4.8.2 Lameness grading

Lameness grading was evaluated on the basis of gait and weight bearing for all the cases of two groups at 1st, 15th, 30th and 60th post-operative days (Table 10).

In group-I, all the animals showed lameness grade of 4 and persistence of same grade 4 in all the animals on 1st post-operative day except case no.8 which had a lameness grade of 3 with weight bearing on paw. All the cases showed touching of paw with weight bearing and gait abnormality on 15th post-operative day with lameness grade 2 except case no.5 which had lameness grade of 3. Case no. 8 showed weight bearing on 10th post-operative day itself (Fig. 20)

On 30th post-operative day all the cases showed normal gait and weight bearing pattern except case no.5 which had a lameness grade of 2. On 60th post-operative day all the cases showed no lameness (grade 0) except case no. 5 which still had occasional mild gait abnormality.

In group-II, pre-operatively all the animals had a lameness grade of 4 and post-operatively had a lameness grade of 4 except case no 12 which lameness grade 3 with occasional non-weight bearing and gait abnormality. On 15th post-operative day, all the cases had moderate lameness with gait abnormality except case no.12 which had only gait abnormality (lameness grade 1) (Fig. 21). Case no. 14 had lameness grade 4 due to pin migration and refracture. On 30th post-operative day, all cases had mild lameness with occasional gait abnormality except case no.12 which had no lameness. Case no. 14 had gait abnormality and occasional weight bearing. All the cases in group-II showed no lameness at 60th post-operative day, except case no. 14 which had gait abnormality with lameness grade of 2.

Table 10. Lameness grading

Group	Case No.	Lameness Grade				
		Pre operative	Post operative			
			Day 1	Day 15	Day 30	Day 60
Group I	1	4	4	2	0	0
	2	4	4	2	0	0
	3	4	4	2	0	0
	4	4	4	2	0	0
	5	4	4	3	2	0
	6	4	4	2	0	0
	7	4	4	2	0	0
	8	4	3	2	0	0
Group II	9	4	4	2	1	0
	10	4	4	2	1	0
	11	4	4	2	1	0
	12	4	3	1	0	0
	13	4	4	2	1	0
	14	4	4	4	3	2

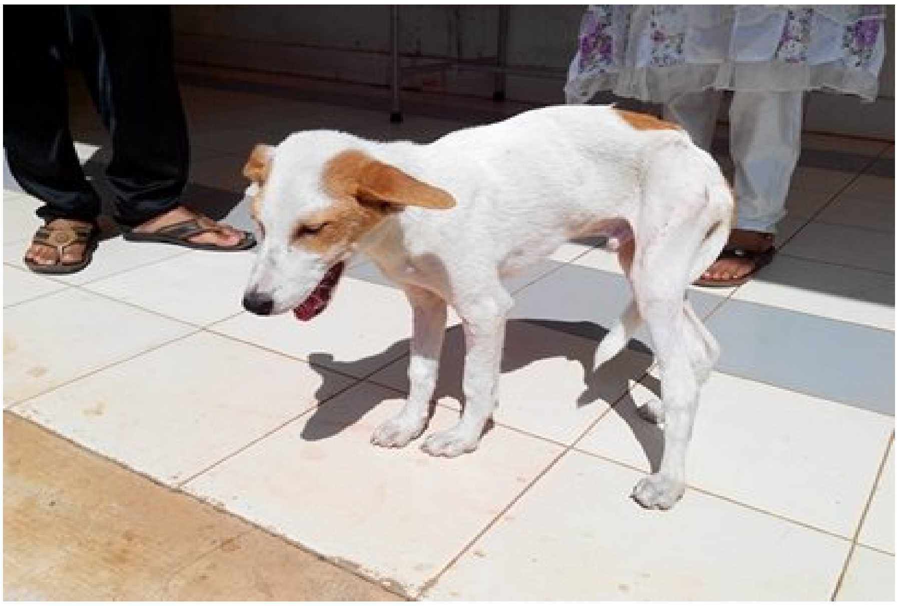

Fig 20. Photograph showing weight-bearing on 10th post-operative day, Case no. 3, group-I

Fig 21. Photograph showing weight-bearing on 15th post-operative day, Case no. 11 group-II

4.8.3 Radiographic Evaluation

Orthogonal radiographs of the repaired bone were taken at regular intervals viz., immediately, 15^{th}, 30^{th} and 60^{th} post-operative days to assess the progress of fracture healing, to determine the type of fracture healing and to check the position of implants.

4.8.3.1 Group-I: Intramedullary pinning

Immediate post-operative radiographs revealed adequate apposition and alignment of the fractured fragments with good cortical contact between the fractured fragments in all the cases. The implants were stable in all the cases. Cerclage wires applied in case no. 1,3,5,6 and 7 were stable (Fig.22, 23, 24, 25 and 26).

Mild to severe periosteal reaction with contact between both the cortices and stable implants showing signs of fracture healing was observed on 15^{th} post-operative day in group-I. In case no. 3 extensive periosteal reaction was observed extending over a greater length of shaft (Fig. 27). Mild periosteal reaction was noticed in cases 1, 4 and 5. In case no. 4 a wedge fragment developed in the proximal fragment near the fracture site due to jumping on 12^{th} post-operative day, which was not present at the time of surgery, but it did not affect the stability of fracture reduction (Fig. 28). In case no. 5, the fracture site collapsed resembling over reduction, due to weight bearing as the owner let the dog out for walking. The reduction was stable (Fig. 29). In case no. 6, 7 and 8 periosteal reaction noticed with stable reduction and implants (Fig. 30, 31 and 32). Cerclage wires applied were stable.

On 30^{th} post-operative day, evident callus was noticed at the fracture site with healing fracture line (Fig. 33). In case no. 1, a little gap was noticed at fracture line

Fig 22: Skiagram showing immediate post-operative reduction - Case no. 1,group –I

Fig 23: Skiagram showing immediate post-operative reduction - Case no.3, group -I

Fig 24: Skiagram showing immediate post-operative reduction - Case no. 5, group –I

Fig 25:Skiagram showing immediate post-operative reduction – Case no.6,group –I

Fig 26: Skiagram showing immediate post-operative reduction - Case no.7 group 1

Fig 27: Skiagram showing extensive periosteal reaction on 15th post-operative the day in case no. 3, group –I

Fig 28: Skiagram showing wedge fragment developed in proximal fragment near fracture site due to jumping on 12th post - operative day in Case no. 4, group –I

Fig 29: Skiagram showing collapse of fracture site on 15th post-operative day Case no. 5, group – I

Fig 30: Skiagram showing periosteal reaction with stable reduction in on 15th post-operative day in Case no. 6, group –I

Fig 31: Skiagram showing periosteal reaction at fracture site on 15th post - operative day in Case no. 7, group –I

Fig 32: Skiagram showing periosteal reaction with stable reduction on 15th post-operative day in Case no. 8, group – I

Fig 33: Skiagram showing callus at the fracture site on 30th post-operative day in Case no. 3, group -I

Fig. 34: Skiagram showing little gap at fracture line suggestive of future delayed union on 30th post-operative day in Case no. 1, group -I

Fig 35: Skiagram showing minimal callus formation with completely separated wedge fragment on 30th post-operative day in Case no. 4, group -I

Fig 36: Skiagram showing big bridging periosteal callus over the shaft with filling up of fracture gap on 30th post-operative day in Case no. 5, group -I

suggestive of future delayed union (Fig. 34). In case no. 4, healing of fracture line was noticed with minimal callus formation with completely separated wedge fragment. It did not affect the stability of the fracture reduction (Fig. 35). In case no. 5, a big bridging periosteal callus was observed over the shaft with filling up of fracture gap (Fig. 36). Cerclage wires applied were stable.

On 60th post-operative day, remodelling of the callus with cortical and medullary continuity of the fracture site was noticed suggestive of complete healing of fracture site (Fig. 37, 38, 39 and 40). In case no. 1, a little gap was noticed at fracture site suggestive of delayed union (Fig. 41). Cerclage wires applied were stable.

4.8.3.2 Group-II: Stack pinning

Immediate post- operative radiographs revealed adequate apposition and alignment of the fractured fragments with adequate cortical contact between the fractured ends (Fig. 42, 43 and 44). In case no.10, a little gap at the fracture site was noticed due to comminution (Fig. 45).

On 15th post-operative day, mild to moderate periosteal reaction was observed at the fracture site in all the cases suggestive of healing (Fig. 46 and 47). Implants were stable in all the cases except case no. 13 and 14 . In case no. 13 there was distal migration of one pin, which was removed. In case no. 14 proximal migration of both the pins with refracture due to violent jumping of the dog on 10th post-operative day was observed (Fig. 48).

On 30th post-operative day, radiographs revealed stable implants with intact fracture fragments and hard callus over the fracture site filling the fracture line, except case no's 13 and 14 (Fig. 49)

On 60th Post-operative day, radiographs revealed stable implants. Cortical and medullary continuity at the fracture site with remodelling of the hard callus suggestive of complete fracture healing was observed (Fig. 50 and 51).

Fig 37: Skiagram showing remodelling of the callus with cortical and medullary continuity of the fracture site on 60^{th} post-operative day in Case no. 4, group -I

Fig 38: Skiagram showing remodelling of the callus with cortical and medullary continuity of the fracture site on 60^{th} post-operative day in Case no. 5, group -I

Fig 39: Skiagram showing remodelling of the callus with cortical and medullary continuity of the fracture site on 60^{th} post-operative day in Case no. 6, group -I

Fig 40: Skiagram showing remodelling of the callus with cortical and medullary continuity of the fracture site on 60^{th} post-operative day in Case no. 8, group -I

Fig 41: Skiagram showing little gap at fracture site suggestive of delayed union on 60th post-operative day in Case no. 1, group -I

Fig 42: Skiagram showing immediate post-operative reduction - Case no. 11, group II

Fig 43: Skiagram showing immediate operative reduction - Case no. 12, group II

Fig 44: Skiagram showing immediate post-operative reduction Case no. 13, group II

Fig 45: Skiagram showing immediate post-operative reduction with little gap-Case no. 10, group -II

Fig 46: Skiagram showing moderate periosteal reaction at the fracture site on 15th post-operative day in Case no. 10,group II

Fig 47: Skiagram showing moderate periosteal reaction at the fracture site on 15th post-operative day in Case no. 12, group –II

Fig 48: Skiagram showing proximal migration of both the pins with refracture on 15th post-operative day in Case no. 14, group -II

Fig 49: Skiagram showing hard callus over the fracture site filling the fracture on 30th post-operative day in Case no. 10, group -II

Fig 50: Skiagram showing cortical and medullary continuity at the fracture site with remodelling of the hard callus on 60th post-operative day in Case no. 10, group – II

Fig 51: Skiagram showing cortical and medullary continuity at the fracture site with remodelling of the hard callus on 60th post-operative day in Case no. 12, group –II

4.8.4 Functional limb outcome

At 60th post-operative day, all the animals were evaluated for functional limb outcome and grouped as excellent 7 (50%), good 4 (28.57 %), fair 2 (14.28 %) and poor 1 (7.14 %) (Table 11).

In group I out of 8 fractures treated 2 (25 %) were excellent, 4 (50 %) were good and 1 (12.5 %) was fair. Out of the 6 dogs treated 3 (50 %) were excellent, 2 (33.33 %) were good and 1 (16.66 %) was poor in group II

Table 11. Functional limb outcome

Group	No. of fractures treated	Excellent	Good	Fair	Poor
I	8	4	3	1	_
II	6	3	1	1	1
Total	14	7	4	2	1

4.8.5 Complications

4.8.5.1 Intra-operative complications

Difficulty was encountered in reduction of the fracture in case no. 5 of group I, due to separation of very large bone fragment with extensive soft tissue injury

Reduction was difficult in case no. 10 of group II due to comminution and un reducible fragments were removed during surgery.

4.8.5.2 Post-operative complications

Seroma was developed at the point of pin projection from the trochanteric fossa in case no. 5, 6 and 8 of group I and case no. 11, 12 and 13 of group II (Fig. 52 and 53)

Proximal pin migration was noticed in case no. 4 of group I. The pin was tapped in to the distal fragment and the wound was re-sutured.

In case no. 13 of group II, one pin migrated distally and came out from near stifle joint. The pin was removed and the stable 2nd pin was retained to maintain fracture stability on 15th Post-operative day. In case no. 14 of group II two pins were migrated proximally and there was refracture resulting in comminution due to jumping from height. The migrated pins were removed and the case was managed conservatively with modified Robert Jones' bandage.

4.9 IMPLANT REMOVAL

The Steinmann pins were removed on or after 60th post operative day except in case no.5 of group-I and case no. 10 and 11 of group-II. Pin removal was done under 2% lignocaine hydrochloride infiltration which was found to be satisfactory. After aseptic preparation of site and 2% lignocaine HCl infiltration, a nick was given over point of pin projection. Subcutis was incised directly under the skin. The pin was held with a needle holder and removed. Povidone iodine 0.5ml was injected into the wound and skin incision closed with single cross mattress suture using black braided silk. Antibiotic was administered for three days. In case no. 5 of group-I and 10 and 11 of group-II the pins were removed on 90th post operative day due to complexity of the fractures (Fig. 54 and 55).

Fig 52: Photograph showing seroma at the point of pin projection from the trochanteric fossa in Case no. 5, group -I

Fig 53: Photograph showing seroma at the point of pin projection from the trochanteric fossa in Case no. 12, group -II

Fig. 54 Skiagram showing healed fracture after pin removal - Case no. 5, group I

Fig. 55 Skiagram showing healed fracture after pin removal - Case no. 10, group I I

4.10 SERUM BIOCHEMISTRY

The mean ± SE values of biochemical parameters were tabulated in Table no. 12.

Table 12. Mean ± SE values of serum biochemical parameters in group I and group II

Day	Calcium (mg/dl)		Phosphorous (mg/dl)		Alkaline phosphatase (I U)	
	Group-I	Group-II	Group-I	Group-II	Group-I	Group-II
0	8.61 ± 0.62	9.34 ± 1.47	4.18 ± 0.39	5.77 ± 0.63	89.46 ± 12.01^{1}	92.78 ± 3.04^{1}
15	8.96 ± 0.54	9.82 ± 1.25	4.35 ± 0.38	5.85 ± 0.68	107.30 ± 9.521^{12}	108.73 ± 3.32^{12}
30	8.94 ± 0.46	9.75 ± 1.25	4.36 ± 0.42	5.83 ± 0.66	100.99 ± 9.28^{1}	102.85 ± 2.50^{1}
60	9.25 ± 0.57	10.07 ± 1.26	4.19 ± 0.39	5.72 ± 0.65	87.48 ± 11.47^{1}	91.63 ± 3.05^{1}

Means with different superscripts (numerical) between days in a group differ significantly ($P<0.01$)

4.10.1 Serum calcium

There was no significant difference between the groups at different time periods but elevation of the serum calcium levels within the groups from 0 post-operative day up to 60th post-operative day. However, statistically no significant difference was observed between the groups and time periods.

4.10.2 Serum phosphorus

Statistical analysis revealed no significant difference between the groups and time periods. However, elevation of serum phosphorus levels was observed from 0th post-operative day and returned to normal base value by 60th post-operative day

4.10.3 Serum alkaline phosphatase

The serum alkaline phosphatase level was higher in group II compared to group I without any statistical significance.

With in groups, elevation in the serum alkaline phosphatase levels was observed up to 15^{th} post-operative day and reached a peak on 15^{th} post-operative day with a gradual return to normal base value on 60^{th} post-operative day with statistically significant difference between day 0^{th} and 15^{th} post-operative days whereas no significant difference was observed between day 15 and 30 and 60 ($P < 0.01$).

CHAPTER V

5. DISCUSSION

In the present study, out of 338 total number of fracture cases recorded, 230 (68.63%) were long bone fractures. Among the long bone fractures highest incidence was observed in femur (33.92%) followed by radius and ulna (30.86%), tibia and fibula (28.69%) and least in the humerus (6.52%). Singh *et. al.* (1983), Thilagar and Balasubramanian (1988), Hansda *et. al*. (2012), Tambe *et. al*. (2012), Kushwaha *et. al*. (2012) and Hari Krishna *et. al.* (2013) also reported higher incidence of femur fracture among long bone fractures. The highest incidence of fracture in femur might be due to exposure of hind quarters to the major force of impact. This was in accordance in Harasen (2003).

In the present study, all the femur fractures recorded were closed. This might be due to heavy musculature covering the femur bone. Similar findings were recorded by Beale (2004). Among 78 femur fractures recorded, 41 (52.50%) were diaphyseal, 26 (33.33%) were distal femur and 11 (4.10%) were proximal femur fractures. Similar findings were observed by Kumar *et. al.* (2007), Tercanlioglu and Sarierler (2009), who reported that the most common site of fracture was shaft of the femur (73.21%).

Braden *et. al*. (1995) also found that 28% of long bone fractures occurred in femoral diaphysis. Hansda *et. al.* (2012) reported that 50% of femur fractures were midshaft followed by distal third (33.33%), proximal third (11.11%) and supracondylar (5.55%).

Out of the 78 femur fractures recorded, the incidence was highest in Pomeranian (35.89%) followed by Non-Descript (34.62%), Labrador Retriever (20.51%), German Shepherd Dog (3.85%), Daschund (2.56%), Cocker Spaniel and Kanni (1.28% each). Similar findings were observed by Hari Krishna (2013), with highest incidence in medium sized breeds. Aithal *et. al.* (1999), Hansda *et. al.* (2012) and Jani *et. al.* (2014) recorded highest incidence in Non-descript dogs. On the contrary Ali (2013) and Bishnoi *et. al.* (2013) observed more incidences in German Shepherd Dog.

In the present study, highest incidence was observed in young dogs aged below 1 year (56.41%) followed by 1 to 6 years age group (33.33%) and above 6 years age group (10.25%). Similar findings were reported by Kolata *et. al.* (1974), Hansda *et. al.* (2012), Bishnoi *et. al.* (2013) and Jani *et. al.* (2014). Tercanlioglu and Sarierler (2009) and Singh and Saha (2012) opined that occurrence of metaphyseal and diaphyseal fractures were common in mature dogs.

Among the 78 femur fractures recorded 43 were in males (55.12%) and 35 were in females (44.87%) which was in accordance with Hansda *et. al.* (2012) and Bishnoi *et. al.* (2013) whereas Jani *et. al.* (2014) observed significantly higher incidence of fractures in males (75.83%). The higher incidence of fractures in males might be due to their wandering habit which were ‘entire’ males, was in accordance with Ali (2013).

Out of 14 cases of femur fractures included in the present study, the main etiological factor was automobile accident (57.14%) followed by fall from height (28.57%) and unknown etiology (14.29%). Fossum (1997) and Aithal *et. al.* (1999) also recorded higher incidence of fracture due to automobile accident. On the contrary Hari Krishna (2013) found fall from height was the major etiological factor for fracture incidence.

Detailed clinical and orthopaedic examination of dogs presented for treatment helped in knowing the health status of the animal and probable location and type of fracture.

Clinical signs like non-weight bearing, soft tissue swelling, tenderness, pain, and crepitus and abnormal mobility were noticed as observed by Piermattei and Flo (1997), Mohindroo *et. al.* (2006), Sharma *et. al.* (2011), Singh and Saha (2012), Tiwari *et. al.* (2012) and Shrestha and Thapa (2013). In one case bruising due to extensive soft tissue injury (Gazi and Makhdoomi, 2012) was noticed. Range of stifle joint motion was normal in all the cases except Case no. 5, which had a reduced range of stifle joint motion due to extensive soft tissue injury.

Lateral and cranio-caudal radiographs proved useful in confirmatory diagnosis, identifying the location, classification of fracture and selection of appropriate pins (Langley-Hobbs, 2003 and Shales, 2008a).

Fractures were classified based on AO/ASIF classification and Winquist-Hansen (W-H) classification (Miller *et. al.,* 1998). Out of 14 femur fractures studied, ten were transverse or short oblique over-riding fractures and designated as 3 2 A 1, one was oblique over-riding and designated as 3 2 A 2, one was oblique, over-riding, comminuted with large bone fragment and designated as 3 2 C 2, one was transverse over-riding comminuted and designated as 3 2 B 2 and one was over-riding and severely comminuted and designated as 3 2 C 3. According to Winquist-Hansen classification, 9 were simple 2 piece fractures (grade '0'), 2 were grade II with one small unimportant chip, one was grade III and one was grade IV with comminution and one was segmental with grade V.

Rani *et. al.* (2007) classified femur fractures as oblique (88.88%) and transverse (22.22%) in dogs. They also noticed higher incidence of right femur fractures (55.56%) than left femur (44.44%). The fractures were simple (78.57%) or multiple (27.43%) in the present study. Out of the 14 fractures studied, oblique fractures were more common (42.85%) followed by transverse (28.17%), comminuted or multiple (21.43%) and spiral (7.14%). The left hind limb was affected more (64.28%) than the right limb (35.72%) which was in accordance with Rani *et. al.* (2007).

Pre-operative lateral and cranio-caudal radiographic views of the fractured femur and contralateral femur served as a template in selection of the Steinmann pin. The IM pin s were selected in such a way that they fill only 70-80% of medullary canal at isthmus of the diaphysis (McLaughlin, 1999). The classification helped in pre-operative planning and surgical approach. No major deviations were noticed in the selected IM pin s during surgery in all the cases.

Premedication with atropine-acepromazine-butorphanol @ 0.04 mg, 0.03mg and 0.1 mg/kg b.wt, taken in a syringe and administered i.m. 30 minutes prior to induction provided satisfactory sedation as observed by Roon *et. al.* (2007), Ranpariya *et. al.* (2013) and Nithin (2016). Induction of anaesthesia with ketamine and diazepam @ 5mg/kg b.wt. and 0.3 mg/kg b.wt. respectively i.v. was satisfactory and facilitated easy intubation, followed by 1.5 – 2.5 % isoflurane with oxygen provided satisfactory surgical plane of anaesthesia throughout the orthopaedic procedure which was in concurrence with Ranpariya *et. al.* (2013) and Nithin (2016). Earlier workers Hellyer *et. al.* (1991) and Ranpariya *et. al.* (2013) reported that ketamine-midazolam combination provided satisfactory anaesthesia for orthopaedic procedures. Ranpariya *et. al.* (2013) opined that isoflurane anaesthesia provided stable maintenance for orthopaedic procedures as observed in the present study.

Cranio-lateral approach (Rani *et. al*., 2012) was used to expose the fractured femur shaft. The procedure as described by Johnson (2014) to approach femur shaft was satisfactory and provided good exposure of fractured fragments and facilitated proper alignment and reduction of the fracture. Similar approach for successful internal fixation of femur fractures using IM pin was reported by Mohindroo *et. al.* (2006), Das *et. al.* (2012) and Singh and Saha (2012)

Lateral and craniocaudal pre-operative radiographs taken in the present study were appropriate and helped in selection of implants and operative plan. Successful femoral shaft fracture healing outcome depends on a comprehensive preoperative assessment and knowledge of the surgical anatomy (Slatter, 2003).

Femur shaft fractures can be stabilised with a variety of techniques viz., IM pin and wire, plate-rod construct, interlocking nail, external skeletal fixation and plating. Femur fractures were generally not amicable to conservative treatment and some kind of internal fixation required (Beale, 2004). Vertenten *et. al.* (2010) opined that in fracture repair, proper reduction and immobilisation were essential to achieve optimal bone healing which could be accomplished through the use of specific reduction technique and adequate blood supply would allow the bone to counteract possible infection and to receive the needed circulating factors and nutrients.

Intramedullary pinning was a simple and most economic method of immobilisation of diaphyseal femur fractures (Kumar and Gahlot, 2013). IM pins were best when used in combination with other implants like cerclage wire, lag screw or external fixator for adequate stabilisation of fracture (Newton and Nunamaker, 1985). In present study, Steinmann or IM pins and cerclage wire provided effective stabilisation of femoral shaft fractures which was in accordance with Beale (2004). IM pin s when used for fracture stabilisation, were good at resisting bending forces in all the directions due to their position close to neutral axis of the bone while they could not neutralise tension, torsional and compression forces (Shales, 2008b) and had poor rotational stability due to smooth surface of the IM pin . Similar findings were reported by Whitehair and Vasseur (1992).

Intramedullary pinning was most commonly used system of internal fixation for femoral shaft fractures in dogs. IM pin acts as internal splint due to its placement in medullary canal close to neutral axis of the bone and it shares loading with bones, maintains axial alignment of stabilised fracture and resists bending forces in all the directions. IM pins provided poor rotational stability and could not neutralise tension and compression forces.

In the present study, in group-I, transverse, oblique, spiral or segmental fractures were stabilised with Steinmann pins size ranging from 2.5 mm to 5.0 mm with or without the use of full cerclage wires as per need. Transverse and short oblique fractures (Case no. 2, 4 and 8) were stabilised with IM pin alone. Whereas oblique (Case no. 1, 6 and 7), spiral (Case no. 3) and segmental fractures (Case no. 5) were stabilised by IM pin and full cerclage wires. Single Steinmann pin used in group-I provided adequate reduction and stability of the fracture with good cortical contact between the fracture fragments. Cerclage wires were applied in a group of 2 as minimum and ranged up to 5. This technique provided good stability and axial alignment of the fracture which was in accordance with Beale (2004). Intramedullary pinning can be performed in normograde or retrograde technique (Stiffler, 2004). Retrograde technique followed in the present study was found to be satisfactory and did not produce any complications like sciatic neuropraxia. The technique was found to be most economic and easy to perform. It was also observed that the technique was least traumatic to the bone (Stiffler, 2004) and also surrounding soft tissue. Similar findings were recorded by Rani *et al*. (2007) and Kumar and Gahlot (2013). It did not interfere with periosteal callus due its intramedullary placement. Minimally traumatic nature of the technique resulted in better healing and early return to weight bearing as observed by Mohindroo *et. al*. (2006). A minimum of two full cerclage wires of appropriate size were applied (Shales, 2008b) in cases of oblique, spiral or segmental fractures increased the stability of reduction by providing interfragmentary compression, as observed by McLaughlin (1999). Singh and Saha (2012) also treated a case of comminuted diaphyseal femur fracture in a dog using retrograde intramedullary pinning and cerclage wire following biological osteosynthesis principles as was done in the present study. Whereas Gazi and Makhdoomi (2012) treated a case of old comminuted fracture by intramedullary pinning in a dog, by passing the pin in normograde manner through the distal articulor surface in a dog. Das *et. al*. (2012) treated a bilateral femur and tibia fractures by intramedullary pinning with success. Cerclage wires used in the present study added to the axial and rotational stability of the reduction which was in concurrence with Beale (2004).

Newton and Nunamaker (1985) opined that use of hemi cerclage or full cerclage wires alone without an intramedullary device was contraindicated and results in fixation failure. To increase the stability of the reduction against rotational, compression or shear forces, the IM pin was engaged in both proximal and distal cortices without penetrating the joint as reported by Stiffler (2004). The average time taken for surgery in group-I was 51 minutes (range 39 to 99 minutes).

In group II, two Steinmann pins of appropriate size were used for "stack pinning" to fill 70-80% of the marrow cavity to stabilize the fracture. In group II, out of the six fractures studied, two transverse fractures (Case no. 9 and 13) and two short oblique fractures (Case no. 12 and 14) were stabilised by two IM pins alone whereas two comminuted fractures (Case no. 10 and 11) were stabilised with two IM pins each and cerclage wires (4 and 3 cerclage wires respectively).

Two Steinmann pins used in group II provided good reduction and stability of the fracture with good contact between the fracture fragments. Retrograde method followed was found to be satisfactory (Das *et. al.* 2012). Similar findings were reported by Rani *et. al.* (2007) and they opined that double intramedullary pining with cerclage wiring was an excellent technique for femoral diaphyseal oblique fractures in dogs and they provided alignment by their tight fit. Stack pinning involves the use of several pins rather than one pin to fill the cavity. As a general rule stack pinning was necessary only for humerus or femur (Piermattei *et. al.*, 2006). The reducible wedge fragments (Case no. 10 and 11) were reduced by cerclage wires which provided additional stability to the reduction by interfragmentary compression in comminuted fractures. Similar procedure was adapted by Singh and Saha (2012). Two Steinmann pins used in group II did not provide any additional rotational stability in the present study as observed by Dallman *et.al.* (1990) and Gibson (1991). Whereas Whitehair and Vasseur (1992) opined that the placement of a single large IM pin in an attempt to "fill the medullary canal" was an ineffective method for preventing rotation in transverse fractures because of limited IM pin-bone contact and smooth surface of the Steinmann pin. Stack pinning was a useful technique to improve torsional stability. In one in-vivo study, multiple IM pins provided approximately twice the rotational stability as that of a single IM pin (Lewis *et. al.,* 2009).

In Case no. 9, tension band wiring using single K-wire was performed as an ancillary fixation method to stabilise trochanteric major fracture. The average time taken for surgery in group II was 60.5 minutes (range 52 to 75 minutes).

Post-operatively all the dogs in two groups were given Tab. Cephalexin @ 22 mg/kg b.wt. b.i.d for one week and Syp. Meloxicam @ 0.2 mg/kg b.wt. s.i.d for 4 days orally. Modified Robert Jones bandage applied to the repaired limb provided good adjunct support to the internal fixation and helped in further stabilisation of the reduction. This was in accordance with the findings of Mohindroo *et. al.* (2006). Elizabethan collar was applied till suture removal as advocated by Whitehair and Vasseur (1992). Wound dressing was done 3^{rd} post-operative day and 10^{th} post-operative day using povidone iodine. The wounds healed without any complications in all the cases. Skin sutures were removed on 10^{th} post-operative day.

All the animals in two groups except case no 14 in group-II showed early return to weight bearing and normal gait by 30^{th} post-operative day. This might be due to less traumatic nature of the technique and less soft tissue manipulation together with least interference with periosteal callus. In group-I, case no. 5 had gait abnormality on 30^{th} post-operative day (lameness grade 2) might be due to extensive soft tissue injury and segmental nature of the fracture. In group- II case no's. 9, 10, 11 and 13 had occasional gait abnormality on 30th post-operative day whereas case no. 14 had occasional non-weight bearing together with gait abnormality. This might be due to refracture on 10th post-operative day caused by jumping and subsequently, both the IM pins were removed on 15th post-operative day. On 60th post-operative day all the animals in both the groups had no lameness with normal weight bearing pattern and gait except case no. 14 which had gait abnormality. Mohindroo *et. al.* (2006) reported similar findings with IM pinning and cerclage wires in bilateral femur repair fracture in a dog and attributed the early weight bearing (within one month after surgery) to good fracture stability provided by the technique. Similar findings were recorded by Hansda *et. al*. (2012) who observed complete weight bearing on 25.66 ± 0.33 days following femur fracture stabilisation using IM pinning.

Tiwari *et. al*. (2012) observed mild weight bearing one to two weeks post-operatively after femur fracture repair using intramedullary pinning in a dog. On the contrary Kumar and Gahlot (2013) observed partial weight bearing on 25th post-operative day fallowing femur fracture stabilisation using IM pinning.

Lateral and cranio-caudal radiographic views were taken on 0, 15th, 30th and 60th post-operative days for evaluation of fracture reduction, healing pattern and to assess the progress of fracture healing in all the cases of two groups.

Lateral and cranio-caudal radiographic views taken were found to be satisfactory in the present study which was in concurrence with Langley-Hobbs (2003) and Shales (2008b).

In group I, immediate post-operative radiographs revealed adequate apposition and alignment of the fractured fragments with good cortical contact between the fractured fragments in the cases. The implants were stable in all the cases. On 15th

post-operative day, the implants were stable with contact between the cortices. Mild to severe periosteal reaction was observed at fracture site extending over the shaft indicative of ongoing healing process. Hansda *et. al.* (2012) observed callus formation by day 20 after femur fracture repair. In case no.4 a wedge fragment from proximal segment was separated this was not presented at time of surgery. This might be due to weight bearing by the dog. However, this did not affect the stability of the reduction. In case no. 5 fracture site collapsed, due to weight bearing, as owner let the dog out for walking. On 30th post-operative day evident callus was noticed at the fracture site with healing fracture line bridging periosteal callus was noticed. Chawla *et. al*. (1983) also noticed more periosteal reaction with simple cooptation and IM pinning than with plating. On 60th post-operative day, denser callus with cortical and medullary continuity at the fracture site with complete bony union was noticed suggestive of complete healing of fracture site. Remodelling of the callus occurred. The presence of denser callus indicates mineralisation. In case no.1 a little gap was noticed at fracture site suggestive of delayed union with stable reduction. On the contrary, Hansda *et. al*. (2012) noticed complete healing of fracture site with remodelling by 40th post-operative day itself. Tiwari *et. al*. (2012) observed bony union on a radiograph at 5 to 7 weeks post-operatively after femur fracture stabilisation using intramedullary pinning. The presence of callus indicates secondary healing as observed by Awad *et. al*. (2013) and Hari Krishna *et. al*. (2013) in femur fracture healing in dogs. However, in case no.1 and 4 the callus was small or minimal like primary healing.

In group II, immediate post-operative radiographs revealed adequate apposition and alignment of the fractured fragments with good cortical contact between fractured ends. In case no.10, a gap was noticed at fracture site as few un reducible chips were removed due to comminution. On the 15th post-operative day, the implants were stable in all the cases except case no.13 and 14. In case no .13 there was distal migration of one pin, which was removed. In case no. 14 proximal migration of both the pins with refracture was observed. The migration of pins in both the cases was due to jumping of the dogs. Similar findings were observed by Kumar and Gahlot (2013). Periosteal reaction was evident with development of bridging periosteal callus in all the cases. On 30th post-operative day, radiographs revealed stable implants with intact fracture fragments. Hard and denser callus over the fracture site filling the fracture line was noticed except case no's. 13 and 14. Nagaraja *et. al*. (1997) during radiography noticed bridging periosteal callus extending 1 cm above and below the fracture line on 4th post-operative week as observed in the present study. On 60th post-operative day, radiographs revealed stable implants, cortical and medullary continuity at the fracture site was observed. Small dense callus with remodelling was present. All these changes were suggestive of complete healing. Secondary bone healing was observed in group-II. Whereas Dubey *et. al*. (1993) found complete bony union by 9th to 12th post-operative week. Goodship and Kenwright (1985) opined that weight bearing can lead to micro-motion at the fracture site, which acts as mechanical stimulus to secondary bone healing as observed in the present study. Fragments separated by a gap more than 1 m.m or with inter fragmentary strain greater than 2 % will undergo secondary bone healing (Shales 2008a). New bone development at fracture site was structurally different from that of original bone (Remedios, 1999). Careful preservation of natural biology of the fracture site can leads to rigid healing (Gemmill, 2007) as observed in the present study due to less traumatic nature of the technique.

The duration of fracture healing may vary from 4 to 16 weeks, depending on the age of the patient, type of fracture, method of repair, surgical approach used, compliance of the owner and compliance of the patient (Beale, 2004). Haaland *et. al*. (2009) opined that the mean healing time of fractures was seven weeks (95% confidence interval) (range 5.8 to8.3 weeks) the as observed in present study. Braden *et. al*. (1995) opined that IM pins were satisfactory in small dogs and cats, but plates were better in medium and large dogs. On the contrary, in present study, femur fractures were satisfactorily managed with IM pinning even in large dogs.

In the present study, at 60th post-operative day, all the animals were evaluated for functional limb outcome and grouped as excellent 7 (50%), good 4 (28.57 %), fair 2 (14.28 %) and poor 1 (7.14 %). In group I, out of 8 fractures treated 2 (25 %) were excellent, 4 (50 %) were good and 1 (12.5 %) was fair. Out of the 6 dogs treated 3 (50 %) were excellent, 2 (33.33 %) were good and 1 (16.66 %) was poor in group II. By 60th post-operative day, all the animals regained normal full functional limb except case no,14 which had refracture on 10th post-operative day. Whereas Braden *et. al.* (1973) found it be 9.3 weeks and concluded that IM pins with or without ½ Kirschners caused decreased function of the limb, which was not observed in the present study.

The implants were removed on 60th post-operative day after evaluation of radiographic union of the fractures in all the cases of group-I and II except in case no. 5 of group-I and case no. 10 of group-II. The pins were removed under 2 % lignocaine HCl local infiltration by making a nick over the projection of the pin near trochantric fossa was found to satisfactory in all the cases. It did not produce any complications. On the contrary Shrestha and Thapa (2013) removed the IM pins by 45th post-operative day. Singh and Saha (2012) advocated the pin removal after taking radiograph and clinical evidence of improvements as followed in the study. Whereas Shiju *et. al*. (2010b) removed the pin on 6th post-operative week after femur fracture stabilisation using plate and rod technique. In case no.5 of group-I and case no. 10 of group-II, the pins were removed on 90th post-operative day due to complexity of the fracture.

No intra-operative complications were encountered in the present study except for difficult reduction in case no.5 of group-I and case no. 10 of group-II, due to complexity of the fractures (segmental and comminuted respectively). The instability caused after intramedullary pinning can lead to non-union and predisposes to osteomyelitis (Hunt *et. al.,* 1980 and Smith, 1998). However, no such complications were recorded in the present study. The complications associated with IM pins were secondary to instability or inappropriate placement (Stiffler, 2004) was not observed in the present study due to appropriate technique and placement of IM pin.

Seroma developed at the point of pin projection in case no's. 5, 6 and 8 of group I and case no's. 11, 12 and 13 of group II, which was aspirated. This might be due to irritation caused by the pin. Similar findings were reported by Rani *et. al.* (2012). Proximal pin migration was observed in case no. 4 of group I and case no. 14 of group II which was in accordance with Kumar and Gahlot (2013), who reported proximal pin migration, seroma near cut end of pin and limb shortening due to rotational deformity. However, limb shortening was not observed in the present study. Distal migration of one pin was observed in case no.13, group-II on 10th post-operative day, which was removed subsequently. Quadriceps contracture might develop as a result of improper bandage application or technique of femoral fracture repair (Ulusan, 2011). Ayyappan (2012) stated that improper pinning technique leads to damage to sciatic nerve and subsequent neuropathy which was not encountered in the present study might be due to good technique employed.

Ayyappan (2012) opined that intramedullary pinning had no axial and rotational stability leading to fracture collapse, pin loosening and proximal pin migration.

In the present study blood was collected and serum separated on 0, 15th, 30th, and 60th post-operative days for estimation of serum calcium, Phosphorus and alkaline phosphatase in all the cases of two groups.

There was no significant difference between the groups at different time periods. Elevation of the serum calcium levels within the groups from 0 post-operative day up to 60th post-operative day was observed. However, statistically no significant difference was observed between the groups and time periods. Which was in concurrence with Rani *et. al*. (2012). They observed reduction in serum calcium on 3rd post-operative day fallowed elevation up to 60th post-operative day. They opined that initial decline might be due to increased urinary excavation of the after traumatic bone injury. The increase in the serum calcium up to 60th post-operative day might be due to fracture healing process. On the contrary Bush, (1991) and Nagaraja *et. al*. (2003) observed elevation of serum calcium up to 15th post-operative day with a gradual decline to near base value on 60th post-operative day. They attributed the same to ongoing rapid calcification of fracture site.

No statistically significant difference was observed between the groups and time periods with regard to serum phosphorus. However, within the group elevation of serum phosphorus was observed from 0th post-operative day, reached peak on 30th post-operative day and returned to near base value by 60th post-operative day. Similar findings were observed by Siemens (1970). Whereas Nagaraja *et. al*. (2003) found an increase in the serum phosphorus levels up to 15^{th} post-operative day, which rapidly declined thereafter. The increase in the serum calcium could be due to mineralisation process and that of phosphorus could be due to necrotic disintegration of cells at the fracture site (Nagaraja *et. al.*, 2003).

The serum alkaline phosphatase level was higher in group II compared to group I without any statistical significance. With in groups, elevation in the serum alkaline phosphatase levels was observed up to 15^{th} post-operative day and reached a peak on 15^{th} post-operative day with a gradual return to normal base value on 60^{th} post-operative day with statistically significant difference between day 0^{th} and 15^{th} post-operative days whereas no significant difference was observed between day 15and 30 and 60 (P< 0.01). Which was in accordance with Maiti *et. al*. (1999). Ghosh *et. al*. (2003), Umashankar and Ranganath (2008), Hansda *et. al*. (2012) and Rani *et. al*. (2012), observed an increase in alkaline phosphatase activity up to 21^{st} post-operative day and returned to near base value on 60^{th} post-operative day.

Increase in the alkaline phosphatase activity was observed during osteoblastic activity with high increase in most of compression methods of internal fixation (Guyton, 1981). The increase in alkaline phosphatase activity might be attributed to increased chondroblastic proliferation to cause bone formation during fracture repair and formation of bone matrix (Maiti *et. al*., 1999 and Rani *et. al*., 2012). Komnenou *et. al.* (2005) explained that the detection of specific biochemical markers of bone formation in serum, such as alkaline phosphatase (ALP) activity can be clinically useful in evaluating the progress of the healing process and serves as an additional tool in predicting fractures at risk of developing a non-union.

To conclude, intramedullary pinning was an easy, most economic, less time consuming and least traumatic technique for the stabilisation of femur fracture in dogs with good outcome. Among two groups, theoretically stack pinning had an advantage of increased torsional and rotational stability. However, in practice no such advantage was observed. Though the technique of IM pinning had disadvantages poor shear, tension, rotational stability and pin migration, with adaptation of good technique and proper post-operative care it yielded good results in the present study. The seroma formation, which is common in this technique, did not interfere with healing or outcome. The technique resulted in early weight bearing and good functional limb out come. The technique was highly recommended for long bone fracture stabilisation in dogs under field conditions. However, further biomechanical studies need to be conducted for evaluating the theoretical advantage of stack pinning.

CHAPTER VI

6. SUMMARY

The present study entitled "Femur shaft fracture stabilisation using intramedullary pinning and stack pinning in dogs" was carried out with an aim to compare the techniques for femur shaft fracture repair in dogs. The following points were summarised:

1. In the present study, out of 338 total number of fracture cases recorded, 230 (68.63%) were long bone fractures. Among the long bone fractures highest incidence was observed in femur (33.92%) followed by radius and ulna (30.86%), tibia and fibula (28.69%) and least in the humerus (6.52%).

2. Among 78 femur fractures recorded, 41 (52.50%) were diaphyseal, 26 (33.33%) were distal femur and 11 (4.10%) were proximal femur fractures.

3. Out of the 78 femur fractures recorded, the incidence was highest in Pomeranian (35.89%) followed by Non-Descript (34.62%), Labrador Retriever (20.51%), German Shepherd Dog (3.85%), Daschund (2.56%), Cocker Spaniel and Kanni (1.28% each).

4. In the present study, highest incidence was observed in young dogs aged below 1 year (56.41%) followed by 1 to 6 years age group (33.33%) and above 6 years age group (10.25%). Among the 78 femur fractures recorded 43 were in males (55.12%) and 35 were in females (44.87%).

5. Out of 14 cases of femur fractures included in the present study, the main etiological factor was automobile accident (57.14%) followed by fall from height (28.57%) and unknown etiology (14.29%).

6. The cases selected were grouped randomly in to two groups of 6 each. In group I, the fracture was stabilised with single Steinmann pin and in group II two Steinmann pins were used as "stack pinning" with Cerclage wires as ancillary fixation, if needed. In either group the pins were selected to fill only 70-80 % of the medullary canal. Clinical signs like non-weight bearing, soft tissue swelling, tenderness, pain, and crepitus and abnormal mobility were noticed in all the animals of two groups.

7. Lateral and cranio-caudal radiographs proved useful in confirmatory diagnosis, identifying the location, classification of fracture and selection of appropriate pins.

8. Out of 14 femur fractures studied, ten were transverse or short oblique over-riding fractures and designated as 3 2 A 1, one was oblique over-riding and designated as 3 2 A 2, one was oblique, over-riding, comminuted with large bone fragment and designated as 3 2 C 2, one was transverse over-riding comminuted and designated as 3 2 B 2 and one was over-riding and severely comminuted and designated as 3 2 C 3 as per AO/ASIF classification. According to Winquist-Hansen classification, 9 were simple 2 piece fractures

(grade ‘0’), 2 were grade II with one small unimportant chip, one was grade III and one was grade IV with comminution and one was segmental with grade V.

9. Premedication with atropine-acepromazine-butorphanol @ 0.04 mg, 0.03mg and 0.1 mg/kg b.wt, taken in a syringe and administered i.m. 30 minutes prior to induction provided satisfactory sedation. Induction of anaesthesia with ketamine and diazepam @ 5mg/kg b.wt. and 0.3 mg/kg b.wt. respectively i.v. was satisfactory and facilitated easy intubation, followed by 1.5 – 2.5 % isoflurane with oxygen provided satisfactory surgical plane of anaesthesia throughout the orthopaedic procedure.

10. Cranio-lateral approach was used to expose the fractured femur shaft. The procedure was satisfactory and provided good exposure of fractured fragments and facilitated proper alignment and reduction of the fracture.

11. Retrograde technique followed in the present study was found to be satisfactory and did not produce any complications like sciatic neuropraxia.

12. In the present study, in group-I, transverse, oblique, spiral or segmental fractures were stabilised with Steinmann pins size ranging from 2.5 mm to 5.0 mm with or without the use of full cerclage wires as per need. Transverse and short oblique fractures (Case no. 2, 4 and 8) were stabilised with IM pin alone. Whereas oblique (Case no. 1, 6 and 7), spiral (Case no. 3) and segmental fractures (Case no. 5) were stabilised by IM pin and full cerclage wires.

13. In group II, two Steinmann pins of appropriate size were used to fill 70-80% of the marrow cavity to stabilize the fracture as “stack pinning”. In group II, out of the six fractures studied, two transverse fractures (Case no. 9 and 13)

and two short oblique fractures (Case no. 12 and 14) were stabilised by two IM pins alone whereas two comminuted fractures (Case no. 10 and 11) were stabilised with two IM pins each and cerclage wires (4 and 3 cerclage wires respectively).

14. Post-operatively all the dogs in two groups were given Tab. Cephalexin @ 22 mg/kg b.wt. b.i.d for one week and syrup Meloxicam @ 0.2 mg/kg b.wt. s.i.d for 4 days orally. Modified Robert Jones bandage applied to the repaired limb provided good adjunct support to the internal fixation and helped in further stabilisation of the reduction. Wound dressing was done 3rd post-operative day and 10th post-operative day using povidone iodine. The wounds healed without any complications in all the cases. Skin sutures were removed on 10th post-operative day.

15. All the animals in two groups except case no 14 in group-II showed early return to weight bearing and normal gait by 30th post-operative day.

16. Lateral and cranio-caudal radiographic views were taken on 0th, 15th, 30th and 60th post-operative days for evaluation of fracture reduction, healing pattern and to assess the progress of fracture healing in all the cases of two groups.

17. In group I, on 15th post-operative day, mild to severe periosteal reaction was observed at fracture site extending over the shaft indicative of ongoing healing process. On 30th post-operative day evident callus was noticed at the fracture site with healing fracture line bridging periosteal callus was noticed. On 60th post-operative day, denser callus with cortical and medullary continuity at the fracture site with complete bony union was noticed suggestive of complete

healing of fracture site. Remodelling of the callus occurred. The presence of denser callus indicates mineralisation.

18. In group II, on the 15th post-operative day, periosteal reaction was evident with development of bridging periosteal callus in all the cases. On 30th post-operative day, hard and denser callus over the fracture site filling the fracture line was noticed. On 60th post-operative day, cortical and medullary continuity at the fracture site was observed. Small dense callus with remodelling was present. All these changes were suggestive of complete healing. Secondary bone healing was observed in group-I and group-II.

19. In all the animals of both the groups the implants were stable, except case no.13 and 14 of group II. In case no. 13 there was distal migration of one pin, which was removed. In case no. 14 proximal migration of both the pins with refracture was observed.

20. In the present study, at 60th post-operative day, all the animals were evaluated for functional limb outcome and grouped as excellent, good, fair and poor. In group I, out of 8 fractures treated 2 (25 %) were excellent, 4 (50 %) were good and 1 (12.5 %) was fair. Out of the 6 dogs treated 3 (50 %) were excellent, 2 (33.33 %) were good and 1 (16.66 %) was poor in group II. By 60th post-operative day, all the animals regained normal full functional limb.

21. The implants were removed on 60th post-operative day after evaluation of radiographic union of the fractures in all the cases of group-I and II under 2 % lignocaine HCl local infiltration.

22. Seroma developed at the point of pin projection in case no's. 5, 6 and 8 of group I and case no's. 11, 12 and 13 of group II, which was aspirated. This might be due to irritation caused by the pin. Proximal pin migration was observed in case no. 4 of group I and case no. 14 of group II. Distal migration of one pin was observed in case no.13, group-II, which was removed subsequently.

23. In the present study blood was collected and serum separated on 0^{th}, 15^{th}, 30^{th}, and 60^{th} post-operative days for estimation of serum calcium, Phosphorus and alkaline phosphatase in all the cases of two groups. Elevation of the serum calcium levels within the groups from 0^{th} postoperative day up to 60^{th} postoperative day was observed. However, statistically no significant difference was observed between the groups and time periods. No statistically significant difference was observed between the groups and time periods with regard to serum phosphorus. However, within the group elevation of serum phosphorus was observed from 0^{th} post-operative day, reached peak on 30^{th} post-operative day and returned to near base value by 60^{th} post-operative day. The serum alkaline phosphatase level was higher in group II compared to group I without any statistical significance. With in groups, elevation in the serum alkaline phosphatase levels was observed up to 15^{th} postoperative day and reached a peak on 15^{th} postoperative day with a gradual return to normal base value on 60^{th} postoperative day with statistically significant difference between day 0 and 15^{th} postoperative days whereas no significant difference was observed between day 15and 30 and 60 ($P< 0.01$).

24. To conclude, intramedullary pinning is an easy, most economic, less time consuming and least traumatic technique for the stabilisation of femur fracture

in dogs with good outcome. Among two groups, theoretically stack pinning had an advantage of increased torsional or rotational stability. However, in the present study no such advantage was observed. Though the technique of IM pinning had disadvantages poor shear, tension, rotational stability and pin migration, with adaptation of good technique and proper post-operative care it yielded good results in the present study. The technique resulted in early weight bearing and good functional limb out come. The technique was highly recommended for long bone fracture stabilisation in dogs under field conditions. However, further biomechanical studies need to be conducted for evaluating the theoretical advantage of stack pinning.

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