A CLINICAL STUDY ON REPAIR OF TIBIAL FRACTURES USING INTRAMEDULLARY INTERLOCKING NAIL IN DOGS

By
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CERTIFICATE

This is to certify that Mr. **BELDHARI ABHISHEK (RVM/2019-020)** has satisfactorily prosecuted the course of research and that the thesis entitled **"A CLINICAL STUDY ON REPAIR OF TIBIAL FRACTURES USING INTRAMEDULLARY INTERLOCKING NAIL IN DOGS"** submitted is the result of original work done and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

Date: 31-03-2022

Place: Hyderabad

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Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"A CLINICAL STUDY ON REPAIR OF TIBIAL FRACTURES USING INTRAMEDULLARY INTERLOCKING NAIL IN DOGS"** submitted in partial fulfillment of the requirements for the degree of **Master of Veterinary Science (VETERINARY SURGERY AND RADIOLOGY)** of **P.V. Narsimha Rao Telangana Veterinary University** is a record of *bona fide* research work carried out by **Mr. BELDHARI ABHISHEK (RVM/2019-020),** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted by the student 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.

The final *Viva Voce examination* was held on 31 -03-2022 and the Thesis is approved by the Student Advisory Committee.

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LIST OF ABBREVIATIONS

Abbreviation		**Full form**
%	-	Per cent
Fig.	-	Figure
kg	-	Kilogram (s)
IV	-	Intravenous
mg	-	Milligram
mm	-	Millimeter
µg	-	Microgram
g	-	Gram (s)
dL	-	Decilitre
µL	-	Microlitre
<	-	Less than
>	-	More than
±	-	Plus or Minus
U/L	-	Units/Litre
No.	-	Number
ANOVA	-	Analysis of Variance
AO	-	Arbeitsgameinschaft fur Osteosynthesefragen
DLC	-	Differential Leukocyte Count
EDTA	-	Ethylene Diamine Tetra Acetic Acid
Hb	-	Haemoglobin

IFCC	-	International Federation of Clinical Chemistry
IILN	-	Intramedullary Interlocking Nail
ILN	-	Interlocking nail
MIPO	-	Minimal Invasive Plate Osteosynthesis
SC	-	Subcutaneous
SPSS	-	Statistical Package for the Social Sciences
S.E	-	Standard error
TEC	-	Total Erythrocytic Count.
TLC	-	Total Leukocyte Count

DECLARATION

I, **BELDHARI ABHISHEK (RVM/2019-020)** hereby declare that the thesis entitled **"A CLINICAL STUDY ON REPAIR OF TIBIAL FRACTURES USING INTRAMEDULLARY INTERLOCKING NAIL IN DOGS"** submitted to P.V. Narsimha Rao Telangana Veterinary University for the degree of **MASTER OF VETERINARY SCIENCE** is a result of original research work done by me. It is further declared that the thesis or any part thereof has not been submitted for any other degree or diploma.

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ABSTRACT

The present clinical study was conducted on seven dogs presented with tibia fractures to Department of Surgery and Radiology at College of Veterinary Science Rajendranagar, Hyderabad. The age of the seven dogs ranged from 9-42 months. Out of these seven dogs, six were male and one was female. Among the seven dogs, one dog was a Labrador retriever, one was a German shepherd, one was a Great dane, one was a Mongrel, one was a Doberman and two were Golden retriever. The body weight of the dogs ranged from 12 to 40 kg.

The seven cases of tibia fractures were diagnosed by clinical signs, orthopaedic examination and survey radiography. The clinical signs observed in the dogs presented for treatment were lameness immediately after traumatic injury, pain on manipulation, abnormal angulation, swelling, non-weight bearing, dangling of the limb and crepitation at the fracture site.

Pre-operative radiographic examination in two orthogonal views, i.e., medio-lateral and cranio-caudal radiographs revealed proximal diaphyseal fracture in two dogs, mid diaphyseal fractures in four dogs and distal diaphyseal fractures in one dog. Pre-operative radiographs also showed the type of fractures as transverse fracture in three dogs, oblique fracture in two dogs, communited fracture in one dog and spiral fracture in one dog. All the seven dogs in the study had closed fractures.

These fractures were stabilized with 5.0mm, 6.0mm, 7.0mm and 8.0 mm intramedullary interlocking nails resulted in good fracture fixation and immobilization. The length of the bone and diameter of the medullary cavity at the isthmus region, as measured from the medio-lateral radiographs, were used to determine the length and thickness of the nail to be used respectively. The screw lengths were determined by measuring the transcortical diameter of the bone at different regions from the cranio-caudal radiographs obtained pre-operatively. Cranio-medial parapatellar approach used provided good exposure of the fracture site and enabled good fracture fixation in dogs with tibia fracture to perform intramedullary interlocking nail.

Immediate post-operative radiographic evaluation confirmed proper placement of the nail and screws, apposition and alignment of the fracture fragments in all the seven dogs. Immobilization was considered satisfactory in all the cases. The nail length, diameter and position were appropriate in all cases. Screw length, size and position were considered appropriate in all cases. Follow-up radiographs taken on 15th, 30th, 60th and 90th post-operative days revealed secondary bone healing with periosteal callus formation. Good implant stability throughout the period of study without any complications could be achieved in six dogs. In one dog, nail bending was observed above the fracture site by 15th post-operative day due to overuse of stabilized fractured limb and hyperactivity and heavyweight of the dog.

All the dogs which were diagnosed for tibia fractures showed grade V lameness before surgical treatment. Post-operatively, four dogs progressed to grade I lameness by 30th post-operative day, two dogs progressed to grade I lameness by 60th post-operative day and one dogs progressed to grade II lameness by the end of 60th post- operative day.

The haemato-biochemical parameters were of little value in assessing the fracture healing.

Based on present study, it was concluded that intramedullary interlocking nail (IILN) was successful in the treatment of tibial fractures and offered remarkable improvement and good recompense in limb function in six out of seven dogs. The application of interlocking nail was found to be effective with features like being light in weight and it is advantageous because it provides resistance against axial, torsional and bending forces. The implant used in this technique is economical, making it amenable to use in veterinary practice. In the opinion of the author, intramedullary interlocking nail has potential for application for repair of tibia fracture in dogs weighing less than 40kg.

CHAPTER I

INTRODUCTION

Fractures are common orthopaedic problems in small animal veterinary practice. Fracture is defined as the discontinuity in the connective tissue, bone, and/or cartilage (Newton and Nunamaker, 1985). The most commonly affected bones are the femur and tibia. Tibial fractures may present in a variety of forms and are common, as there is minimal soft tissue coverage over the craniomedial aspect of the tibia, open fractures are common.

There are four main principles of fracture repair set forth by the Arbeitsgemeinschaft für Osteosynthesefragen (AO): anatomical reduction, stable fixation, preservation of the blood supply, and early active pain-free mobilization (Gautier *et al*. 1992 and Perren, 2002).

Fracture healing is a process of bone regeneration and is divided into well-documented stages: inflammation, connective tissue and fibrocartilage formation (soft callus), bony bridging or mineralization (hard callus), and remodeling. The primary goal of any fracture fixation is to rigid stabilization of fracture fragments and maintaining both length and alignment. Rigid fixation of fracture supports healing during the first stage, however after the development of the bridging callus, it may interfere with the normal progression of bone healing. During the remodelling phase, mechanical loading of the bone becomes significant, as result of increasing load stimulates callus remodeling and maturation. (Aron, 1998)

Healing of the fracture occurs by a natural process aided by stabilization of the fracture fragments with fixation devices. Different internal and external techniques are available for fracture fixation in dogs. Fixation of long bone fractures with plates and screws effectively stabilizes the bone ends. Besides providing rigid fixation, bone plates control all the forces acting on the fracture site and allow the early return of limb function (McLaughlin and Roush, 1999). Complications like stress protection of the bone, in which plate act as load bearers, and will not allow the load to transmit through the bone causing the weak callus formation underneath the plate and more prone for fracture after plate removal (Tonino *et al*. 1976 and Woo *et al*. 1976).

Intramedullary fixation methods are better in preserving the periosteal blood supply as compared to plate fixation. Intramedullary fixation devices like intramedullary pins (Hulse and Aron, 1994) and interlocking nails (Muir and Johnson, 1996 and Singh *et al.* 2007) have been used for the management of simple and complicated cases of fracture in small animals.

Intramedullary pinning is a primary and most frequently used technique to stabilize fractures, as it is relatively inexpensive and, easier to implant than other forms of fixation (McLaughlin, 1999). However, they provide less stability, resulting in a slower return to limb function and involve more after-care. An intramedullary pin acts as load sharer, they cannot provide sufficient stability in comminuted fractures leading to collapse at the fracture site and it counteracts only bending forces while intramedullary interlocking nails resist both bending as well as torsional forces (Bernarde *et al.* 2001).

Intramedullary interlocking nailing (IILN) has many advantages over other fixation techniques (Klemm and Borner, 1986) and is ideal for the repair of comminuted diaphyseal fractures (Muir and Johnson, 1996 and Raghunath and Singh, 2002). Interlocking nail (ILN) is better suited for comminuted fractures. Interlocking nailing, which preserves the periosteal blood supply, may represent a less invasive alternative to plating (DeCamp *et al.* 2016).

In the process of development of better osteosynthetic techniques, intramedullary interlocking nailing is a useful supplement for long bone fracture fixation and has been in use in human orthopaedics since last three decades, where used it as a modification of Kuntscher nail (Huckstep 1986). IILN first introduced in humans in 1974 (Kempf *et al.*1985).

The first reported use of the ILN fixation in a clinical case in a dog was reported in 1993 with a custom made device, which did not require the image intensification for the screw placement (Dueland *et al.* 1999). IILN is an intramedullary rods with transverse holes positioned at set distances along their length to allow the placement of the transcortical screws creating a woven pattern of a vertical nail and horizontal screws (McLaughlin, 1999). They are inserted into the medullary cavity and the screws are positioned proximal and distal to the fracture site. ILN is locked at the place of its origin using fluoroscopy to guide screw placement, but, a jig used allows blind placement of screws with very good accuracy (Mosses *et al.* 2002).

Later Krettek *et al.* (1999) developed proximal mounted radiation free aiming devices to help in interlocking the nail with bone, which eliminates use of radiation and high cost image intensifiers. The same technology was adopted in veterinary orthopaedics and IILN has become an effective means of fracture fixation in femur, tibia and humerus (Muir *et al.* 1993).

The Interlocking nails could counteract all the forces and act both as load bearer in initial period of fixation and load sharer once the callus has bridged the fracture gap (Roush and McLaughlin, 1999).

Considering the above facts, it is proposed to assess the utilization of intramedullary interlocking nailing in the tibia bone fractures in canines with the following objectives.

1. To diagnose and treat the cases of the tibial fractures in dogs with interlocking nail.
2. To study the efficacy of interlocking nail for the repair of the tibial fractures in dogs.
3. To evaluate the fracture healing clinically and radiographically.
4. To evaluate the fracture healing haematologically and biochemically.

CHAPTER II

REVIEW OF LITERATURE

2.1 ANATOMY OF TIBIA

Tibia is a long, thick bone that lies in the medial part of the crus, or anatomic leg. It articulates proximally with the femur, distally with the tarsus, and on its lateral side the fibula. The proximal half of the tibia is more massive triangular in cross section and then its distal half, which is nearly cylindrical (Evans and De Lahunta, 2013).

The proximal end of the tibia is relatively flat and triangular, with its apex cranial. It consists of two condyles with articular surface and an intercondylar eminence for ligamentous attachments that lie between the condyles. In the fresh state they are covered by articular cartilage and have only a small area of contact with the articular cartilage of the femoral condyles. The larger area of contact is with the menisci. Functionally the tibial condyles are separated from lateral femoral condyles by menisci. These fibrocartilages are biconcave, incomplete discs that are open toward the axis of the bone. The central edges of these C-shaped cartilages are thin and concave, and their peripheral margins are thick and convex.

The intercondylar eminence is a low but stout divided eminence between the medial and the lateral tibial condyles. The condyles are more expansive than the articular areas located on their proximal surfaces. Between the condyles caudally is the large popliteal notch. The extensor groove of the tibia is a smaller notch that cuts into the lateral condyle as far as the articular surface.

On the caudolateral surface of the lateral condyle is an obliquely placed articular surface for the head of the fibula the tibial tuberosity is the large, quadrangular, proximocranial process that provides insertion for the quadriceps femoris and biceps femoris and sartorius. Extending distally from the tibial tuberosity is the cranial border of the tibia, formerly called the tibial crest. To it insert gracilis and semitendinosus and parts of the sartorius and biceps femoris. The semimembranosus inserts on the caudal part of the medial condyle, and the proximal part of the origin of the tibialis cranialis arises from the lateral condyle.

The body (corpus tibiae) is three-sided throughout its proximal half, whereas the distal half is essentially quadrilateral or cylindrical. Three surfaces and three borders are recognized in the proximal half of the tibia. These are the caudal, medial, and lateral surfaces and the medial, lateral and cranial borders. The lateral border or interosseous border is replaced in the distal half of the tibia by a narrow, flat surface apposed to the adjacent, closely lying fibula. The caudal surface presents an oblique popliteal line that courses from the proximal part of the lateral border to the middle of the medial border. At the junction of the proximal and middle thirds of the lateral border is the distally directed nutrient foramen of the bone. The muscle popliteus inserts on the proximal medial part of the caudal surface, the proximal part of the medial border, and the adjacent medial surface of the tibia proximal to the popliteal line. The muscles flexor digitorum lateralis, tibialis caudalis, and flexor digitorum medialis arise from the proximal half of the caudal surface in lateral to medial sequence. Running obliquely distolaterally across the distal part of the caudal surface may be a vascular groove that extends to the distal end of the bone adjacent to the lateral malleolus.

The medial surface of the tibia is wide and nearly flat proximally, as it is partly formed by the cranial border of the tibia. Near this cranial border in large specimens is a low, but wide, muscular line for the insertions of the mm. semitendinosus, gracilis, and sartorius. The medial surface of the tibia is relatively smooth throughout, as it is largely subcutaneous in life.

The lateral surface (facies lateralis) of the tibia is smooth, wide, and concave proximally, flat in the middle, and narrow and convex distally. Part of the m. biceps femoris inserts on the medial surface of the cranial border of the tibia, and just caudal to this attachment the m. tibialis cranialis arises. This muscle intimately covers the lateral surface of the tibia. The m. flexor digitorum lateralis arises from the proximal three-fourths of the lateral border of the tibia. The m. fibularis brevis arises from the lateral surfaces of the distal two thirds of the fibula and tibia.

The distal end of the tibia is quadrilateral and slightly more massive than the adjacent part of the body. The distal articular surface is in the form of two nearly sagittal, arciform grooves, the cochlea tibiae, which receive the ridges of the trochlea of the talus. The grooves are separated by an intermediate ridge. The whole medial part of the distal extremity of the tibia is the medial malleolus. Its cranial part is formed by a stout, pyramid-shaped process. Caudal to this is a semilunar notch. The small, but distinct sulcus for the tendon of the m. flexor digitorum medialis grooves the lip of the medial malleolus at the center of the semilunar notch.

On the caudal side of the distal extremity is a much wider sulcus for the tendon of the m. flexor digitorum lateralis. The lateral surface of the distal extremity of the tibia is in an oblique plane as it slopes caudolaterally. It is slightly flattened by the fibula. At the distal end of the fibular surface is a small articular surface for articulation with the distal end of the fibula. No muscles attach to the distal half of the tibia except for a small portion of m. fibularis brevis on the lateral side.

2.2 INCIDENCE

2.2.1 Incidence and Etiology of Fractures

Maala and Celo (1975) recorded the incidence of fractures in different bones as follows femur (69.80%), radius (18.60%), tibia (3.60%), ulna (3.6%), tibia-fibula (2.4%), and metacarpals (1.2%) in dogs.

Phillips (1979) conducted a survey in 284 canine and 298 felines over two year period and reported that road accidents were major cause of fractures in canine followed by falls and crush injuries. The commonly affected bones in dogs were radius and ulna (17.3%), pelvis (15.8%), femur (14.8), and tibia (14.8%).

Balagopalan *et al.* (1995) conducted a review study on 208 canine fracture cases in which they recorded the highest incidence of fracture of long bones in German Shepherd(27.90%) followed by Doberman Pinscher (17.80%), nondescript (17.30%), and Pomeranian (15.40%). In bones, the incidence was highest in the femur (38.90%) followed by the tibia (18.80%). it was more in the age group of 3-6 months (30.80%) and day old to 3 months (27.90%).

Zaal and Hazewinkel (1996) conducted study on 202 tibial fractures, in 138 dogs and 64 cats. They concluded that 73% of the tibial fractures in dogs and cats were in the diaphysis, oblique fracture being the most frequent (24%). Proximal tibial fractures in dogs were usually extra-articular and 87% of this involved avulsion of the tibial tubercle. Malleolar fractures accounted for 57% of the distal fractures.

Aithal *et al.*(1999) had recorded the incidence of various long bone fractures in canines in this study he stated that the percentage of tibia bone fracture was around 17.16 of which occurrence is more in the middle and proximal third.

Harasen (2003) reported in a study conducted in 282 fractures cases that 16% (45/282) of all long bone fractures occurred in the tibia, 61% (45/74) of all tibial fractures are diaphyseal, 62% of tibial diaphyseal fractures were simple transverse or oblique, while 38% were comminuted. He stated that tibial diaphysis is a good site at which to utilize the principles of biologic fracture repair.

Uma Rani *et al.* (2004) conducted a survey among 85 fracture cases in canines and reported that maximum fractures were recorded in radius and ulna (39.41%) followed by femur (33.23%) and tibia (27.36%).

Raghunath *et al.* (2007) concluded that automobile trauma was recorded as the major etiology for canine long bone fractures accounting for 56 per cent of total cases followed by fall from height in 34 per cent of cases, 9 per cent of cases were due to abuse (hitting/kicking) and 1 per cent of cases were due to crush injury.

Simon *et al.* (2010) had conducted survey to analyse the pelvic limb fractures in canine the authors stated that in pelvic limb the incidence of tibia and fibula was about 42.67 per cent. Tibia fractures were common in the proximal diaphysis (68.5%), middle third (32.4%) and distal (19.01%).

Kushwaha *et al.* (2011) conducted a clinical study on the incidence and management of fracture in 77 cases. In dogs, fractures were highest in the femur (65%), followed by radius-ulna (12.50%), tibia (12.50%), and humerus (10%). In dogs, the transverse fractures were 60%, oblique- 35%, and 5% were comminuted fractures. In dogs, fractures were more in distal one third (52.50%) followed by midshaft (30%) and proximal third (17.5%) of the shaft.

Ali (2013) recorded the occurrence of different fractures in canines and felines. The principal cause of fractures in dogs was roadside accidents whereas in cats it was a fall from height. The ages of the fractured dog ranged from 4 months to 12 years. Tibial fracture in dogs and cats represented 21.5% and 10% respectively.

Rhangani (2014) surveyed a total of 402 cases of fractures. Of these, 59(14.7%) were appendicular fractures. In the hind limb, femoral fractures had the highest incidence (30.5%), followed by tibia-fibula fractures (18.6%). The principal cause of fractures was unknown trauma; followed by motor traffic accidents, human abuse, animal bites, falls and indoor trauma. The most common types of fractures encountered were complete simple transverse fractures (65%), followed by oblique (15%) and comminuted (5%) fractures.

Singh *et al.* (2015) recorded the fracture occurrence pattern and reported that major cause of fracture was automobile accident (42.10%), followed by a fall from height (31.58%). The femur was found to be the most common bone (47.37%) involved in the fracture, followed by tibia-fibula (36.84%) and radius-ulna (15.79 %).

radiographic examination conducted in two orthogonal views revealed that 14 (73.68%) fractures were multiple whereas, 5 (26.32%) fractures were comminuted.

Eyarefe and Oyetayo (2016) reported in their study on prevalence of fractures in dogs that incidence of fracture in femur (57.69%), tibia and fibula (10.26%), humerus (6.41%), radius-ulna (5.13%), mandible (5.13%), metacarpal (3.85%), tibia (3.85%), metatarsal (2.56%), rib (1.28%) and tarsal (1.28%).

Libardoni *et al*. (2016) conducted a retrospective study in a population of 1,200 dogs of which 79.6% had appendicular fractures, where 23.5% had fractures on the femur, 23.4% had pelvic fractures, 22% had tibial and fibular fractures, 17.6% had radius and ulna fractures, 7.5% had humeral fractures and 6% had distal limb fractures (tarsus, carpus, metacarpus, metatarsus, and phalanges). The most frequent cause was car accidents (72.2%). Most affected dogs were male (52.5%), juvenile (42%), mixed breed (51.4%), and small size (42.7%)

Saini *et al.* (2017) stated that automobile accident was the major cause of fractures in canines (76.19%). Among the long bones, femur was most commonly involved (80.95 %), followed by tibia (19.05%) and other bones.

Keosengthong *et al*. (2019) studied 1780 fracture cases in dogs and stated that pelvic limb was the most affected limb (85.2%) among which femur bone (29.6%) was the most commonly involved bone followed by tibia-fibula (11.2%) in dogs.

Kumar *et al.* (2020) conducted study on the incidence of fractures in 261 cases and found incidence in dogs to be 75.86%. The major cause of fracture was Automobile accident (65.15%) followed by fall from height (7.61%). Out of 198 cases of fracture in dogs the complete fracture was reported in 114 cases and incomplete fracture was recorded in 84 cases. Complete fracture was found in 114 cases (57.57%) as compared to incomplete fracture, where it was recorded in 84 cases (42.42%).

2.2.2. Breed, Age, And Sex Wise Incidence

Maala and Celo (1975) recorded the incidence of fractures in different bones and observed that incidence is more in males (64.3%) compared to females (35.7%)

Phillips (1979) conducted a survey in 284 canine and 298 felines over two year period and reported that males were most effected compared to females and 80% of cases were noticed in animals less than 3years of age.

Boone *et al.* (1986) reviewed canine and feline tibial diaphyseal fractures in 195 cases. Spiral and oblique fracture patterns were the most frequent in both juvenile (animals less than 12 months old) and adult animals (animals more than 12 months old). Comminuted fractures and open fractures were seen more commonly in the adult animal.

Balagopalan *et al.* (1995) conducted a review study on 208 canine fracture cases in which they recorded the highest incidence of fracture of long bones in German Shepherd(27.90%) followed by Doberman Pinscher (17.80%), nondescript (17.30%), and Pomeranian (15.40%). Also incidence was more in the age group of 3-6 months (30.80%) and day old to 3 months (27.90%).

Uma Rani *et al.* (2004) conducted a survey among 85 fracture cases in canines and reported that the incidence was higher in males (71.76%) when compared to females (28.24%). The fractures were more often in younger animals of less than 1 year of age (59.82%), especially between 7-9 month old (23.30%) followed by 4-6 month old (16.88%).

Raghunath *et al*. (2007) reported highest incidence of long bone fractures in young dogs between 6-12 months age group with 63.64% of the total cases dogs and 1 year or less than 1 year age (55%) followed by 12-24 months (17%), 24-36 months (11%), 36-48 months (5%) and more than 48 months (12%) of age. Incidence is higher in males (82%) compared to female (18%). Breedwise incidence is reported as German Shepherd dogs (47%) followed by Labrador (15%), Mongrel (9%), Doberman (9%), Gaddi (5%), Pointer (3%), Great Dane (3%), Spitz (3%) and Grey Hound (3%).The authors concluded that medium body weight dogs (body weight 10-20 kg) were most commonly involved (55 %) followed by heavy 10 dogs (body weight 20 kg and above) (41 %) and light weight group (10 kg and less) (4 %).

Simon *et al.* (2010) had conducted survey to analyse the pelvic limb fractures in canine the authors reported that incidence is more in young animals and majority is seen in nondescript dog and male dogs are proned compared to female.

Kushwaha *et al.* (2011) conducted a clinical study on the incidence and management of fracture in 77 cases. In which they reported that in dogs, the incidence of fracture was more in Spitz (35.14%) followed by non-descript dogs (27.03%), German shepherd (21.62%), Labrador (5.40%), and other breeds (10.81%).

Minar *et al.* (2013) performed a study and reported in their study that fracture incidence was higher in male dogs (54%) than female (46 %)

Rhangani (2014) surveyed a total of 402 cases of fractures. Ninety percent (90%) of appendicular fractures affected entire males and females. The affected dog's age was ranged from 4 months to 10 years. The German shepherd breed of dogs and its crosses were the most affected. Male dogs (69%) were more affected than female (31%).

Singh *et al.* (2015) recorded the overall incidence of fracture was as 0.95 % for all species of animals and in dog was 0.76 %. The mean age was recorded to be 26.32±5.14 months. Majority of animals were non-descript (42.10%). Fractures were recorded more in male animals (77.78%).

Eyarefe and Oyetayo (2016) stated that out of 618 small animal surgery cases, 19.6% were orthopedic in nature across 22 canine breeds, consisting of male dogs (45%), bitches (53%) and 2% unspecified sexes. Orthopaedic conditions were prevalent in Alsatian 34.65%, Rottweiler 19.69%, Mongrel 18.11%, Crossbreeds 4.72%, Boerboel 3.94%, Pomeranian 1.54%, Samoyed 1.54%, Caucasian 1.54%, Neapolitan mastiff 1.54%, Lhasa Apso 0.79%, Keeshond 0.79%, Chihuahua 0.79%, French mastiff 0.79%, Tosa 0.79%, Pit-bull 0.79%, Spitz 0.79%, Bull Mastiff 0.79%, Dachshund 0.79% and Doberman pinscher 0.79%. They also mentioned that young dogs (< 1year) were more involved (60.0%) than adult (> 1 year) (32.0%).

Saini *et al*. (2017) reported that fractures were more common in male animals (76.19%) than in females (23.80%). Highest number of fractures was recorded in dogs aged up to 12 months (52.38%). Medium weight dogs of 20-30 kg were most commonly affected (71.42%) followed by light (10-12 kg) and heavy dogs (>30 kg). Among the different breeds, German shepherds were the most commonly involved (28.57%), followed by Rottweiler and Labrador Retriever(19.05% each).

Keosengthong *et al*. (2019) studied 1780 fracture cases in dogs and stated that in dog's mongrel breed were the most affected at 40.6%. Male dogs (58.4%) were more affected than female dogs (41.6%), approximately 55% of bone fractures occurred in dogs that were less than one-year-old.

Kumar *et al.* (2020) conducted study on the incidence of fractures in 261 cases Most of fractured cases were reported in non- descript breed (76) followed by German shepherd (39), Labrador (34), Belgium Shepherd (13), Rottweiler (11), Doberman(10), Pomeranian (8) and Pug (7). Age wise incidence was maximum in 6 month to 2 year (82) followed by 2 year and above (70) and then 1 month to 6 month (46). Male dog (60.10%) was affected more than female 39.90%.

2.3 CLASSIFICATION

Salter-Harris (1963) proposed a system based on the relationship of fracture lines to epiphyseal plate and to the epiphysis and metaphysis for classification of fractures involving epiphyseal plate. They divided these fractures into five categories – Salter-Harris type I to V

Unger *et al.* (1990) designed a system of classification of long bones fractures in dogs and cats by giving an alpha numeric code with four digits, representing the fracture description in a defined order, in which the first two digits represented the localization of the fracture and the last two digits its morphology. The author classified tibial fractures as Type 4 - 2A indicating diaphyseal, simple or incomplete; Type A1-

incomplete tibia or fibula intact, Type A2-simple oblique tibial, Type A3-simple transverse tibial; Type 4-2B indicating diaphyseal tibial wedge, Type B1- one reducible wedge, Type B2- several reducible wedges, Type B3- non reducible wedge; Type 4-2C indicating diaphyseal complex, Type-C1-reducible wedges, Type C2- segmental, Type C3- non reducible wedges.

Raghunath *et al.* (2007) studied the etiology, age, sex, weight, limb involved and type of fracture in 100 clinical cases with 103 long bone fractures from January 2000 to June 2005 The authors also stated that fractures involving femur accounted for 78 per cent followed by humerus 12 % and tibia 10 %. Left limb involved in 57 per cent cases and right limb in 43 per cent cases. Left femur was fractured in 54 per cent of the cases and right femur in 46 per cent of the cases.

Jimenez-Heras *et al.* (2014) based on location classified fractures as open or closed, simple (two bone fragments) or complex (more than two bone fragments). They also reported that, among 23 cases of tibial fractures, 48% were comminuted or multifragmentary, 3% were transverse, 7% were oblique and 2% were spiral.

2.4 DIAGNOSIS

2.4.1 Physical Examination

Wong (1984) reported that the most consistently noted clinical sign of tibial fractures was the loss of function of the affected limb while crepitus was elicited at the fractured site.

Johnson and Boone (1993) opined that dogs with tibial fractures usually did not bear weight on injured limbs and have palpable swelling and crepitation at the fracture site.

Roush *et al.* (1998) stated that an animal with a fracture was often presented with limb dysfunction, pain, fracture instability, overlying soft tissue trauma, abnormal posture or limb position and crepitus.

Roush and McLaughlin (1999) recommended a complete orthopaedic examination should be performed before expressing the diagnosis to identify the abnormalities and must be examined weight bearing stance, muscle mass and symmetry followed by palpation of the affected limb with associated joints.

Kumar *et al.* (2007) conducted a study on the occurrence and pattern of long bone fractures and described the symptoms of lameness as swelling, shortening of limb or crepitation on palpation of the affected site of the limb in growing dogs.

Johnson (2013) stated that diagnosis of tibial diaphyseal fractures is done based upon the history of trauma of jumping, falling or automobile accidents and physical examination findings like non–weight bearing on the affected limb and have palpable swelling, crepitation, and pain at the fracture site. The fracture may be open, with or without soft tissue loss. Affected animals often appear to have abnormal proprioceptive responses because they are reluctant to move the limb.

Piermattei *et al.* (2016) stated that pain, deformity or change in angulation, abnormal motility, local swelling, loss of function and crepitus were the main symptoms to be noted in clinical examination of fractures. Radiographs of at least two views at right angles to each other are essential for accurate diagnosis and selection of the best procedures for reduction and immobilization.

Chaurasia *et al.* (2019) reported symptoms like swelling, crepitating sound, pain on palpation of the affected area and limping of the affected limb in the dogs with fractures.

2.4.2 Pre-operative Radiographic Examination`

Newton (1985) opined that for diagnosis of any long bone fractures two radiographic orthogonal views of lateral and cranio-caudal projections with stress view were important.

Smith (1988) stated that for a full assessment of a fracture minimum of two planes were needed. The author also opined that further damage to surrounding tissue while taking radiographs increased the risk to the patient.

Hulse and Johnson (1997) stated that the two radiographs were taken at a 90^0 angle to each other to properly evaluate the affected bone, radiographs taken must involve the joints above and below the bone of concern to evaluate fractures. They also suggested that comparing radiographs of the affected and unaffected limbs might aid in determining the issue.

Roush and McLaughlin (1999) opined that lateral and cranio-caudal views of the affected limbs might be taken to diagnose the type of fracture and to select the suitable implant. For proper radiographic positioning sedation might be necessary.

Langley-Hobbs (2003) recommended taking orthogonal radiographic views of the affected and contralateral bone to diagnose the fracture type. The author also opined that oblique views might be useful to confirm the presence of fissures in the bone around the fracture site.

According to Eisenberg and Johnson (2015), to evaluate pathologic bone condition or errors in interpretation of fracture fragment alignment, two projections as close to 90^0 s feasible to each other are required to establish fracture associations.

Piermattei *et al.* (2016) suggested that in cases of fractures, radiographs of at least two views perpendicular to each other were essential for accurate diagnosis and selection of the best procedure for reduction and immobilization.

Hammond (2016) opined the significance of diagnostic imaging in the diagnosis and treatment of fractures cannot be underestimated. Fractures could be recognized and categorized at the time of presentation, allowing for treatment planning. Fractures might then be followed to see if they heal and whether there are any complications.

According to Fossum (2019), cranio-caudal and lateral radiographs, which include joints proximal and distal to the afflicted tibia, should be used to assess the amount of bone and soft tissue injury. After determining that there were no contraindications to the administration of sedatives or anaesthetics, nervous animals or those in great discomfort required sedation or general anaesthesia. To rule out thoracic trauma, a thoracic radiograph should be taken. A cranio-caudal radiograph of the undamaged contralateral tibia was required for correct plate contouring if bridging plate fixation was planned.

2.5 FRACTURE STABILIZATION TECHNIQUE

2.5.1 Pre-operative Consideration

Newton and Nunamaker (1985) advocated that withholding of food for 12 hours and water for 6 hours prior to surgery and pre-operative antibiotic prevented post-operative infection and complications in small animals subjected to orthopaedic surgery.

2.5.2 Anaesthesia

Morgan and Legge (1989) evaluated use of propofol either as a single injection for procedures of short duration, or as an induction agent with maintenance provided by further incremental injections or as an induction agent with maintenance by gaseous agents. They reported that rapid and usually excitement-free recovery of the animals was a valuable feature of anaesthesia with propofol.

Kuusela *et al.* (2001) studied the use of dexmedetomidine as premedicant in dogs undergoing propofol-isoflurane anesthesia. They concluded that dexmedetomidine at least as safe and effective as medetomidine for use as a premedicant in dogs undergoing propofol-isoflurane anesthesia.

Kuusela *et al.* (2003) compared the effect of propofol infusion alone and propofol-isoflurane anaesthesia in dexmedetomidine premedicated dogs. They reported that Propofol/isoflurane anaesthesia was considered more useful than propofol infusion alone because of milder degree of respiratory depression and faster recovery.

Tsai *et al*. (2007) concluded that propofol Total Intravenous Anaesthesia provided a slower but smoother recovery compared with propofol induced, isoflurane maintained anesthesia in dogs. Adverse effects were similar in both protocols.

Ahmad *et al*. (2013) evaluated the suitability of dexmedetomidine at dose rate of 20µg/kg body weight intramuscularly and dexmedetomidine in combination with midazolam-fentanyl or midazolam-fentanyl-ketamine. They concluded that dexmedetomidine alone provides a reliable moderate sedation and analgesia. Addition of midazolam and fentanyl enhances sedation, analgesia and muscle relaxation induced by dexmedetomidine. Addition of ketamine produced deep sedation and complete anaesthesia with lesser cardiopulmonary depression.

Bustamante *et al.* (2018) studied the effects of propofol-isoflurane or propofol anaesthesia on mean arterial blood pressure and ventilation in dogs undergoing orthopaedic surgery receiving epidural anaesthesia. They reported that propofol – isoflurane anaesthesia showed lower incidence of respiratory depression compared to propofol alone.

Hampton *et al.* (2019) recorded the effects of intravenous administration of tiletamine-zolazepam, alfaxalone, ketamine-diazepam, and propofol for induction and maintained with isoflurane gas in healthy dogs. They concluded that all the induction agents used in their study produced satisfactory induction of anesthesia and uncomplicated recovery from anesthesia.

2.5.3 Surgical Approach to Tibia

According to Lipowitz *et al.* (1993) a medial surgical approach to the tibia was relatively easy because medial diaphysis of the bone was not covered by muscle. So this approach was commonly used to expose the shaft of the tibia. Elevating the cranial tibial, long digital flexor, and popliteus muscles in the medial approach may provide further exposure.

Duhautois (2003) stated that after dissection of patellar fat and subperiosteal muscle detachment, the femorotibial joint was positioned in a 90º flexed position, and the nail was put in the craniomedial depression of the tibia. The nail was placed in the craniomedial depression of the tibia, cranial to the cranial cruciate ligament's tibial insertion. To prevent injury to the stifle joint, interlocking nails were put in a normograde direction.

Johnson and Dunning (2005) stated that tibia has a pronounced S-shaped curve in dogs. The proximal and distal tibial articular surfaces cover the ends of the long bone, leaving little nonarticular surface to introduce an ILN. The cranial branch of the medial saphenous artery and vein and the saphenous nerve cross the medial aspect of the tibia.

Glyde and Arnett (2006) reported that approach to tibia medially is easy because it provides several advantages to the surgeon as it is superficial, with only one neurovascular bundle present. Also, minimal muscle elevation is necessary.

Ruedi *et al.* (2007) described that based on knowledge of regional anatomy of the bone the surgical approach has to be chosen such that the approach did not jeopardise major neurovascular structures.

Johnson and Schaeffer (2008) suggested the surgical approach of cranio-medial skin incision parallel to the tibial crest and extending it to the entire length of the tibia, continuing dissection through the fascia, avoiding the medial saphenous vein and nerve crossing the middle to the distal third of the tibial diaphysis.

Déjardin *et al.* (2012) reported that interlocking nail was inserted immediately cranial to the footprint of the cranial cruciate ligament insertion through a small medial parapatellar incision. Care should be taken to preserve the cranial cruciate and intermeniscal ligaments.

2.5.4 IMPLANT USED

2.5.4.1 Intramedullary Interlocking Nail (IILN)

Georgiadis *et al.* (1990), reported in their study that static interlocking nails used for repair of diaphyseal tibia fracture in dogs does not decrease the rate of bony union.

According to Denny (1991), Interlocking nailing is better for unstable long bone fractures such as oblique, spiral, or comminuted fractures.

Dueland and Johnson (1993), recommended the use of interlocking nails for stabilization of fractures of the femur, humerus and tibia diaphysis in dogs.

Muir *et al.* (1993) suggested that interlocking intramedullary nails (IINs) were particularly useful for transverse diaphyseal fractures of the long bones in which Steinmann and other non – interlocking pins provide no adequate rotational stability.

Endo *et al.* (1998) developed an intramedullary interlocking nail method for the treatment of femoral and tibial fractures and used for treatment of 6 dogs and 7 cats with fractures. The interlocking nail with diameter of 4-6mm and length of 60- 140mm, having holes at 10mm interval for screwing. The nail placed on the insertion device into the marrow cavity from the end of the fractured bone in the usual procedure for intramedullary fixation, then fixed by screws at the digital and proximal ends with a jig which was also attached to the insertion device. Animals were able to bear weight on the treated legs within three days and the prognosis was excellent.

Dueland *et al.* (1999) used the interlocking nail in veterinary practice with the help of external aiming device (jig) which aligned the screw with the holes in the nail and reported that high success rate and low complication rate suggest that ILN can be used to repair diaphyseal fractures in dogs.

McLaughlin (1999) reported interlocking nails (ILNs) were indicated for the repair of diaphyseal fractures of the femur, humerus, and tibia and also used for stabilization of infected fractures and corrective osteotomies.

Roush and McLaughlin (1999) opined that ILNs were mainly indicated for diaphyseal fractures of femur, tibia and humerus in small, medium and large dogs.

Harasen (2002) opined that interlocking nailing was the suitable technique for repair of comminuted diaphyseal fractures of femur as it minimally disturbed the fracture milieu and favoured biological osteosynthesis or bridging osteosynthesis.

Moses *et al*. (2002) reported that interlocking nails were useful alternatives to external fixators or bone plates for long bone fractures.

Duhautois (2003) concluded that veterinary interlocking nails (VINs) can be used to stabilize diaphyseal fractures of the femur, tibia, and humerus in dogs and cats provided the implants are appropriately sized for the fractured bone. The use of VINs for these fracture types is supported by their high healing rate (even with unstable fractures), associated with a functional outcome, and low complication rate.

Raghunath and singh (2002) reported that dogs with comminuted tibial fracture were treated by interlocking nail fixation had good limb function and observed weight bearing on 3rd or 4th post-operative day which yielded satisfactory stability at the fracture site.

Beale (2004) concluded that the interlocking nail system was another effective implant system for biological or anatomic fracture management of comminuted fractures in dogs and cats. Interlocking nails were used in dogs and cats for repair of fractures of the humerus, femur and tibia. The interlocking nail system is less expensive than a bone plate system with similar biomechanical properties. Interlocking nails are easy to apply and are a good option for general practitioners not wishing to invest in a bone plate system. Interlocking nails can be effectively used for fractures managed by the principles of biological osteosynthesis or anatomic reduction.

Horstman *et al.* (2004) reported that highly comminuted long-bone fractures could be successfully repaired by using an intramedullary interlocking nail without reconstructing the fracture fragments. Also observed biological osteosynthesis provided clinical advantages with respect to surgical healing time when compared with anatomic reconstruction of comminuted long bone fractures in dogs.

Randy and suber (2004) reported that inadequately stabilized ILN repair of fractures can be stabilized by use of either device like external skeletal fixators to progress the healing of fracture repair.

Nanai and Basinger (2005) reported that interlocking nailing system supplemented with external fixation devices can be used for the repair of communited diaphyseal tibial fracture showed healing without any complications.

Wheeler *et al.* (2004) reported that the Intramedullary interlocking nail fixation has many advantageous biologic and biomechanical properties for stabilizing diaphyseal femoral, humeral, and tibial fractures and also stated that the procedure is economical and results are promising.

Glyde and Arnett (2006), stated that Interlocking nails (ILN) are effective for managing a variety of tibial fractures including comminuted and open fractures.

Patel *et al.* (2007) performed repair of canine tibial shaft fracture using interlocking intramedullary nailing under image intensifier and concluded that excellent limb function was noticed along with complete range of limb motion and dog started weight bearing on effected limb from second day post-surgery.

Patil *et al.* (2008) concluded that interlocking nailing and its enhancement using other techniques has widened the scope of fracture especially in case of communited diaphyseal fractures in canines.

Raghunath and Singh (2008) concluded that interlocking nail (ILN) can be used for repair of wide range of fracture types in dogs. And also reported that Weight bearing can be seen as early as on 2nd-3rd day even in complex fractures and bony union by 8-10 weeks.

Raghunath *et al.* (2012) concluded that canine segmented long bone fracture repaired with static interlocking intramedullary nail lead to satisfactory outcome after complete anatomic reconstruction.

Déjardin *et al.* (2012) concluded that indications for interlocking nailing have expanded to include treatment of periarticular fractures, corrections on angular deformities, and revisions of failed plate osteosynthesis. As they provide accurate and consistent repair stability while allowing semi rigid fixation.

Johnston *et al.* (2012) concluded that the main indication for interlocking nail fixation was the treatment of communited diaphyseal fractures of the long bone, except of the radius.

Piórek *et al.* (2012) reported that Interlocking nails (ILN) are effective tools for the fixation of long bone fractures, including humeral, femoral and tibial fractures. Also biomechanical properties of this method has many advantageous compared with other fixation modalities.

Varshneya *et al.* (2012) concluded that range of motion (ROM) was excellent in all the cases. And partial weight bearing was achieved in 2-4 days and full weight bearing was achieved within 12 days in all animals.

Déjardin *et al.* (2014) demonstrated that angle stable interlocking nails represent a superior alternative to standard interlocking nails in the treatment of canine long bone fractures.

Arican *et al.* (2017) concluded that the use of Interlocking nail (ILN) to repair diaphyseal fractures of the femur, tibia, and humerus in dogs resulted in a good or excellent functional outcome.

Déjardin *et al.* (2020) concluded that interlocking nailing indication have expanded to include treatment of peri-articular fractures, corrections on angular deformities, and revisions of failed plate osteosynthesis. Perfectly suited for MIO, interlocking nailing is an attractive and effective alternative to plate and plate-rod osteosynthesis.

Beale and McCally (2020) stabilized tibial fracture in a dog using interlocking nail for improving axial and torsional alignment and normal limb length which were not achieved through minimal invasive plate rod construct.

İlker (2020) concluded that Interlocking pin and acrylic external fixation combination technique can be considered as an alternative method as it prevents instability that can be caused by using only interlocking nailing, and as it provides a rapid healing.

Jagan and Dilip (2021) concluded that Titanium intramedullary interlocking nailing (Ti-IILN) was successful for the repair of communited diaphyseal femur fractures in dogs with lower rate of failure and fewer complications and offered early return of limb function, with good fracture stability till the completion of the bone healing in all dogs.

2.6 POST-OPERATIVE CARE AND MANAGEMENT

Tobias (1995) reported that Robert Jones bandage provided greater stability than a padded bandage because of its additional thickness. He also stated that it has a tremendous absorbent capacity.

Denny and Butterworth (2000) observed that Robert Jones bandage could be used 5 to 10 days post-operatively to provide additional support and to control edema.

De Camp (2003) stated that, the bulk and mild compression of a Robert Jones bandage provided excellent temporary support for an injured extremity before or after surgical intervention and also reduced swelling.

Nicetto *et al.* (2013) used personalized dosage regimens to administer antibiotics, nonsteroidal anti-inflammatory medicines, and analgesic therapy to all dogs after surgery.

Johnson (2013) stated that Robert Jones bandages and their modifications were the external splints most often used in veterinary patients. These bulky, cotton gauze wrappings were typically used before or after surgery for temporary limb splintage. The thick cotton layer provided mild compression of soft tissue and immobilized fractures without causing vascular compromise. Soft tissue and bone immobilization enhanced the patient comfort, prevented further soft tissue damage from sharp bone fragments, and minimized swelling, which enhanced visualization and palpation of anatomic landmarks during surgery. Also, Robert Jones bandage helped to eliminate dead space after surgery.

According to Fossum (2019), post-operative analgesics should be given, and activity should be limited to leash walking and physical therapy until the fractures healed. Following fracture healing, physical rehabilitation encouraged controlled limb usage and optimal limb function, and post-operative assessments should be performed at 2 and 6 weeks after surgery, then every 6 weeks thereafter.

2.7 POST-OPERATIVE OUTCOME AND EVALUATION

2.7.1 Clinical evaluation

Vasseur *et al.* (1995) during the pre- and post-operative periods, a lameness grade was assigned to each instance based on the weight bearing nature of the stance and walking. The following are the weight-bearing grades:

Grade I - Normal weight bearing on all limbs at rest and while walking.

Grade II - Normal weight bearing at rest, favors affected limb while walking.

Grade III - Partial weight bearing at rest and while walking.

Grade IV - Partial weight bearing at rest; does not bear weight on affected limb while walking.

Grade V - Does not bear weight on limb at rest or while walking.

Guiot and Dejardin (2011) defined the presence of a bridging callus or a callus greater than 50 per cent of the tibial diameter at the level of the fracture site on 3 of 4 cortices on 2 orthogonal views in dogs as clinical union.

2.7.2 Radiographic Evaluation

Chawla *et al.* (1982) in a radiographic study of tibial fracture healing in sheep, found that fractures immobilised by simple coaptation and IM pin had a greater periosteal reaction and a larger callus than those immobilised by plating.

Anderson *et al.* (2002) mentioned that the earliest follow-up in which the fracture gap was filled primarily with uniting minimal callus was indication of radiographic union.

According to Langley-Hobbs (2003), the intervals between follow-up radiographs vary depending on the patient's age, the severity of the fracture, the clinician's confidence in the repair, and the patient's development. Films are typically taken every two to three weeks for immature animals and every four to six weeks for older animals. Follow-up radiographs would be assessed separately as well as in relation to earlier films.

Henry (2007) reported that post-operative imaging is essential for proper evaluation of the reduction and alignment of the fracture as well as placement of orthopedic devices. To accurately interpret the location of bony structures and orthopaedic devices, at least two orthogonal views were required. For analysing radiographs of orthopaedic surgeries, an organized paradigm is essential. One commonly used system goes by the mnemonic ABCDS standing for alignment, bone, cartilage, devices, and soft tissues.

Hudson *et al*. (2009) assessed the fracture healing radiographically for femoral, tibial and radius-ulna fractures which were treated by MIPO in 10 dogs. They noticed visible callus at 5.5 weeks and radiographic union was observed at 16.7 weeks. They also observed early bridging callus formation in three dogs at four weeks

Piermattei *et al.* (2016) mentioned clinical union to be the period in the recovery process of a fracture when healing has progressed to the point that the bone is strong enough, to remove the fixation. These healing times varied somewhat, depending on the type of fixation used. Radiographic evaluation of fracture healing should be routinely performed at the time of expected clinical union.

Aikawa *et al.* (2018) assessed all the dogs under study radiographically and clinically 3 to 4 weeks after surgery, monthly radiographs for 3 to 4 months and annual follow up radiographs if possible in order to study the progress of healing. Bone union was defined as the point when bridging callus was present or when the fracture line was no longer visible.

2.7.3. Haematological evaluation

Tembhurne *et al.* (2010) observed that the hematological parameter such as Hb%, TEC, TLC, PCV, eosinophils, monocytes and basophils were within normal physiological range. The neutrophil count was constantly rising might be due to the response to inflammatory condition during healing of surgical wound and stress during post-operative period, and the numbers were not statistically significant. The rise in neutrophil percentage Neutrophil are the first line of defense and therefore there number got increased after the onset of inflammation.

Singh *et al*. (2017) evaluated the haematological, radiographic and clinical outcome in the different time period and between the groups showed non-significant minor variation during the period of study in healing of femoral fracture with retrograde intramedullary pin in conjunction with demineralized bone matrix in dogs.

Patil *et al.* (2017) found that erythropoisis was indicated by a progressive increase in packed cell volume, haemoglobin, and total erythrocyte count from the day of surgery to the 90th day. On different post-operative days, physiological leucocytopenia, neutropenia, and relative lymphocytosis revealed that the inflammation and surgical stress had subsided. Monocyte and eosinophil counts were within physiological limits indicating free from anaphylactic reactions. Further, the authors opined that physiological and haemato-biochemical findings on different post-operative days aided in determining fracture repair.

Chaurasia *et al.* (2019) reported no significant changes in TEC, TLC, Hb per cent and PCV. They also stated that the mean leucocyte count in all the animals of three groups expressed a no significant decreasing pattern at most of the operative intervals. This progressive decline on different post-operative days indicated that the dog’s condition had returned to normal.

Marvania *et al.* (2020) found that haematological parameters did not change significantly over time and were within normal reference ranges throughout the period of study.

Reddy *et al.* (2021) observed non-significant changes in mean ± SE values of haemoglobin, packed cell volume, were highest at 60th postoperative day. The highest total erythrocyte count was found on the 60th post-operative day. Total leucocyte count did not change significantly. The differential leucocyte count, which included neutrophil, lymphocyte, monocyte, and eosinophil counts, was highest on the day before surgery and lowest on the 90th post-operative day.

Yadav *et al.* (2021), reported that hematological values were within normal range and statistically non-significant throughout the study period due to less surgical stress.

2.7.4. Serum biochemical evaluation

According to Siemesen (1970), serum inorganic phosphorus levels increased immediately after fracture fixation, reached a significantly higher level on the 30th post-operative day, and then returned to normal on the 60th post-operative day

Singh *et al.* (1976) identified a non-significant difference in the levels of serum calcium and inorganic phosphorus during the healing period of experimental ulnar defects in dogs. However, serum alkaline phosphatase levels increased significantly between the seventh and fourteenth postoperative days before returning to normal by the sixth postoperative week. The authors concluded that an increase in serum alkaline phosphatase was due to the formation of fibrous tissue and the early stages of bone healing.

Bush (1991) observed that, serum calcium levels increased slightly on 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 60th post-operative day but it remained above the normal value. The gradual decline in serum calcium levels after the 30th post-operative day could be attributed to faster calcification at the fracture site.

Maiti *et al.* (1999) observed that, an increase in serum alkaline phosphatase level was detected from the 5th post-operative day, peaked at the 15th post-operative day, and then declined until the 60th post-operative day and remained above the baseline values. This increased alkaline phosphatase activity could be a sign of increased chondroblastic proliferation during fracture repair, which leads to bone production.

Nagaraja *et al.* (2003) analysed the feasibility of using plastic rods in the diaphyseal femur fracture based on serum biochemical changes, gross and histopathological changes They found that calcium and phosphorous levels increased steadily up to the 15th post-operative day and rapidly returned to normal, which was statistically non-significant, and that serum alkaline phosphatase concentrations did not differ significantly from pre-operative values.

Uma Rani and Ganesh (2003) analysed blood calcium, phosphorous, and serum alkaline phosphatase levels during femur fracture healing in goats. They found a significant drop in serum calcium levels on the 7th post-operative day in both groups, followed by a significant rise in values from the 1st day until they returned to pre-operative levels on the 60th day in both groups. Up to the 15th post-operative day following surgery, they found a considerable increase in alkaline phosphatase levels in both groups, after which the levels began to reduce.

Mahendra *et al.* (2007) reported no significant changes in serum calcium and serum phosphorus levels post-operatively after treating femur fracture in dogs using intramedullary pinning and cerclage wiring. Throughout the study period, they noticed a considerable increase in serum alkaline phosphatase levels, which could be attributed to enhanced osteogenic activity and calcium salt deposition at the fracture site.

According to Hegde *et al*. (2010), the considerable increase in serum alkaline phosphatase on the day of surgery after fracture immobilisation was attributed to osteogenic cell proliferation, with the periosteum of destructed bone contributing the most serum alkaline phosphatase.

Phaneendra *et al.* (2016) observed that alkaline phosphatase and C-reactive protein could be used as useful biochemical markers in assessing the bone formation and pain respectively. Biochemical parameters along with clinical and radiographical examination provided sound knowledge on the degree of bone healing.

Patil *et al.* (2017) reported that slight hypercalcemia, slight hyperphosphatemia and progressive decrease of serum alkaline phosphatase on different post-operative days indicated osteosynthesis of bone.

According to Kumar *et al.* (2018), biochemical markers such as serum calcium, inorganic phosphorus, alkaline phosphatase, and C-reactive protein can be utilised to measure bone formation and pain. The degree of bone healing was determined using biochemical indicators, as well as clinical and radiographic evaluation.

Reddy *et al.* (2021) observed progressive increase in serum calcium and phosphorus up to 60th post-operative day and then decrease in value and serum alkaline phosphatase were found highest on pre-operative day with gradual decrease up to 90th post-operative day within the normal physiological limits.

Yadav *et al.* (2021), reported that the serum biochemical parameters like serum calcium, phosphorus showed statistically non-significant variations. Whereas, serum alkaline phosphatase levels were elevated upto 30th postoperative day and returned to normalcy by the end of the study period.

2.8 POST-OPERATIVE COMPLICATIONS

Durall and Diaz (1996) reported some complications with the use of interlocking nailing for fracture stabilization in canines like angulation of bone, sclerosis at the distal tip of the nail, and loosening of one screw, non-union, sequestrum formation and incorrect measurement of the length of the nail.

Dueland *et al*. (1999) stated that intra-operative complications were categorized in three major categories: as a result of design deficiency, technical error or errors in decision making during surgery.

McLaughlin (1999) mentioned that the proximal screw hole in the distal fragment is the weakest portion of nail and has more stress concentration hence it is common site for nail breakage. Also reported that missing the screw hole which can be avoided by verifying that the aiming device is tightly attached to the nail. Delayed union can occur with any fixation method and can be minimized by minimally disrupting the fracture hematoma.

Suber *et al.* (2002) reported breakout and screw bending caused interlocking nail failure.

Duhautois (2003) reported that complications could arise from nail position errors that were too close to the fracture site, as well as locking errors that resulted in holes being missed while bolting. He also mentioned delayed union, non-union, implant failure, and locking mistakes as the four most common post-operative complications.

Durall *et al.* (2003) stated in a radiographic study of interlocking nail fixation that screw bending, non-union and screw break were found out.

Horstman *et al.* (2004) recorded complications associated with use of interlocking nail, including difficulties encountered during placement, problems with fracture healing, or maintenance of stability and seroma formation at the fracture site. Failure of interlocking nail fixation due to broken nail, fracture collapse, delayed union.

Wheeler *et al*. (2004) stated that complications associated with interlocking nail fixation include malposition of interlocking screws, nail or screw breakage, and delayed union or nonunion.

Patel *et al.* (2007) reported that common post-operative complications were sideward movement of limbs, loosening of proximal screw and inward rotation of limb is noticed.

Raghunath and Singh (2008) observed post-operative complications like dislodgement of nail with two broken distal screws, nonunion and malunion of the fracture.

Arican *et al.* (2017) described complications include implant failure, including failure of the nail itself, delayed union, non-union, infection and failure of the locking bolt, joint penetration and misdirected locking bolts. They reported that this technical error was related to a failure to align the jig and the ILN accurately. Typically, this occurred if the fixation screw between the ILN and the jig was not applied tightly, if the slide of the jig was not controlled and supported by the muscle, or if the jig moved between locking screw insertions.

2.9 REMOVAL OF IMPLANT

Muir *et al.* (1993) stated that interlocking intramedullary nail (IIN) was removed in a case to minimize mechanical interference with stifle motion, as IIN protruded from tibia plateau.

Endo *et al.* (1998) felt that it would be better to remove intramedullary interlocking nail (IIN) to avoid stress shielding when the fracture has healed.

Mc Laughlin (1999) recommended the implants are generally not removed unless complications occur. If necessary can be removed with a nail extractor.

Larin *et al.* (2001) reported that neutral positioning of the nail minimize bending fatigue and provided greater bending resistance. They also mentioned that interlocking nails could be inserted through a more limited approach than plates thereby minimizing soft tissue disruption. Use of interlocking nail was more aesthetic and implant removal was usually not necessary

Duhautois (2003) opined that veterinary interlocking nails (VIN) seemingly do not interfere with bone physiology. Hence, VINs were not removed unless there was soft tissue irritation.

Raghunath and Singh (2008) reported removal of implant was optional unless it was indicated. This is because that dog with implant in situ had good limb function.

Déjardin *et al.* (2014) mentioned that implant removal is not routinely recommended, may become necessary if complications, such as non-union or infection, require revision.

CHAPTER III

MATERIALS AND METHODS

3.1 SELECTION OF CASES

The present clinical study on stabilization of tibial fractures using intramedullary interlocking nailing was performed on six dogs presented to the Department of Surgery and Radiology, College of Veterinary Science, Rajendranagar, Hyderabad. Routine clinical, orthopaedic and radiographic examinations were performed to diagnose the tibial fractures. After confirming tibial fractures, seven cases were selected for the study. The fractures of the tibia in these dogs were immobilized by open reduction and internal fixation by using 5.0 mm, 6.0 mm, 7.0 mm, 8.0 mm diameter interlocking nails and screws, depending on the fracture configuration and body weight of the dogs.

3.2 ANAMNESIS

Complete details regarding age, sex, breed of the animal, chief complaint and manner of its onset, age and cause of fracture, any previous injury or disease conditions, history of other illnesses and their past treatment, duration of the signs, if any, for the chief complaint were recorded.

3.3 PRE-OPERATIVE EXAMINATION

3.3.1 Pre-operative Clinical and Orthopaedic Examination

First, routine clinical examination followed by an orthopaedic examination of dogs presented with fractures of the tibia was performed. Then dogs were examined for loss of function, abnormal mobility, gait, deformity or change in angulation of affected limb, pain and crepitation at the fracture site. Clinical signs such as swelling, infection or exudation from the fracture site were also recorded. The exclusion of dogs with neurological problems after performing neurological examinations was done. The fractures were temporarily stabilized with a Robert Jones bandage with or without the use of splints until the day of surgery.

3.3.2 Pre-operative Radiographic Examination

Following initial clinical assessment, the dogs were subjected to pre-operative radiographic examination in which two orthogonal views i.e., medio-lateral and cranio-caudal radiographs of fractured tibia including the concerned joints were obtained (Langley-Hobbs, 2003). The site and type of fracture were ascertained from these pre-operative radiographs.

3.3.3 Planning of Surgery

Measurements of the fractured tibia and contralateral normal tibia were obtained from the pre-operative radiographs. These measurements from pre-operative radiographs were used to select the diameter and length of IILN to be used, screws and diameter of intramedullary Steinmann pin. The length of the screw needed for the application of IILN in each patient was determined directly by measuring the medio-lateral thickness of the tibia at different distances of fractured fragments from the cranio-caudal radiographs (Fig 3.1). The thickness of intramedullary interlocking nail was determined by measuring the diameter of the intramedullary cavity at the isthmus region of the tibia and length of nail were determined from medio-lateral radiographs (Fig.3.2).

3.4 PATIENT PREPARATION, ANESTHESIA AND POSITIONING

3.4.1 Pre-operative Patient Preparation

The fractures were temporarily stabilized with a Robert-Jones bandage without the use of splints until the day of surgery. The owners were advised to withhold food for 12 hours and water for 6 hours before surgery. The affected limb was aseptically prepared by clipping the hair from the dorsal midline to below the hock joint. The operative site was shaved and scrubbed using povidone-iodine surgical scrub[1] followed by application of surgical spirit. Similarly, the skin was also prepared over the cephalic vein on both forelimbs for intravenous injections. Normal saline was intravenously infused throughout the surgery.

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1. Betadine Surgical Scrub - Win-Medicare Pvt. Ltd., New Delhi, India.

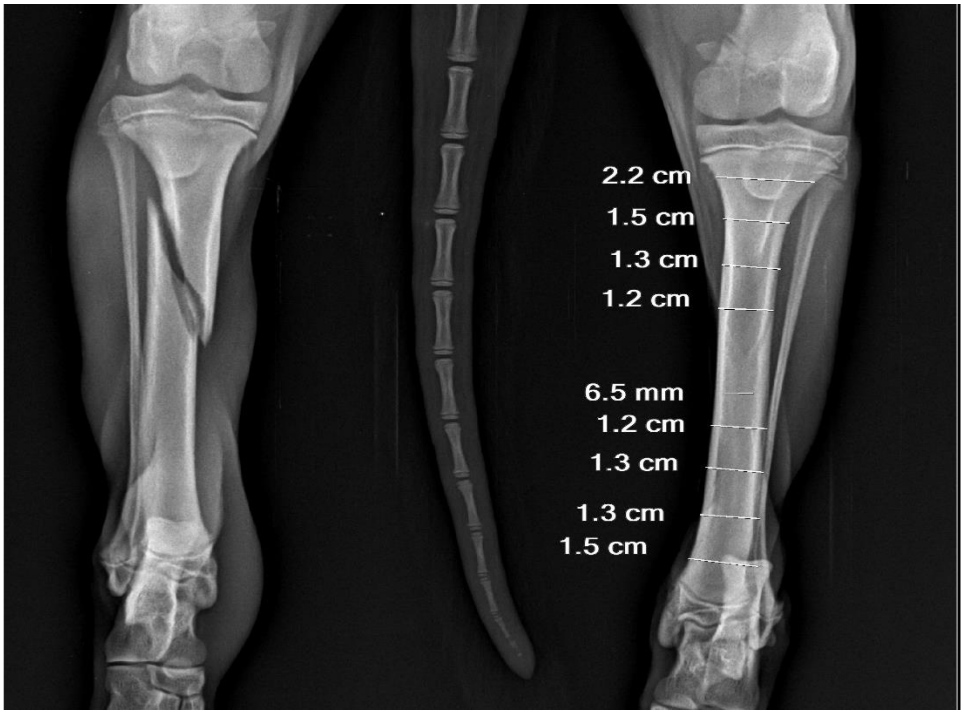

Fig.3.1 Radiograph showing trans-cortical diameter of tibia at different distances in cranio-caudal view.

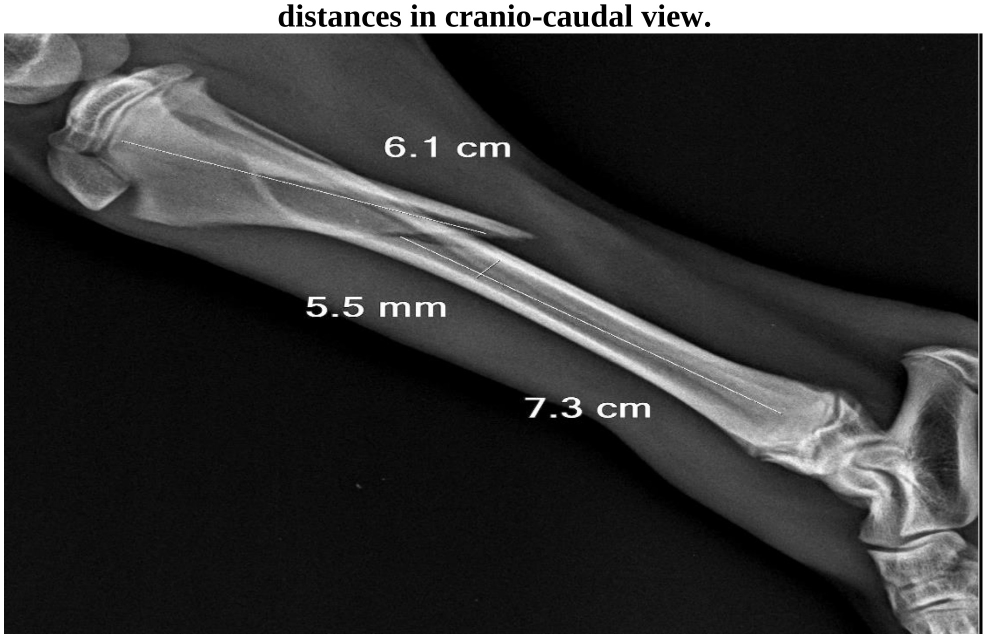

Fig.3.2 Radiographs showing length of tibia and diameter of intramedullary cavity at the isthmus region in medio-lateral view.

3.4.2 Anaesthesia

Atropine sulphate[2] at the rate of 0.04 mg/kg body weight was administered subcutaneously as pre-anaesthetic medication followed by Dexmedetomidine[3] at the rate of 20µg/kg body weight intravenously. Ten minutes later, general anaesthesia was induced with intravenous injection of Propofol[4] at the rate of 4 mg/kg body weight. Following induction, the dogs were intubated with endotracheal tubes of suitable size. Anaesthesia was maintained with isoflurane[5] at the rate of 2.5 in 100% oxygen during the surgical procedure.

3.4.3 Positioning of the Animal

The dogs were positioned in lateral recumbency with the fractured limb on the table with the medial surface facing the surgeon (Fig.3.3). The distal extremity of the limb was covered with a sterile gauze bandage. The prepared site was again painted with 5 % povidone-iodine solution followed by application of spirit. The sterile drape was applied over the operative site.

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2. Atropine Sulphate Injection - Unison Drugs Pvt. Ltd., Chandigarh
3. Dexem – Adinos pharmaceuticals, 11/12, Udyog nagar,S.V. Road, Goregaon,Mumbai-400104, India.
4. Propofol - Claris Life sciences Ltd., Chacharwadi-Vasana, Ahmedabad, Gujarat, India
5. Sosrane – Korten pharmaceuticals Pvt. Ltd., Thane, Tal-palghar(dist)- 401407, Maharastra, India

Fig.3.3 The limb with tibial fracture prepared for surgery.

3.5 MATERIALS USED

3.5.1 Orthopaedic Instruments

A general surgical instrument set and required orthopaedic instruments needed for the procedure were autoclaved. The orthopaedic instrument set includes Perthes bone awl, Gelpi retractors, periosteal elevators, pin inserter, Hohmann's retractors, Senn retractors, bone holding forceps, depth gauge and low-speed high torque electric drill were used for performing intramedullary interlocking nailing procedure(Fig.3.4a,b). The general surgical and orthopaedic instruments and implants and orthopaedic drilling machine were sterilized in an autoclave before surgery while hexagonal head screwdriver and low-speed high torque drill were sterilized in the formaldehyde sterilizer.

3.5.2. Implants

Two interlocking instrument box sets (Fig.3.5) one containing intramedullary interlocking nail[6] (IILN) of varying diameters/thickness of 5mm, 6mm and 7mm with different lengths ranging from (120mm, 140mm, 160mm, 180mm, 200mm and 220mm). 2.0mm non tapping cortical screws of screw length from 6mm to 20mm for 5mm diameter nails and 2.7mm non tapping cortical screws of screw length from 6mm to 30mm for 6mm and 7mm diameter nails

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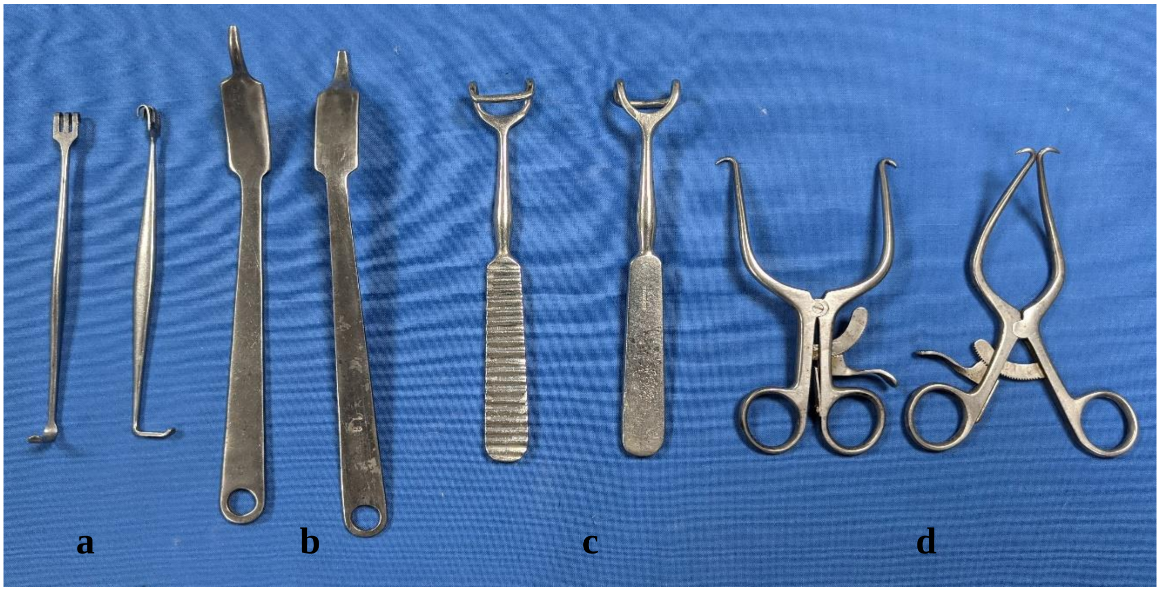
6. Intramedullary interlocking nail - Siora Surgicals Private Limited, Rampura, New Delhi-110035, Delhi, India.

Along with interlocking nails required accessories (Fig.3.6) like proximal and distal aiming device, conical bolt, cannulated socket wrench, drill sleeve for 5mm nail, drill sleeve for 6mm and 7mm nails, 1.5/2.0mm drill bit, 2.0/2.7mm drill bit, 2.0mm extra-long bone tap with T handle, 2.7mm extra-long bone tap with T handle, steinmann pin trocar ended 5.0mm, 6.0mm and 7.0mm, 1.5mm tip extra-long screw driver, 2.7mm tip extra-long screw driver.

The other instrument box set containing intramedullary interlocking nail (IILN) of diameters/thickness of 8mm, 9mm and 10mm with different lengths ranging from (120mm, 140mm, 160mm, 180mm, 200mm and 220mm). 3.5mm cortical screws of screw lengths from 14mm to 60mm for 8mm and 9mm diameter nails and 4.5mm cortical screws of screw lengths from 24mm to 60mm for 10mm diameter nails were used along with proximal and distal aiming device, conical bolt, cannulated socket wrench, drill sleeve for 8mm and 9mm nail, drill sleeve for 10mm nails, 2.5/3.0mm drill bit, 3.2/4.5mm drill bit, 3.5mm extra-long bone tap with t handle, 4.5mm extra-long bone tap with t handle, Steinmann pin trocar ended 8.0mm, 9.0mm and 10.0mm, 2.5mm tip extra-long screw driver, 3.5mm tip extra-long screw driver. The choice of the implant was determined based on the age, weight of the dog and the diameter of the medullary cavity at isthmus region as measured from the pre-operative radiographs and type of fracture.



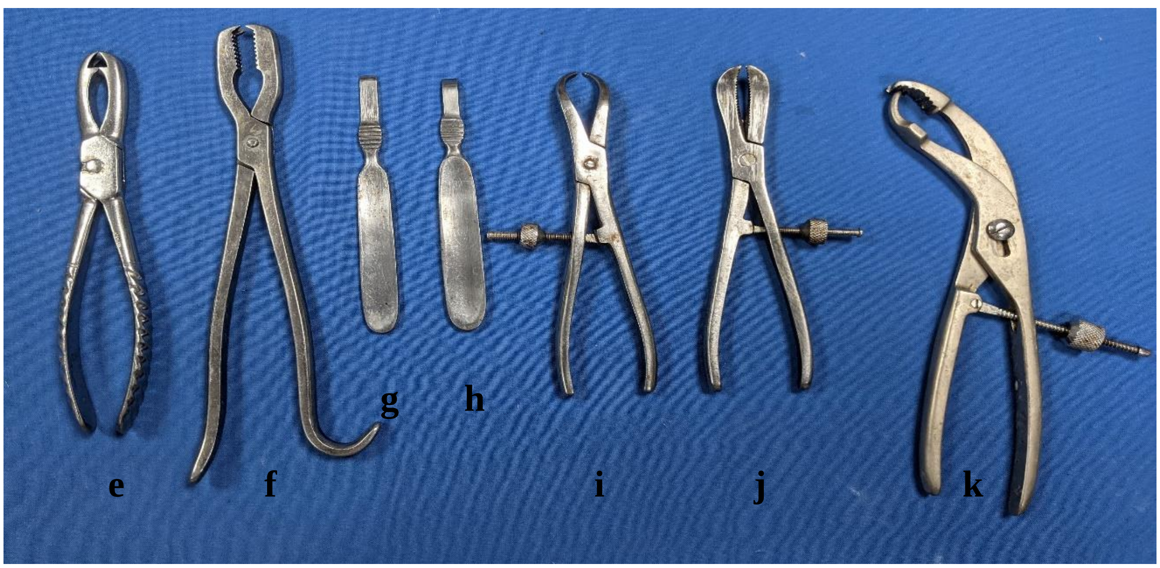
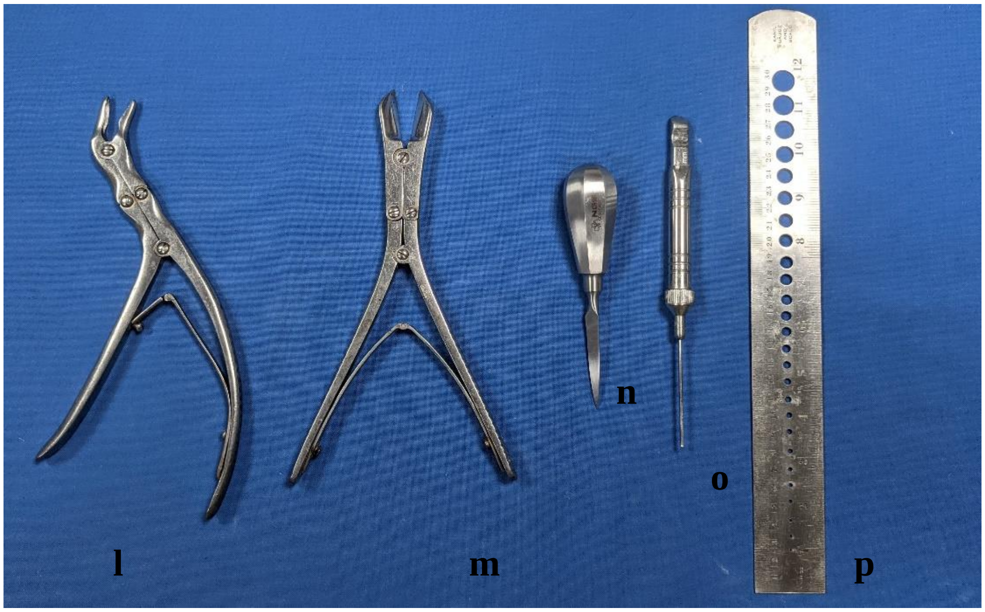


Fig 3.4a Orthopaedic instruments

a. **Senn retractor**
b. **Hohman retractor**
c. **Muscle retractor**
d. **Gelpi retractor**
e. **Ferguson Bone Holding Forceps**
f. **Kern Bone Holding Forceps**
g. **periosteal elevator – straight**
h. **periosteal elevator – curved**
i. **Point Reduction Forceps**
j. **Serrated Reduction Forceps**
k. **Self-Centering Bone Holding Forceps**



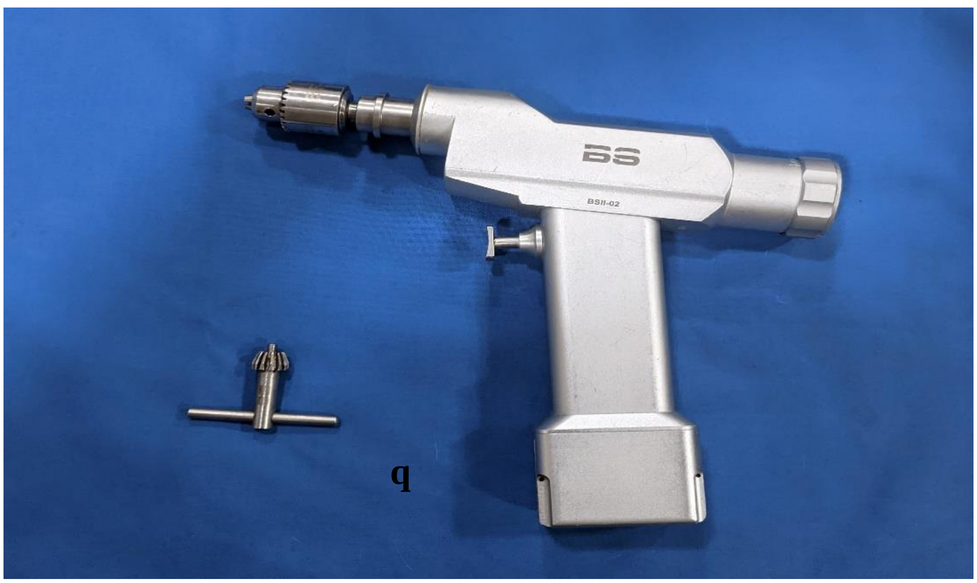


Fig 3.4b Orthopaedic instruments

l. Duck-bill Double action rongeur
m. Bone cutter
n. Perthes bone awl
o. Depth gauge
p. Orthopaedic measuring scale
q. Low Speed High Torque battery operated orthopaedic drilling machine with key

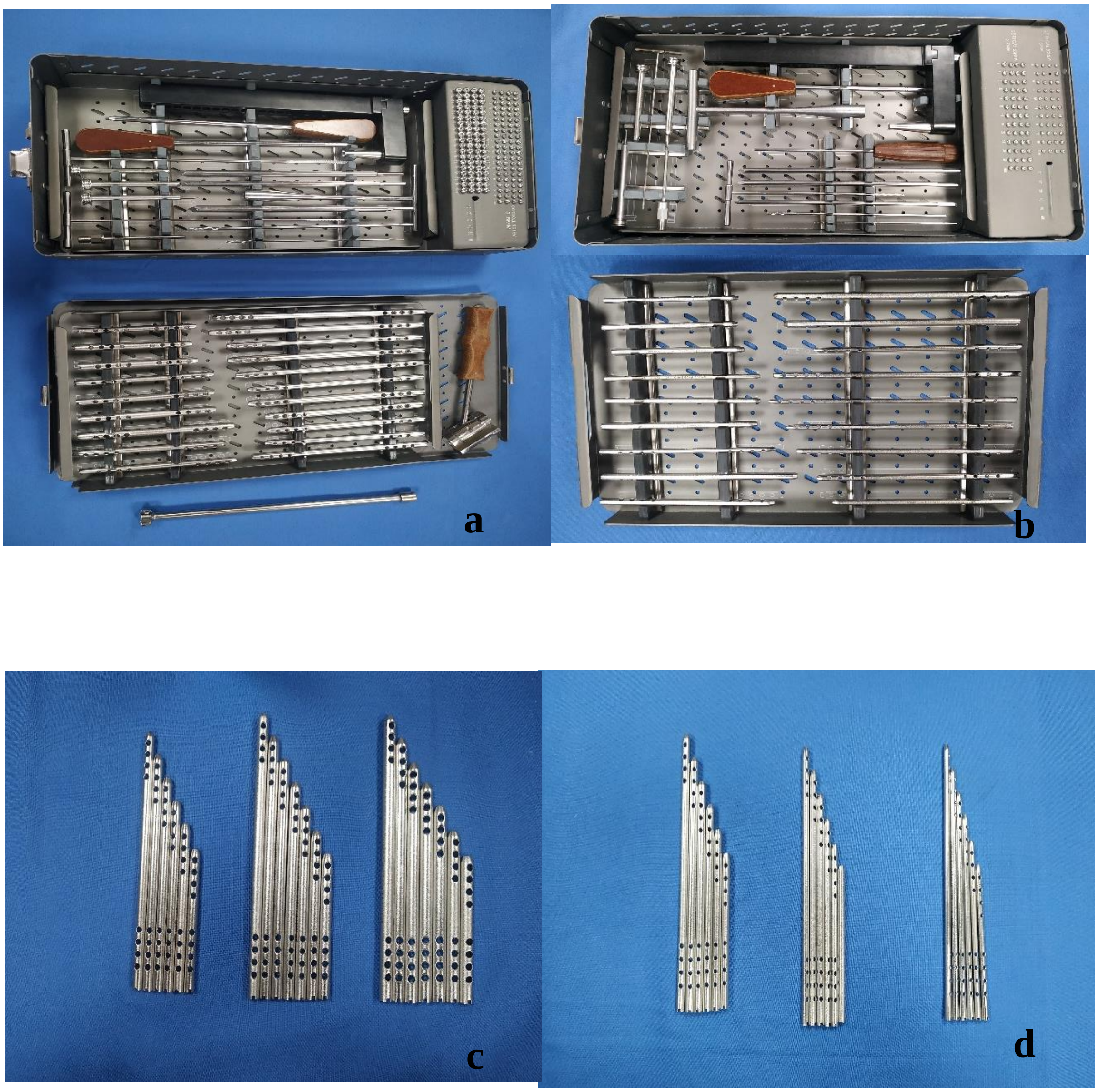


Fig.3.5 Implants

a) **interlocking instrument box set for 8, 9 &10mm nails along with 3.5mm and 4.5mm cotical screws**
b) **interlocking instrument box set for 5, 6 &7mm nails along with 2.0mm and 2.7mm cotical screws**
c) **interlocking nails of 8, 9 &10mm diameter**
d) **interlocking nails of 5, 6 &7mm diameter**

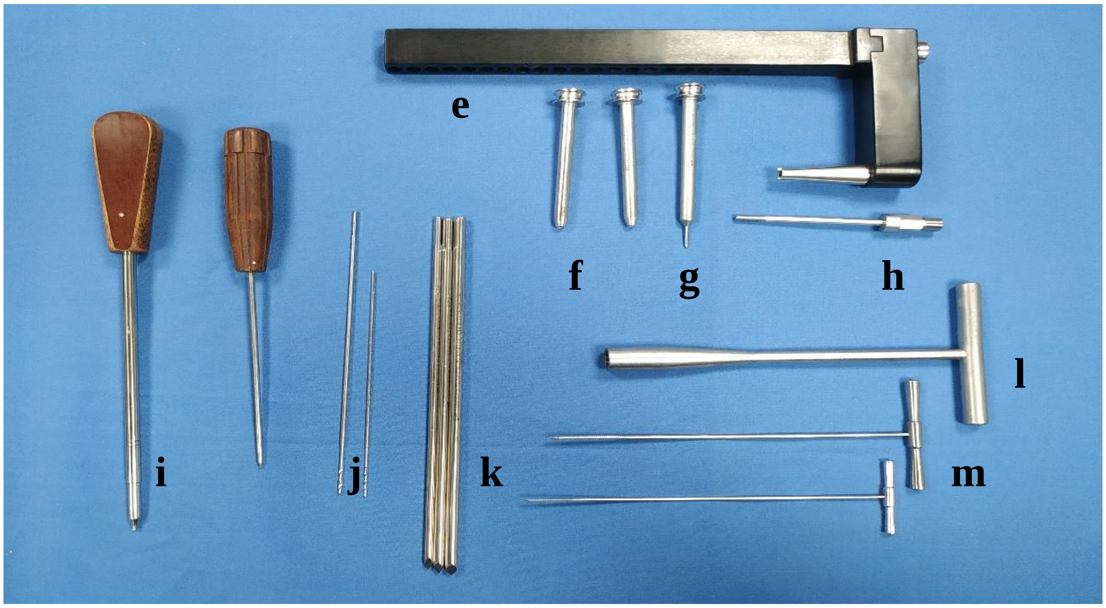


Fig 3.6 Interlocking nail accessories

- **e) Proximal + Distal aiming device**
- **f) Drill sleeves**
- **g) Trocar**
- **h) Conical bolt for nails**
- **i) Extra-long hexagonal screw drivers**
- **j) Long drill bits**
- **k) Steinmann pins trocar ended**
- **l) Cannulated socket wrench**
- **m) Extra-long bone tap with T- handle**
- **n) Extension rod**
- **o) Mallet**

3.6 SURGICAL TECHNIQUE

3.6.1 Surgical Approach to the Tibia

For tibial fracture repair, a cranio-medial, parapatellar approach was followed (Fig.3.7). With the extension of the incision distally provided satisfactory exposure of the fracture fragments. The subcutaneous fascia was opened in the same line followed by a skin incision at the fracture site. Care was taken to protect the dorsal branch of the saphenous vessels and nerves while crossing the field at the midshaft. The bone was exposed by incising the deep crural fascia on the medial shaft of the bone.

3.6.2 Fracture Reduction and Fixation with IILN

The fracture site and fragments were exposed followed by clearing the fascia (Fig.3.8). A periosteal elevator was used to remove redundant soft tissue. The point of entry of the nail should be assessed for normograde approach of IILN implant insertion by taking the standard insertion points, locate the medial tibial condyle at the junction of the cranial and middle thirds. Point of entry for Steinmann pin was created with the use of Perthes bone awl. Fracture reduction was carried out using serrated reduction forceps and the reduced fragments were held in apposition using bone holding forceps (Fig.3.9). Interlocking nail of suitable length was selected based on diameter of medullary cavity at the isthmus region of bone from pre-operative radiographs. A trocar ended Steinmann pin of diameter 1-2mm less than that of selected IILN was used to ream the medullary cavity to create a guidance tract for the interlocking nail, The Steinmann pin was introduced in the proximal fragment followed by the distal fragment then IILN was attached to the proximal and distal aiming device and it is inserted into the medullary cavity through normograde manner. Nail-aiming device complex should not be disturbed thereon. The screw holes were located by observing the gradation on the aiming device. Trocar was used to make a point of entry for the drill bit in the bone and appropriate drill sleeve is used and screw holes were drilled using either 1.5 mm drill bit (for 5mm nail) or 2.0 mm drill bit (for 6mm and 7mm nails) or 2.5mm drill bit (for 8mm and 9mm nails) or 3.2mm drill bit (for 10mm nail) across the bone passing through both the cortices of bone and using a low-speed high torque electric drill (Fig.3.10). To prevent thermal necrosis while drilling, sterile normal saline was used to irrigate the site to cool the drill bit and flush the debris. The length of the screw was determined by measuring the thickness of the bone from pre-operative radiographs and were confirmed during the procedure using the depth gauge. An appropriate bone tap was used based on the screw diameter (Fig 3.11). The screw of suitable length was then placed at the drilled hole and tightened using a hexagonal orthopaedic screwdriver until the tapered end of the screws exited the far cortex of the bone (Fig 3.12).First, the distal segment was locked followed by proximal segment. Once the fixation was over and stability ascertained, the aiming device was detached by loosening the threaded bolt in the aiming device (Fig.3.13).The fracture gaps were not reconstructed. Bone chips or small fragments were left as such and no further manipulation was done at the fracture site. Minimal instrumentation was used for achieving the reduction of fracture ends. The stability of the implant was ascertained. Interlocking nailing was done in static mode in all the animals.

3.6.3 Closure of the Surgical Wound

Subcuticular sutures were applied in simple continuous pattern using No. 2-0 polyglactin 910[7] (Fig.3.14) and the skin incision was closed in a row of cruciate mattress sutures using 2-0 polyamide[8] (Fig.3.15)

3.7 POST-OPERATIVE CARE AND MANAGEMENT

A thin layer of sterile gauze bandage dipped in 5% Povidone-iodine solution was covered the incision site, and a thick layer of the cotton pad was wrapped over the limb. It was then covered with a gauze bandage and finally, a layer of surgical paper tape was applied to provide additional protection. The dressing was changed every alternate day until the sutures were removed on the 14th post-operative day. Antibiotic therapy with injection Ceftriaxone sodium was administered at the dose rate of 20mg/kg body weight as an intramuscular injection for 7 days post-operatively. Injection Meloxicam was administered at the dose rate of 0.3 mg/kg by intramuscular injection for 3 days. Owners were advised to restrict the movement of the animal for the first 2 weeks following surgery and then to allow leash walk for the next few weeks.

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7. Vicryl-Johnson and Johnson Pvt. Ltd., Waluj, Aurangabad, India.

8. Ethilon- Johnson and Johnson Pvt. Ltd., Waluj, Aurangabad, India.

Fig.3.7 Cranio-medial skin incision made directly over tibial shaft

Fig.3.8 Fracture fragments exposed.

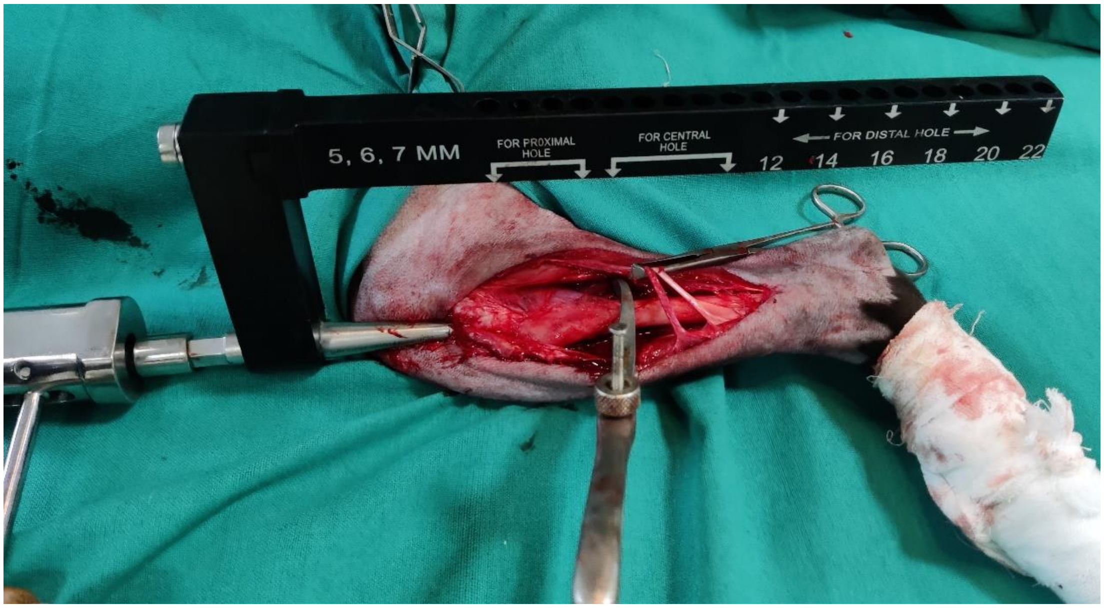


Fig.3.9 Fracture fragments aligned and stabilized with serrated forceps and interlocking nail is inserted and attached to an aiming device.

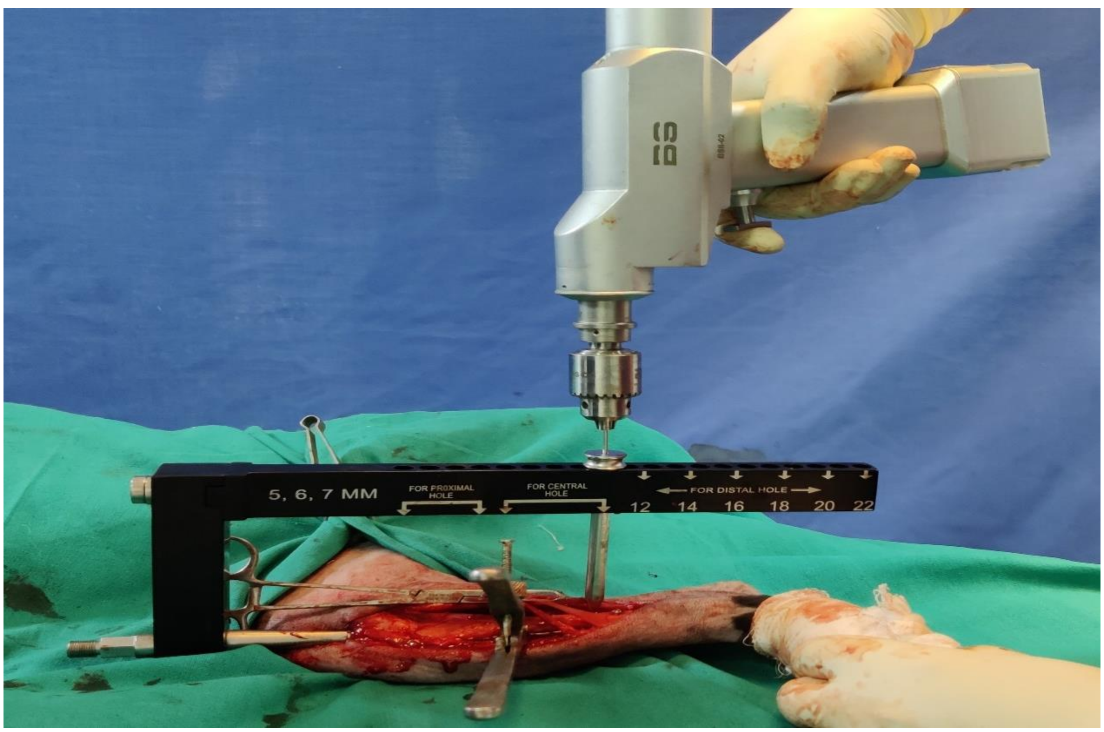


Fig.3.10 Drilling a hole across the bone through interlocking nail using low speed high torque orthopaedic drilling machine.

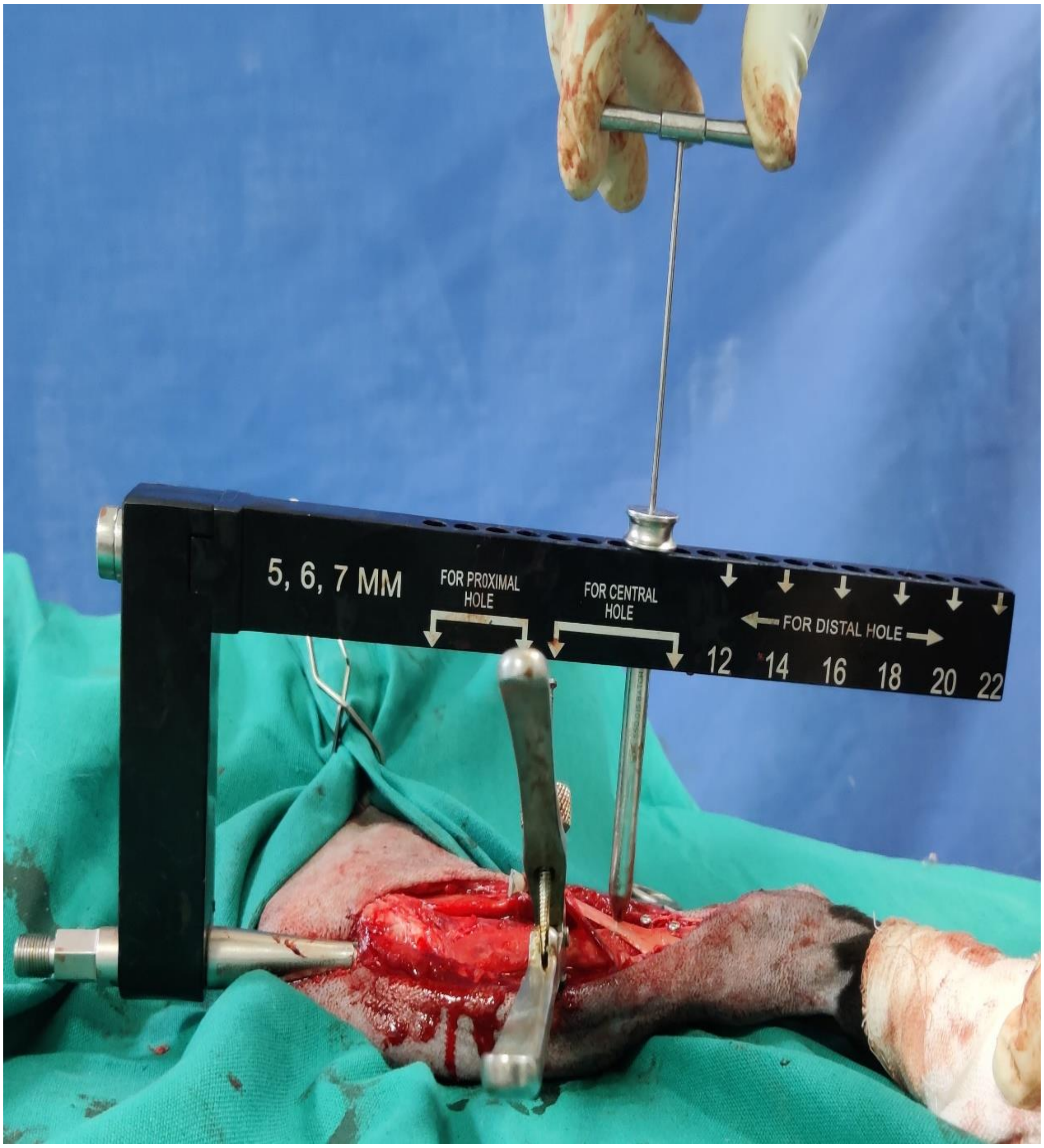


Fig.3.11 Tapping of screw hole across the bone through interlocking nail using appropriate bone tap

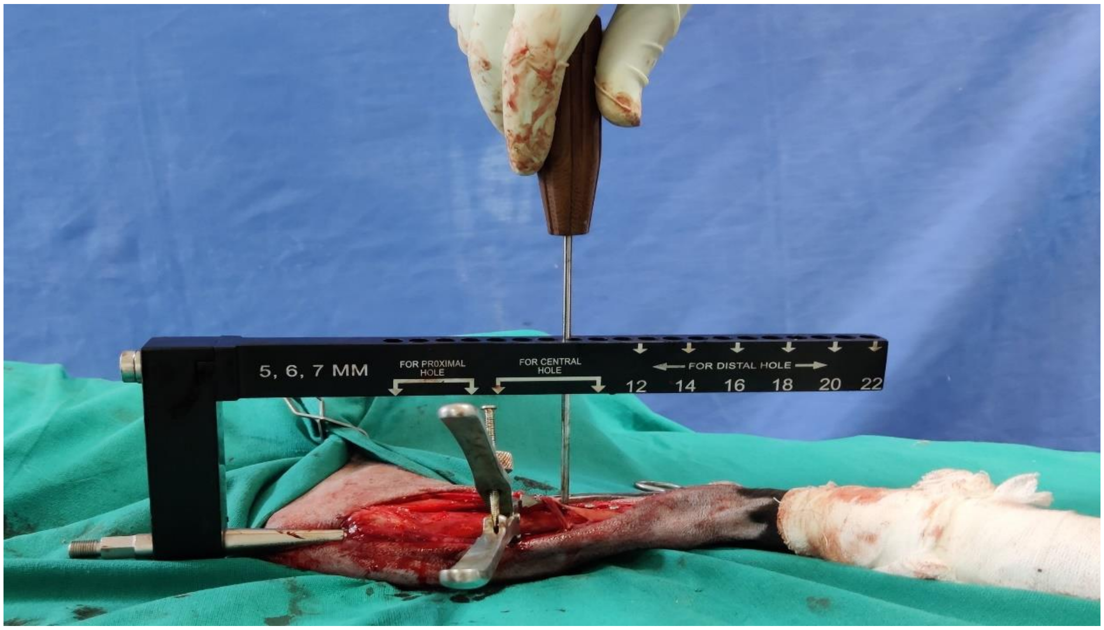


Fig.3.12 Tightening of cortical bone screws using hexagonal orthopaedic screw driver

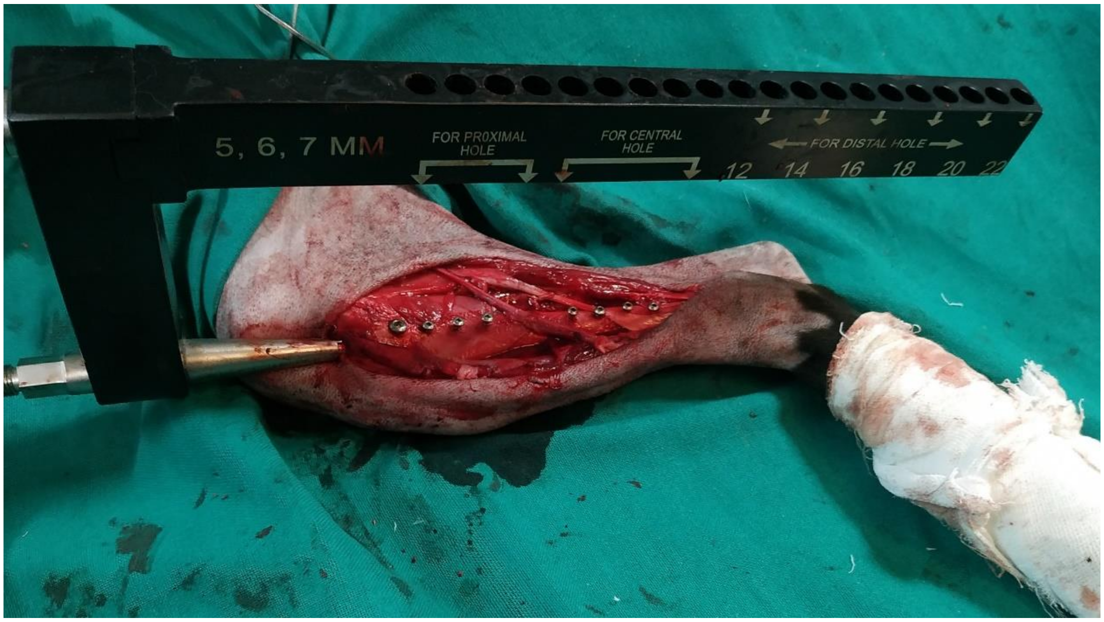


Fig.3.13 Fracture stabilization completed with interlocking nail

Fig.3.14 Sub-cutaneous incision closed with row of continuous sutures.

Fig.3.15 The skin incision closed in a row of cruciate mattress sutures.

3.8 EVALUATION OF FRACTURE HEALING

3.8.1 Clinical Evaluation

Clinical evaluation was carried out every alternate day to check the appearance of the suture line and the presence of any swelling or exudation from it until the sutures were removed. The postoperative day on which the dog started bearing weight was recorded. After suture removal, the dogs were examined once a week for implant stability until fracture healing was considered satisfactory

3.8.2 Lameness Grading

A lameness grade was assigned in all the cases during pre and post-operative periods based on the weight-bearing nature during stance and while walking. Weight-bearing was graded as follows (Vasseur et al. 1995).

Grade I - Normal weight-bearing on all limbs at rest and while walking.

Grade II- Normal weight-bearing at rest and favours affected limb while walking.

Grade III- Partial weight-bearing at rest and while walking.

Grade IV- Partial weight-bearing at rest and does not bear weight on affected limb while walking.

Grade V- Does not bear weight on the limb at rest or while walking.

3.8.3 Radiographic Evaluation

Cranio-caudal and Medio-lateral radiographs of the operated limb were obtained immediately after surgery and on 15^{th}, 30^{th}, 60^{th} and 90^{th} post-operative days and whenever needed, on later dates to assess the progress of bone healing.

3.8.4 Hematological Evaluation

Blood samples were collected in EDTA coated vials in all the cases the day before surgery and on the 15^{th}, 30^{th} and 60^{th} day post-surgery. Haemoglobin (g/dL), Packed Cell Volume (%), Total Erythrocyte Count (x 10^6 /μL), Total Leucocyte Count (x 10^3 /μL) and Differential Leucocyte Count (cells/μL) were estimated on the above said intervals as per the methods described by Jain (1993).

3.8.5 Serum Biochemical Evaluation

Blood samples were collected and serum was separated in all the cases before surgery and on the 15^{th}, 30^{th} and 60^{th} day post-surgery. Serum alkaline phosphatase, calcium and phosphorous were estimated.

3.8.5.1 Serum Alkaline Phosphatase (U/L):

Serum alkaline phosphatase (U/L) was estimated by IFCC (International Federation of Clinical Chemistry) kinetic assay method (Young, 1997).

3.8.5.2 Serum Calcium (mg/dL):

The levels of calcium (mg/dL) in serum were determined by OCPC (Orthocresophthalein complexone) method (Lin *et al.*1999).

3.8.5.3 Serum Phosphorus (mg/dL):

The levels of inorganic phosphorus (mg/dL) in serum were determined by Phospho Molybdate method (Young, 2000).

3.9 STATISTICAL ANALYSIS

The data regarding haematological and serum biochemical values were subjected to standard statistical analysis using one-way ANOVA as described by Snedecor and Cochran (1994) using SPSS 15 software package.

CHAPTER IV

RESULTS

4.1 SELECTION OF CASES

A total of 80 clinical cases of long bone fractures were recorded in dogs during the period of the study. Out of these 80 cases, fractures involving tibia were encountered in 12 cases (15 %). Out of these 12 cases, seven dogs that were considered suitable for the study were selected and the fracture fixation was performed using intramedullary interlocking nail.

4.2 ANAMNESIS

4.2.1 Signalment of the Cases

The age of these seven dogs ranged from 9 months to 42 months with a mean of 19.86 ±5.10 months. Out of these seven dogs six were males and one female. Among the seven dogs, one dog was a Labrador retriever, one was a German shepherd, one was a Great dane, one was a Mongrels, one was a Doberman and two were Golden retriever. The body weight of the dogs ranged from 12-40 kg with a mean of 24.43±3.70kg.

4.2.2 Etiology and Age of the Fracture

In these seven dogs the main cause for occurrence of fractures were found to be fall from height in four (66.6%) dogs and automobile accident in two (33.3%) dogs. The dogs were presented for treatment between 2 to 7 days after fracture occurrence with a mean of 3.43±0.65 days. Concurrent illnesses were not reported in any of the dogs. Details of the cases are presented in Table 4.1

Table 4.1 – Clinical history of the dogs selected for the study

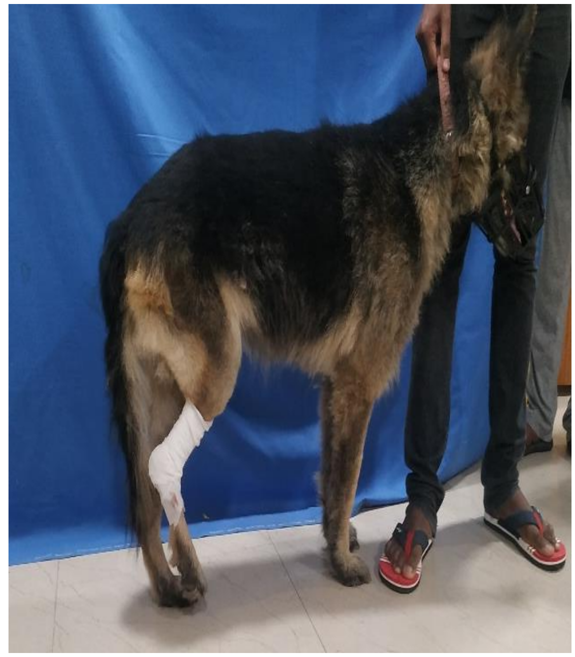
Case no.	Breed	Age (months)	Sex	Body weight (kg)	Cause	Days since fracture
1.	Labrador Retriever	11	Male	30	Fall from height	3
2.	Mongrel	36	Female	20	Automobile accident	4
3.	German Shepherd	42	Male	27	Fall from height	3
4.	Golden Retriever	9	Male	12	Fall from height	2
5.	Doberman	10	Male	14	Automobile accident	7
6.	Great Dane	13	Male	40	Automobile accident	3
7.	Golden Retriever	18	Male	28	Automobile accident	2
Mean		**19.86±5.10**		**24.43±3.70**		**3.43±0.65**

4.3 PRE-OPERATIVE OBSERVATIONS

4.3.1 Pre-operative Clinical Observations

The dogs presented for treatment of tibial fractures exhibited symptoms like pain, lameness, swelling, non-weight bearing, abnormal angulation and dangling of the limb (Fig.4.1 and 4.2). In all the dogs, crepitation was noticed at the fracture site on physical examination. All the seven dogs had closed fractures and had no neurological deficits.

Case 1



Case 2

Case 3

Case 4

Fig.4.1 Cases no.1, 2, 3 and 4 –Dangling and non-weight bearing of fractured limb (grade V).

Case 5

Case 6

Case 7

Fig.4.2 Cases no.5, 6 and 7 –Dangling and non-weight bearing of fractured limb (grade V).

4.3.2 Pre-operative Radiographic Observations

Orthogonal views of plain Medio-lateral and cranio-caudal radiographs of the affected bone including the proximal and distal joints were found to be satisfactory to confirm the tentative diagnosis. Pre-operative radiographs revealed tibia fractures and also showed the type of fracture as transverse fractures in all seven dogs. Pre-operative radiographs of the dogs with tibia fractures are presented in Fig.4.3 to Fig 4.8. The details regarding the fractures encountered in all the dogs are presented in Table 4.2. Measurements obtained from the pre-operative radiographs of the affected limb like length of the bone and trans-cortical diameter at different regions and diameter of medullary cavity at the isthmus region of bone proved vital in selecting the appropriate length and diameter of interlocking nail to be used and the length of the screws.

Table 4.2 - Pre-operative radiographic observations

S.No.	Affected side	Location of fracture	Type of fracture
1.	Right	Proximal diaphyseal	Closed complete oblique overriding
2.	Right	Distal diaphyseal	Closed complete spiral overriding
3.	Left	Mid-diaphyseal	Closed complete transverse overriding
4.	Right	Proximal diaphyseal	Closed complete oblique overriding
5.	Right	Mid-diaphyseal	Closed complete transverse overriding
6.	Left	Mid-diaphyseal	Closed complete communited overriding
7.	Right	Mid-diaphyseal	Closed complete transverse overriding

Fig.4.3 Case 1- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

Fig.4.4 Case 2- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

Fig.4.5 Case 3- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

Fig.4.6 Case 4- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

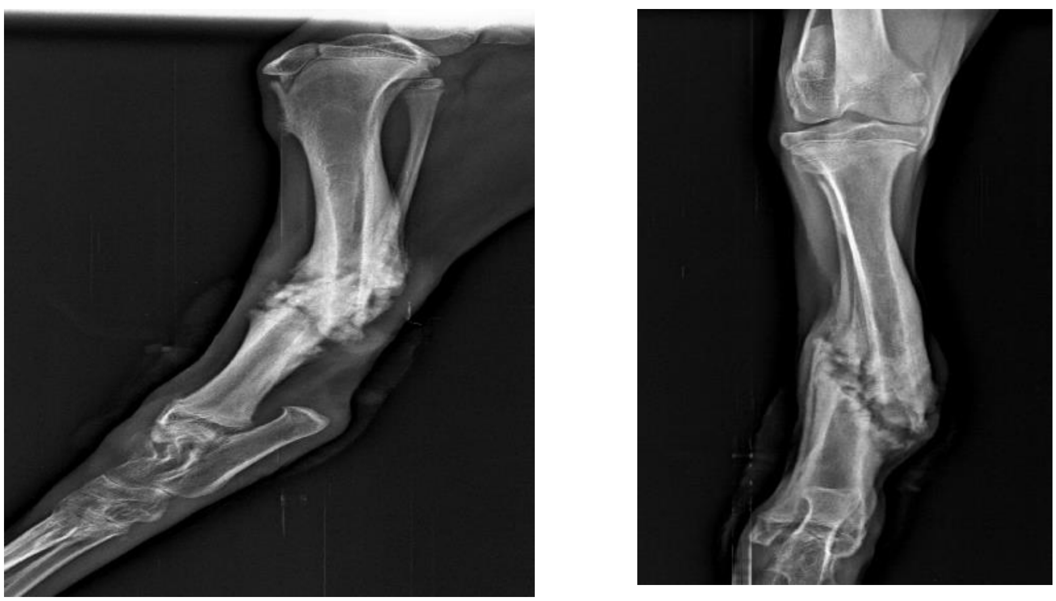


Fig.4.7 Case 5- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

Fig.4.8 Case 6- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

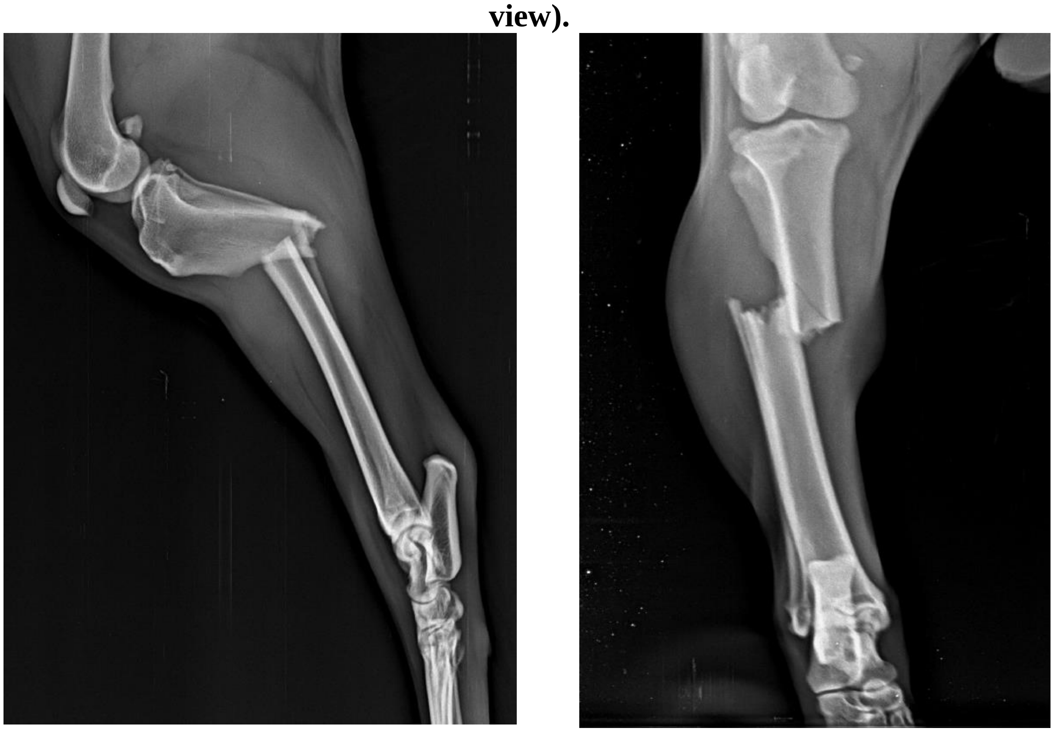


Fig.4.9 Case 7- Pre-Operative Radiograph (medio-lateral and cranio-caudal view).

4.4 PATIENT PREPARATION, ANAESTHESIA AND POSITIONING

The patient preparation and anaesthetic protocol followed for the surgery was found to be adequate to carry out the surgical interventions. The operative site was shaved and scrubbed using povidone-iodine surgical scrub. Painting the surgical site with 5% povidone iodine solution followed by application of surgical spirit and the draping was considered satisfactory since post-operatively no signs of infection were encountered in any of the dogs that underwent surgery.

In all the dogs, inhalant anesthetic regimen was followed with the use of Atropine sulphate at the rate of 0.04 mg/kg body weight was administered subcutaneously followed by Dexmedetomidine at the rate of 20µg/kg body weight intravenously. Dogs were induced with intravenous injection of Propofol at the rate of 4 mg/kg body weight. Following induction, the dogs were intubated with endotracheal tubes of suitable size. Anaesthesia was maintained with isoflurane at the rate of 2.5 in 100% oxygen during the surgical procedure offered a satisfactory surgical plane of anesthesia during the surgical process with no major complications and all dogs recovered quickly.

The dogs were positioned in lateral recumbency with the medial side of fractured limb facing the surgeon facilitated decent exposure of the surgical site. Covering the distal extremity of the limb with sterile gauze bandage facilitated manipulation of the limb during surgery without compromising sterility. Aseptic preparation of surgical site and adequate draping done was considered satisfactory since infection was not encountered in any of the seven dogs post-operatively.

4.5. MATERIALS USED

4.5.1 Implants

Intramedullary interlocking nail used for stabilization of tibia fractures resulted in good fracture fixation and immobilization. The length and diameter of the nail to be used was determined by the length of the bone and diameter of medullary cavity at the isthmus region measured from the medio-lateral radiographs obtained pre-operatively. 5.0mm intramedullary interlocking nails of lengths 120mm, 140mm, 160mm were used in animals weighing 12kg, 20kg and 14kg dogs respectively. 6.0mm intramedullary interlocking nails of lengths 160mm and 180mm were used in two dogs weighing 30kg and 28kgs respectively. 7.0mm intramedullary interlocking nail of length 200mm was used in one dogs weighing 27 kg 8.0mm intramedullary interlocking nail of length 220mm was used in one dog weighing 40 kg.

4.5.2 Screws

In the present study, 2.0 mm, 2.7mm and 3.5 mm non tapping cortical screws varying from 14 mm to 40 mm were used in seven dogs. The length of the screws was determined by measuring the trans-cortical diameter of the bone at different regions from the cranio-caudal radiographs obtained pre-operatively and confirmed by measuring with depth gauze intra-operatively.

4.6 SURGICAL TECHNIQUE

4.6.1 Surgical Approach to Tibia

The cranio-medial parapatellar approach with extension of incision distally provided satisfactory exposure of the fracture fragments with minimal soft tissue disruption. Care was taken to protect the dorsal branch of the saphenous vessels and nerves while crossing the field at the midshaft. This approach facilitated adequate reduction of fracture fragments and normal alignment and position of implants for fracture reduction. Arthrotomy of the stifle joint provided adequate exposure of tibial plateau and facilitated the entry point for insertion of interlocking nail.

4.6.2 Fracture Reduction and Fixation with intramedullary interlocking nail

Following principles of indirect fracture reduction. A trocar ended Steinmann pin (of size1-2mm less than diameter of selected nail) was inserted into the medullary cavity through a normograde manner with the help of a perthes bone awl. The appropriate size intramedullary Interlocking nail using an aiming device was inserted in to the medullary cavity through the guidance tract made by the pin. The fracture was reduced and held in opposition with the help of bone-holding forceps applied proximal and distal to the fracture site. With the nail in its final position, a drilling sleeve is applied to ensure the drill holes are accurately aligned to the holes in the nail.

The drill bits of size 1.5mm for 5.0mm diameter nails, 2.0mm for 6.0mm and 7.0mm nails and 2.5mm for 8.0mm nails were suitable for drilling holes across the bone. Cortical screws of diameter 2.0mm, 2.7mm and 3.5mm were suitable after tapping with appropriate bone tap of size 2.0mm, 2.7mm and 3.5mm respectively provided excellent results in the present study.

4.6.3 Closure of the Surgical Wound

In the present study, following fracture repair, closure of subcuticular fascia in a row of simple continuous pattern using 2-0 polyglactin 910 and the skin incision with a row of cruciate mattress sutures using 2-0 polyamide, resulted in uneventful healing of the suture line.

Fig.4.10 Suture removal on 14th post-operative day

4.7 POST-OPERATIVE CARE AND MANAGEMENT

Dressing the surgical wound with 5% povidone iodine pads was found to be effective in keeping the site clean in all the dogs. Application of Robert Jones bandage provided satisfactory immobilization of the limb. The use of injection ceftriaxone sodium effectively prevented post-operative infection. The skin sutures were removed between 10^{th} to 12^{th} post-operative days in all the dogs (Fig.4.9). None of the dogs developed post-operative swelling and suture dehiscence and the surgical wounds healed well in all the dogs without any complications.

4.8 EVALUATION OF FRACTURE HEALING

4.8.1 Post-operative Lameness Grading

All the dogs in the present study showed partial weight bearing from 1^{st} postoperative day. Weight bearing was by 3^{rd} post-operative day in two dogs, 4^{th} post-operative day in two dogs, 7^{th} post-operative day in one dog, 10^{th} post-operative day in one dog and 45^{th} post-operative day in one dog. Lameness grading based on weight bearing was recorded in all animals pre-operatively showed grade V lameness before surgical stabilization of the fracture (Fig. 4.1 and 4.2). Post-operatively, four dogs progressed to grade I lameness by 30^{th} post–operative, two dogs by 60^{th} post –operative day (Fig 4.11-4.16) and one dog progressed to grade II by the end of 60^{th} post-operative day (Fig 4.17). All the cases under this study were examined for functional limb outcome and categorized as excellent, good, fair and poor. The functional outcome was graded excellent in six dogs and good in one dog.

Table 4.3 – Post-operative details of lameness grading.

Case No.	Intra medullary inter locking nail diameter used	Pre-operative Lameness Grading	Post - operative Lameness Grading on					Complete Weight Bearing on
			1	15	30	60	90	
1.	6.0 mm	V	III	I	I	I	I	3rd day
2.	7.0 mm	V	IV	III	I	I	I	10th day
3.	5.0 mm	V	IV	III	II	I	I	7th day
4.	5.0 mm	V	III	I	I	I	I	3rd day
5.	5.0 mm	V	III	I	I	I	I	4th day
6.	8.0 mm	V	IV	IV	III	II	II	45th day
7.	6.0 mm	V	III	II	II	I	I	4th day
MEAN		**5.0± 0.0**	**3.43± 0.20**	**2.14± 0.46**	**1.43± 0.30**	**1.14± 0.14**	**1.14± 0.14**	

Grade I- Normal weight bearing on all limbs at rest and while walking.

Grade II- Normal weight bearing at rest, favors affected limb while walking.

Grade III- Partial weight bearing at rest and while walking.

Grade IV- Partial weight bearing at rest; does not bear weight on affected limb while walking.

Grade V- Does not bear weight on limb at rest or while walking.

7th post-operative day

15th post-operative day

60th post-operative day

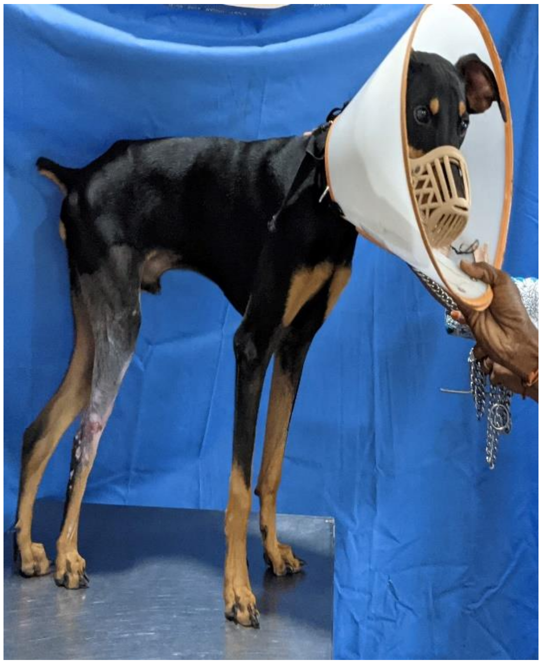
90th post-operative day

Fig. 4.11 Case No.1 – Progressive weight bearing of right hind limb on different post-operative days.

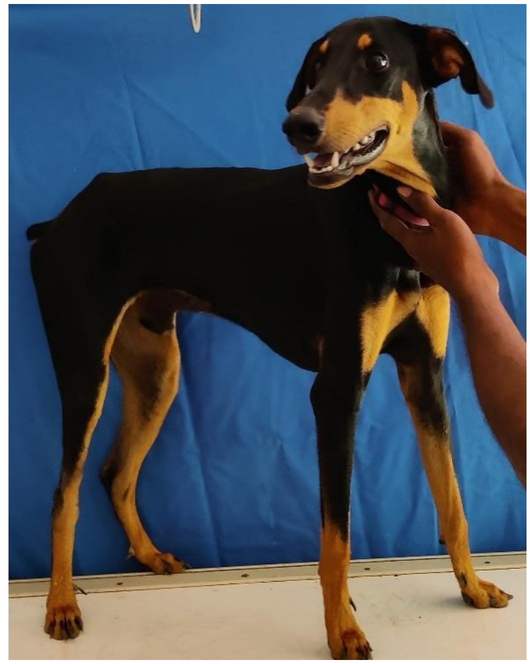
7th post-operative day **30th post-operative day** **45th post-operative day**

60th post-operative day **90th post-operative day**

Fig. 4.12 Case No.4 – Progressive weight bearing of right hind limb on different post-operative days.

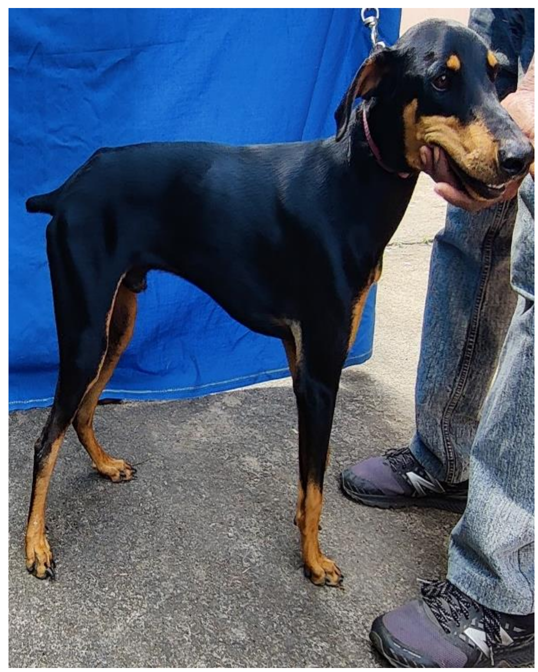


15th post-operative day



30th post-operative day

60th post-operative day



90th post-operative day

Fig. 4.13 Case No.5 – Progressive weight bearing of right hind limb on different post-operative days.

15th post-operative day **30th post-operative day**

45th post-operative day **60th post-operative day**

Fig. 4.14 Case No.7 – Progressive weight bearing of right hind limb on different post-operative days.

Fig. 4.15 Case No.3 – Progressive weight bearing of left hind limb on 30th post-operative day.

7th post-operative day **15th post-operative day**

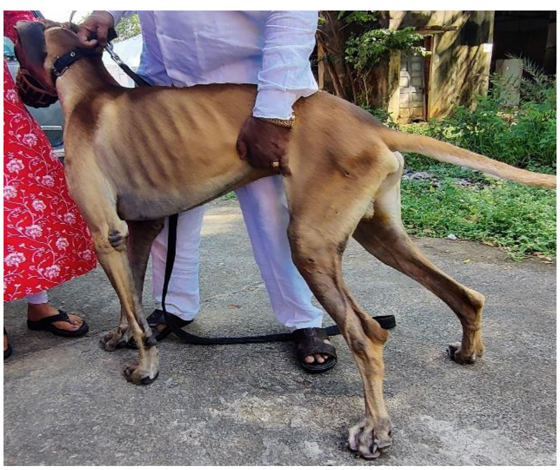
Fig. 4.16 Case No.2 – Progressive weight bearing of right hind limb on different post-operative days.

7th post-operative day

10th post-operative day

30th post-operative day

45th post-operative day



60th post-operative day

90th post-operative day

Fig. 4.17 Case No.6 – Progressive weight bearing of left hind limb on different post-operative days.

4.8.2 Post-operative Radiographic Observations

Post-operative radiographic evaluation confirmed proper placement of the intramedullary interlocking nail and screws, good apposition and proper alignment of the fracture fragments in all the seven dogs (Fig.4.18 and 4.19). An additional cerclage wiring was applied in one dog (case no.2) along with intramedullary interlocking nail to immobilize the large wedge fracture fragments. Length of the pin and screws, their size and position were appropriate in all cases. Sequential post-operative radiographs showed progressive bone healing. Post-operatively no screw loosening was observed in any of the cases.

Follow-up radiographs obtained on the 15th post-operative day depicted proper position and good alignment of the fracture fragments in all dogs and presence of periosteal callus seen in five out seven cases and minimum to no callus in remaining two cases. However the radiolucent fracture line was still discernible in all the cases.

Radiographs obtained on the 30th post-operative day showed evidence of callus formation in all dogs. The callus was opaque and smooth. Radiolucent fracture line was faintly visible. The closure of fracture gap and presence of complete bridging periosteal callus was seen in almost all cases.

Radiographs obtained on the 60th post-operative day revealed dense callus of reduced size; fracture line barely visible and corticomedullary remodeling (stage of early clinical union).

Radiographs obtained on the 90th post-operative day revealed distinct cortico-medullary separation caused by remodeling; fracture line not visible. The various stages of radiographic healing are depicted in Fig.4.18-4.27

Case 1 Case 2 Case 3 Case 4

Case 5 Case 6 Case7

Fig.4.18 Immediate Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (medio-lateral view).

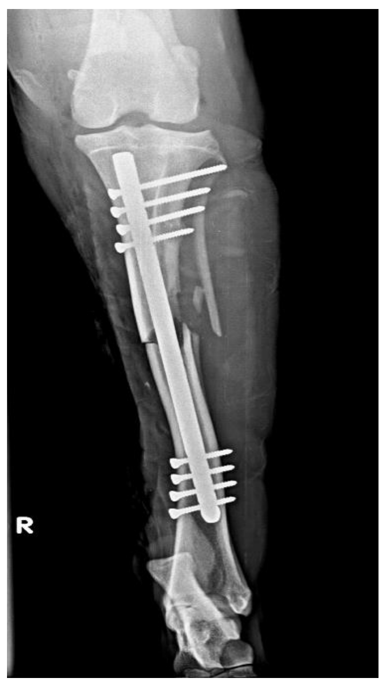

Case 1


Case 2


Case3


Case 4


Case 5



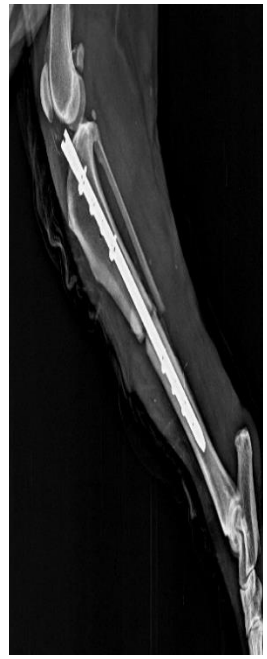
Case 6


Case 7

Fig.4.19 Immediate Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (cranio-caudal view).

Case 1

Case 2



Case 3

Case 4

Case 5

Case 6

Case7

Fig.4.20 15th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (medio-lateral view).

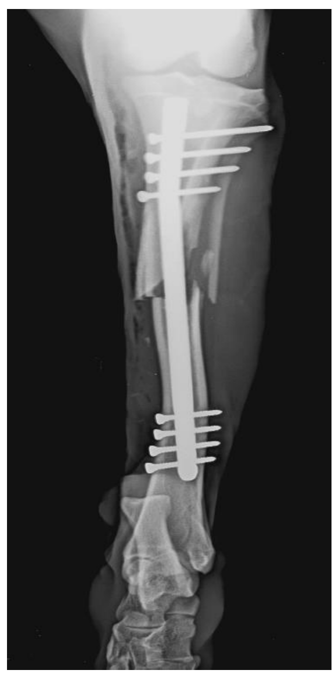
Case 1

Case 2

Case3

Case 4

Case 5



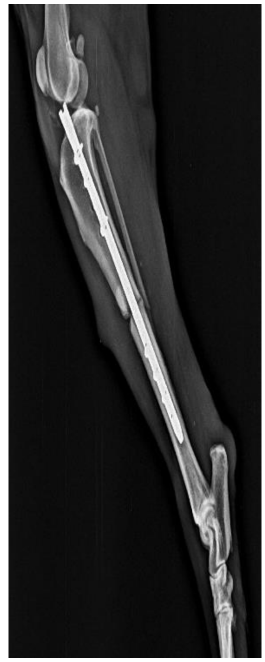
Case 6

Case 7

Fig.4.21 15th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (cranio-caudal view).

Case 1

Case 2



Case 3

Case 4

Case 5

Case 6

Case7

Fig.4.22 30th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (medio-lateral view).


Case 1


Case 2


Case3


Case 4


Case 5


Case 6


Case 7

Fig.4.23 30^{th} day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (cranio-caudal view).

Case 1

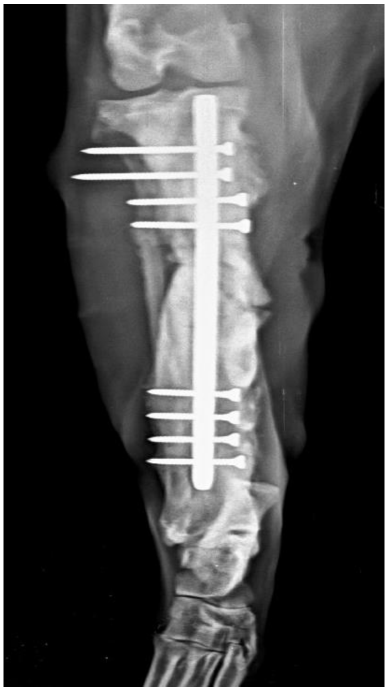
Case 4

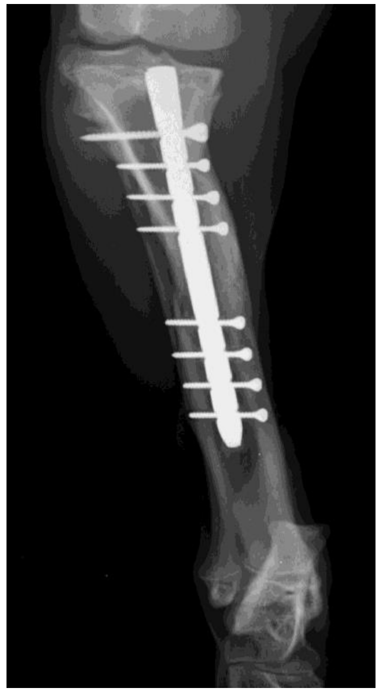
Case 5

Case 6

Case7

Fig.4.24 60th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (medio-lateral view).


Case 1


Case 4


Case 5


Case 6


Case7

Fig.4.25 60th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (cranio-caudal view).

Case 1

Case 4

Case 6

Case 7

Fig.4.26 90th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (medio-lateral view).

Case 1

Case 4

Case 6

Case7

Fig.4.27 90th day Post-operative radiographs of dogs with tibia fractures stabilized with intramedullary interlocking nail (cranio-caudal view).

4.8.3 Haematological Observations

The mean ± SE values of haematological parameters of haemoglobin, packed cell volume, total erythrocyte count, total leukocyte count and differential leukocyte counts are presented in Table 4.4. Standard statistical analysis was done using one way ANOVA as described by Snedecor and Cochran (1994) using statistical package for the social sciences (SPSS) 15 software package.

4.8.3.1 Haemoglobin (g/dL)

The mean ± SE values of hemoglobin on day before surgery and on 15^{th} ,30^{th} and 60^{th} day of surgery were found to be 13.89 ± 1.45, 13.77 ± 1.16, 14.07 ± 0.92 and 14.10 ± 1.42 respectively. Standard statistical analysis by one-way ANOVA method revealed that there was no significant difference ($P > 0.05$) among the four intervals. Highest value 14.10 ± 1.42 g/dL was observed on 60^{th} post-operative day, whereas the lowest value 13.89 ± 1.45 g/dL was observed on day before surgery.

4.8.3.2 Packed Cell Volume (%)

The mean ± SE values of packed cell volume on day before surgery and on 15^{th}, 30^{th} and 60^{th} day of surgery were found to be 38.49 ± 2.00, 38.73 ± 1.65, 39.59 ± 1.37 and 41.16 ± 0.85 respectively. No significant difference ($P>0.05$) was observed among the packed cell volumes between four intervals. Highest value of 41.16 ± 0.85 % was observed on 60^{th} post-operative day, whereas the lowest value 38.49 ± 2.0 % was on the day before surgery.

4.8.3.3 Total Erythrocyte Count ($x10^6$ /µL)

The mean ± SE values of total erythrocyte count on day before surgery and on 15th, 30th and 60th day of surgery were found to be 5.37 ± 0.23, 5.54 ± 0.27, 5.66 ± 0.16 and 5.77 ± 0.17 respectively. No significant difference (P>0.05) was observed among the total erythrocyte count between four intervals. Highest value 5.77 ± 0.17 x 10^6 /µL was observed on 60th post-operative day, whereas the lowest value 5.37 ± 0.23 x 10^6 /µL was on day before surgery.

4.8.3.4 Total Leucocyte Count ($x10^3$ /µL)

The mean ± SE values of total leucocyte count on day before surgery and on 15th, 30th and 60th day of surgery were found to be 13.06 ± 0.69, 12.24 ± 0.37, 11.79 ± 0.38 and 10.79 ± 0.44 x 10^3/ µL respectively. No significant difference (P>0.05) was observed among the total leucocyte count between four intervals. Highest value 13.06 ± 0.69 x 10^3 /µL was observed on day before surgery, whereas the lowest value 10.79 ± 0.44 x 10^3 /µL was on 60th post-operative day.

4.8.3.5 Neutrophil Count (X 10^3 cells/µL)

The mean ± SE values of neutrophil count on day before surgery and on 15th , 30th and 60th day of surgery were found to be 7.9 ± 0.36, 7.67 ± 0.52, 7.31 ± 0.25 and 6.80 ± 0.37 x 10^3 cells/ μL respectively. No significant difference (P>0.05) was observed among the neutrophil count between four intervals. Highest value 7.9 ± 0.36 X 10^3 cells/ μL was observed on day before surgery, whereas the lowest value 6.80 ± 0.37 X 10^3 cells/ μL was on 60th post-operative day.

4.8.3.6 Lymphocyte Count (X 10^3 cells/μL)

The mean ± SE values of lymphocyte count on day before surgery and on 15th , 30th and 60th day of surgery were found to be 2.14 ± 0.21, 2.31 ± 0.21, 2.57 ±0.17 and 2.73 ± 0.17 X 10^3 cells/ μL respectively. No significant difference (P>0.05) was observed among the lymphocyte count between four intervals. Highest value 2.73 ± 0.17 X 10^3 cells/ μL was observed at 60^{th} post-operative day, whereas the lowest value 2.14 ± 0.21 X 10^3 cells/μL was on day before surgery

4.8.3.7 Monocyte Count (X 10^3 cells/μL)

The mean ± SE values of monocyte count on day before surgery and on 15^{th}, 30^{th} and 60^{th} day of surgery were found to be 0.21 ± 0.02, 0.19 ± 0.03, 0.17 ± 0.03 and 0.15 ± 0.02 X 10^3 cells/μL respectively. No significant difference (P>0.05) was observed among the monocyte count between four intervals. Highest value 0.21 ± 0.02 X 10^3 cells/μL was observed on day before surgery, whereas the lowest value 0.15 ± 0.02 X 10^3 cells/μL was on 60^{th} post-operative day.

4.8.3.8 Eosinophil Count (X 10^3 cells/μL)

The mean ± SE values of eosinophil count on day before surgery and on 15^{th} , 30^{th} and 60^{th} day of surgery were found to be 0.19 ± 0.012, 0.16 ± 0.012, 0.13 ± 0.011 and 0.04 ± 0.008 X 10^3 cells/μL respectively. No significant difference (P>0.05) was observed among the eosinophil count between four intervals. Highest value 0.19 ± 0.012 X 10^3 cells/μL was observed on day before surgery, whereas the lowest value 0.04 ± 0.008 X 10^3 cells/μL was on 60^{th} post-operative day.

Table 4.4 Haematological parameters (Mean ± SE)

Parameter	Pre – operative	Post –operative		
	0^{th} day	15^{th} day	30^{th} day	60^{th} day
Hb (g/dL)	13.89±1.45	13.77±1.16	14.07±0.92	14.10±1.42
PCV (%)	38.49±2.0	38.73±1.65	39.59±1.37	41.16±.085
TEC (x 10^6 /µL)	5.37±.0.23	5.54±0.27	5.66±0.16	5.77±0.17
TLC (x 10^3/µL)	13.06±0.69	12.24±0.37	11.79±0.38	10.79±0.44
Neutrophils (x10^3cells/µL)	7.90±0.36	7.67±0.52	7.31±0.25	6.80±0.37
Lymphocytes (x10^3cells/µL)	2.14±0.21	2.31±0.21	2.57±0.17	2.73±0.17
Monocytes (x10^3cells/µL)	0.21±0.02	0.19±0.03	0.17±0.03	0.15±0.02
Eosinophils (x10^3cells/µL)	0.19±0.012	0.16±0.012	0.13±0.11	0.04±0.008

4.8.4 Serum Biochemical Evaluation

The mean ± SE values of biochemical parameters of serum alkaline phosphatase, serum calcium and serum phosphorus are shown in Table 4.5.

4.8.4.1 Serum Alkaline Phosphatase (U/L)

The mean ± SE values of serum alkaline phosphatase on day before surgery and on 15th, 30th and 60th day of surgery were found to be 99.43 ± 1.70, 130.57 ± 2.38, 120.49 ± 4.10 and 100.14 ±1.40 U/L respectively. No significant difference (P>0.05) was observed among the serum alkaline phosphatase between four intervals. Highest value was 130.57 ± 2.38 observed on 15th post-operative day, whereas the lowest value on day before surgery which was 99.43 ± 1.70.

4.8.4.2 Serum Calcium (mg/dL)

The mean ± SE values of calcium on day before surgery and on 15th, 30th and 60th day of surgery were found to be 9.63 ± 0.28, 10.07 ± 0.44, 9.55 ± 0.45 and 9.36 ± 0.30 mg/dL respectively. No significant difference (P>0.05) was observed among the serum calcium between four intervals with highest value recorded i.e., 10.07 ± 0.44 on 15th post-operative day.

4.8.4.3 Serum Phosphorous (mg/dL)

The mean ± SE values of phosphorus on day before surgery and on 15th, 30th and 60th day of surgery were found to be 5.28 ± 0.25, 5.30 ± 0.27, 5.33 ± 0.16 and 5.39 ± 0.17 mg/dL respectively. There was no significant variation in serum phosphorus levels post-operatively and the values were within the normal range.

Table 4.5-Serum biochemical parameters (Mean ± SE)

Day	Alkaline Phosphatase (U/dL)	Calcium (mg/dL)	Phosphorous (mg/dL)
0	99.43±1.70	9.63±0.28	5.28±0.25
15	130.57±2.38	10.07±0.44	5.30±0.27
30	120.49±4.10	9.55±0.45	5.32±0.16
60	100.14±1.40	9.36±0.30	5.39±0.17

4.9 POST-OPERATIVE COMPLICATIONS

One complication was observed in a dog on 15^{th} postoperative day, in which dog showed signs of mild to moderate weight bearing lameness. Up on radiographic examination revealed that nail was slightly bent above fracture site near screw area in the proximal fracture fragment this was due to weight and hyperactivity of the dog

CHAPTER V

DISCUSSION

The term "fracture" refers to a discontinuity in the connective tissue, bone, or cartilage (Newton and Nunamaker, 1985). The main objective of any fracture fixation is too rigid stabilization of fracture fragments, maintaining both limb length and alignment, restoring the function of the affected bone and the soft tissue and obtaining a cosmetically acceptable appearance. (Gautier *et al.* 1992, Aron, 1998 and Perren, 2002). The type of fracture repair stabilization system selected is based on the animal's size and age, the fracture configuration biological considerations, and the owner's financial resources. There are several methods of fracture stabilization internally by bone plating (McLaughlin and Roush, 1999), intramedullary nails (Hulse and Aron, 1994 and McLaughlin, 1999) and interlocking nails (Muir and Johnson, 1996 and Singh *et al.* 2007).

The bone plates and screws and interlocking nails are the most common methods of fracture stabilization. The outcome of surgical treatment associated with fracture cases are directly related to selecting the effective treatment protocols and appropriate fixation devices. Therefore in fracture treatment, it is important to choose an implant system or fixation device which are capable of neutralizing all the fracture forces at the site and allowing rapid bone healing.

Unlike bone plates, interlocking nails fully support the concepts of biological osteosynthesis, which suggest that in the treatment of long bone shaft fractures, soft tissue protection and restoration of blood flow to bone fragments are more important than anatomical reconstruction.(Aron *et al.* 1998) and have advantages over other techniques (Klemm and Borner, 1986). Also, interlocking nailing may be a less invasive alternative to plating since it protects the periosteal blood supply (DeCamp *et al.* 2016).

Intramedullary interlocking nail (IILN) was first introduced in humans in 1974 (Kempf *et al*. 1985). In veterinary orthopaedics, the same technique has been implemented, and in the femur, tibia, and humerus, IILN has proven to be a viable method of fracture fixation. (Muir *et al.* 1993).

All forces acting on fractures are resisted by intramedullary interlocking nails (IILN). The locking bone screws or bolts offer axial and rotational support, while the nail provides bending support (Bernarde *et al.* 2001). Interlocking nails are introduced into the medullary canal and secured with screws or cross-locking bolts in the proximal and distal fracture fragments (static mode) or solely on the proximal or distal fracture fragments (dynamic mode) (Dueland *et al.* 1999).

Intramedullary Interlocking nails are utilised in the repair of both simple and comminuted tibia fractures using the osteosynthesis procedure (Raghunath and Singh, 2002). IILN may be a reliable fracture repair technique. When using the IILN approach, the required length of the proximal and distal regions of the fractured bone must be preserved for fixing transverse locking screws. Although interlocking nails are most commonly used to treat closed fractures, they can also be utilised to treat open and infected fractures (Dueland *et al.* 1999 and Moses *et al.* 2002).

The method presented reduces blood loss during the treatment, speeds up healing and limb function recovery, and reduces the risk of complications such infections or incomplete bone union. Plate osteosynthesis is a longer operation than intramedullary nail fracture repair. The ILN technique, being a biological osteosynthesis method, minimises disruption to the fracture site's blood supply (Dueland *et al.* 1999).

The IILN system is useful because it prevents the fracture from collapsing. Periosteal stripping is decreased and is kept to a minimum. When compared to plating, there is less disruption to the blood flow. Other advantages include increased load-sharing capabilities, decreased implant failure rate, and resistance to bacterial infections. Resistance to torsional forces is attributed to the spring back mechanism, whereby, a construct under reasonable torsional loads deforms drastically and then returns to its previous shape after the load is diminished (Roush and McLaughlin, 1999 and Dueland *et al.* 1999).

The present study entitled "A Clinical study on repair of tibial fractures using intramedullary interlocking nail in dogs" was contemplated to study the clinical outcome of intramedullary interlocking nail for the treatment of the tibial fracturein dogs.

5.1 ANAMNESIS

During the period of present study, a total of 80 clinical cases of long bone fractures were recorded in dogs during the period of the study. Out of these 80 cases, fractures involving tibia were encountered in 12 cases (15%). Out of these 12 cases, seven dogs that were considered suitable for the study were selected and the fracture fixation was performed using intramedullary interlocking nail. This findings was in accordance with Philips (1979), Kushawaha *et al.* (2011), Eyarefe and Oyetayo (2016) and Keosenthong *et al.* (2019) who reported prevalence of tibial fractures as 14.8%, 12.8%, 10.26% and 11.2% respectively and this was in relation to others who reported the incidence as 18.81%, 17.16% ,18.61% and 19.05% by Balagopalan *et al.* (1995), Aithal *et al.(*1999), Rhanghani (2014) and Saini *et al*. (2017) respectively

In contrary to results of the study, the incidence of tibial fractures reported as 26%, 27.39%, 21.5% and 22% by Harasen (2003), Umarani (2004), Ali (2013) and Libardoni *et al.* (2016) respectively. Maala and celo (1975) reported 2.4% and Singh *et al*. (2015) reported 36.8% as tibial fracture incidence among other bone fractures in dog.

The results of the present study showed that the age of the dogs presented with tibia fractures ranged from 9-42 months with a mean of 19.86 ± 5.10 months. This findings was in agreement with Phillips (1979), Boone *et al.* (1986), Rhanghani (2014) and Kumar *et al.* (2020). Varied observations were made in the study Simon *et al.* (2010).

In the present study one dog was Labrador Retriever (14.29%), one was German Shepherd (14.29%), one was Great Dane (14.29%), one was Mongrel (14.29%), one was Doberman (14.29%) and two were Golden Retrievers (28.57%). However, these results differed from the findings of Singh *et al.* (2015) and Keosenthong *et al.* (2019) in which most fracture cases were seen in nondescript breeds

In the present study six out of seven dogs were male indicating that fractures were more common in males than in females. This findings was in agreement with

Maala and celo (1975), Phillips (1979), Umarani (2004), Raghunath (2007), Rhanghani (2014), Singh *et al.* (2015), Saini *et al.* (2017) and Kumar *et al.* (2020). This could be due to the territorial and roaming behavior of the male dogs which made them exposed to traumatic injuries. In contrary fracture incidence reported as 45% in male dogs, 53% in bitches and 2% in unspecified sexes by Eyarefe and Oyetayo (2016)

The body weight of the dogs in the study ranged from 12-40 kg with a mean of 24.43±3.70 kg. Varied observations were made in the study of Raghunath (2007) were the medium weight dogs (10-20 kg) most commonly affected.

Out of seven dogs the main cause of fractures was found to be trauma due to automobile accidents in four (57.14%) dogs and followed by fall from height in three (42.85%) dogs which concurred with the findings of Phillips (1979), Raghunath *et al*. (2007), Ali (2013), Singh *et al*. (2015), Libardoni *et al*. (2016), Saini *et al*. (2017) and Kumar *et al*. (2020). Varied observations were made in the study of Rhanghani (2014) where unknown trauma was principal cause of fracture followed by motor traffic accidents, human abuse, animal bites, falls and indoor trauma.

5.2 PRE-OPERATIVE OBSERVATIONS

In the present study, the clinical signs of fracture noticed were pain on manipulation, abnormal angulation and lameness. Other symptoms included non-weight bearing, swelling, dangling of the affected limb and crepitation at the fracture site on physical examination. Because affected animals were reluctant to move the leg, they often appeared to have abnormal proprioceptive responses. Similar observations were recorded by Wong (1984), Johnson and Boone (1993), Roush *et al*. (1998), Kumar (2007), Johnson (2013) and Chaurasia *et al*. (2019)

All the fractures were closed type of fractures. De Camp (2003) stated that the bulk and mild compression of a Robert Jones bandage provide excellent temporary support for an injured extremity before or after surgical intervention and reduced swelling.

In the present study, the medio-lateral and cranio-caudal radiographs facilitated well in diagnosing the type of fracture encountered. This is also reported by Newton (1985), Smith (1988), Hulse and Johnson (1997), Roush and McLaughlin (1999), Eisenberg and Johnson (2015), Hammond (2016), Piermattei *et al.* (2016) and Fossum (2019) who recommended that, two orthogonal views of the concerned bone should be obtained for proper fracture treatment planning.

Preoperative radiographs revealed 4 mid-diaphyseal (57.14%), 2 proximal diaphyseal (28.57%) and 1 distal diaphyseal (14.29%) fractures. Out of seven dogs in the present study 2 dogs had complete short oblique fractures (28.57%), 3 dogs had complete transverse fractures (42.86%), one dog had a complete spiral fracture (14.29%) and one dog had a complete communited fracture (14.29%). These finding were in congruence with Aithal *et al*. (1999) stated occurrence of tibia fracture is more in the middle and proximal third of the diaphysis Harasen (2003) reported that 61% of all tibial fractures were diaphyseal, 62% of tibial diaphyseal fractures were simple transverse or oblique, while 38% were comminuted. Rhangani (2014) mentioned that common types of fractures encountered were complete simple transverse fractures (65%), followed by oblique (15%) and comminuted (5%) fractures.

In contrary to the findings Zaal and Hazewinkel (1996) reported that oblique fracture being the most frequent among diaphyseal tibial fracture. Simon *et al.* (2010) stated incidence of tibia fractures as proximal diaphysis (68.5 %), middle third (32.4%) and distal (19.01 %).

5.3 PATIENT PREPARATION, ANAESTHESIA AND POSITIONING

The affected limb was aseptically prepared by clipping the hair from a wide area surrounding the fracture site, taking care to include the upper and lower joints. The operative site was shaved and scrubbed using povidone iodine surgical scrub, followed by application of surgical spirit.

Anaesthetic protocol with atropine sulphate as pre-anaesthetic, dexmedotomidine as premedicant, induction with propofol infusion and maintenance with isoflurane gas in 100% oxygen was considered satisfactory for surgical procedure. Similar protocol were adopted by so many researchers in their studies like Morgan and Legge (1989), Kuusela *et al.* (2001), Kuusela *et al.* (2003), Tsai *et al*. (2007), Ahmad *et al*. (2013), Bustamante *et al.* (2018) and Hampton *et al.* (2019)

Positioning of the dogs in lateral recumbency with the fractured limb down and the contralateral limb secured out of the way facilitated satisfactory surgical intervention. Application of sterile drape to expose only the affected limb and covering the limb with sterile bandage cloth distal to the tarsus facilitated handling of the limb without contamination during surgery.

5.4 IMPLANT USED

In the present study in 5mm, 6mm, 7mm and 8mm intramedullary interlocking nails and cortical screws were used for repair of tibial transverse, oblique, spiral and comminuted diaphyseal fractures proved adequate for fracture reduction and immobilization without infections. Other researchers who worked on intramedullary interlocking technique reported that it is advantageous over other immobilization techniques for repair of oblique, spiral and comminuted diaphyseal fractures of tibia over conventional techniques, Georgiadis *et al.* (1990), Denny (1991), Dueland and Johnson (1993), Muir *et al.* (1993), Endo *et al.* (1998), Dueland *et al.* (1999), McLaughlin (1999), Roush and McLaughlin (1999), Raghunath and Singh (2002), Duhautois (2003), Beale (2004), Horstman *et al.* (2004) Wheeler *et al.* (2004), Glyde and Arnett (2006), Patel *et al.* (2007), Patil *et al.* (2008), Raghunath and Singh (2008), Piórek *et al.* (2012), Varshneya *et al.* (2012), Raghunath *et al.* (2012), Déjardin *et al.* (2012), Arican *et al.* (2017), Déjardin *et al.* (2020), Beale and McCally (2020) and Jagan and Dilip (2021).

5.5 SURGICAL TECHNIQUE

The cranio-medial parapatellar approach with extension of incision distally over the tibial diaphysis provided good exposure of the fracture fragments with minimal soft tissue disruption was found satisfactory. This approach was also reported by Lipowitz *et al.* (1993), Duhautois (2003), Johnson and Dunning (2005), Ruedi *et al.* (2007), Johnson and Schaeffer (2008) and Déjardin *et al.* (2012).

5.6 POST-OPERATIVE CARE AND MANAGEMENT

In the present study, dressing the surgical wound with 5% povidone iodine pads was found to be effective in keeping the site clean in all the dogs. Restriction of the movement of the animal for 10 days and then to allowing the dog on leash walking prevented postoperative trauma. This is in congruence with Tobias (1995), Denny and Butterworth (2000), De Camp (2003), Johnson (2013) and Nicetto *et al*. (2013). Robert-Jones bandage was applied for ten days after surgery for all the dogs in the present study decreased postoperative edema of the limb. This was also reported by Fossum (2019). In the present study, ceftriaxone was found satisfactory in preventing post-operative infection in all the dogs. Surgical wounds healed well in all the dogs without any complications.

5.7 EVALUATION OF FRACTURE HEALING

5.7.1 Post-operative Lameness Grading

Post-operative lameness grading showed gradual improvement to normal weight bearing over the period of study. The lameness grade was carried out in accordance with the protocol developed by Vasseur *et al.* (1995). Lameness grading based on weight bearing recorded in all the dogs post-operatively.

All the seven dogs in the present study showed partial weight bearing on 1st post-operative day. All dogs showed normal weight bearing at rest, while the weight bearing of the affected limb while walking was observed on 3rd post-operative day in two dogs,

4^{th} post-operative day in two dogs, 7^{th} post-operative day in one dog, 10^{th} post-operative day in one dog and 45^{th} post-operative day in one dog.

All animals showed lameness grade V preoperatively based on weight bearing recorded before surgical repair of the fracture. Post-operatively, grade I lameness was achieved in four dogs by 30^{th} post-operative day, two dogs by 60^{th} post-operative day and one dog (case no.6) progressed to grade II by the end of 90^{th} post-operative day due to instability but, showed satisfactory radiographic healing on 60^{th} post-operative day.

5.7.2 Post-operative Radiographic Observations

Radiographic evaluation which was carried out on 0^{th}, 15^{th}, 30^{th}, 60^{th} and 90^{th} post-operative days to assess the status and condition of fracture apposition, alignment and healing showed good apposition of the fracture ends. Radiographic evaluation of fracture healing was routinely performed at the time of expected clinical union. (Piermattei *et al.* 2016 and Langley-Hobbs 2003).

According to Henry (2007), post-operative imaging is necessary for proper evaluation of the reduction and alignment of the fracture as well as placement of orthopaedic devices and at least two orthogonal views were required to interpret the location of bony structures and orthopaedic devices accurately.

Primary bone healing with minimal callus formation was noticed in case five. Similar observations were made by Anderson *et al.* (2002).

Follow-up radiographs obtained on the 15th post-operative day depicted proper position and good alignment of the fracture fragments in all dogs however the radiolucent fracture line was still discernible in all the cases. (Langley-Hobbs 2003 and Guiot and Dejardin 2011).

Radiographs obtained on the 30th post-operative day revealed bridging callus. The callus was smoother and opaque. Radiolucent fracture line was faintly visible with progressive cortico-medullary continuity with unstructured and patchy mineralization of bridging callus, these findings are similar to Chawla *et al.* (1982) and Hudson *et al*. (2009).

Radiographs obtained on the 60th post-operative day revealed dense callus of decreasing in size, fracture line disappeared and the callus became radio-dense with restitution of cortico-medullary continuity. These findings were also reported by Aikawa *et al.* (2018).

Radiographs obtained on the 90th post-operative day revealed completed bone healing with distinct cortico-medullary continuity caused by remodeling of excess callus. These findings are in agreement with Piermattei *et al.* (2016) and Aikawa *et al.* (2018).

5.7.3 Haematological Observations

The mean ± SE values of haemoglobin and packed cell volume did not differ significantly ($P > 0.05$). The Haemoglobin levels and packed cell volume on the 15th, 30th and 60th post-operative days were higher when compared to the day before surgery. However, all the values were within the normal physiological limits throughout the course of the present study. This could be due to physical stress during the fracture, blood loss during surgery, and haemodilution and anaesthetic during the internal fixing procedure. These findings are in agreement with the findings of Singh *et al.* (2017) and Patil *et al.* (2017).

The mean ± SE values of total leukocyte count did not differ significantly (P > 0.05). Highest value was observed on pre-operative day before surgery when compared to post-operative days. Physiological reduction in total leukocyte count was reported to be suggestive of gradual decrease in inflammatory reaction (Maiti *et al.*1999). Leukocytosis occurred in conditions where there was corticosteroid release in state of stress, pain, anaesthesia, trauma and surgical manipulation, decrease in total leukocyte count was reported to be suggestive of gradual decrease in inflammatory reaction. This was in correlation with Chaurasia *et al.* (2019) and Marvania *et al.* (2020).

The mean ± SE values of differential leucocyte count The differential leucocyte count like neutrophil count decreased on 15^{th}, 30^{th} and 60^{th} post-operative days when compared to pre-operative day before surgery in all the cases which did not differ significantly. This may be due to reduced inflammatory response which led to progressive fracture healing without any exudation similiar findings reported by Patil *et al.* (2017), Chaurasia *et al.* (2019), Reddy *et al.* (2021) and Yadav *et al.* (2021).

The mean ± SE values of the lymphocyte count was increased on 15^{th}, 30^{th} and 60^{th} post-operative days when compared to pre-operative day before surgery which did not differ significantly. Neutropenia with relative lymphocytosis indicated gradual decrease of inflammatory reaction Patil *et al.* (2017) and Chaurasia *et al.* (2019). .

The mean ± SE values of the monocyte and eosinophil count were higher pre-operatively when compared to the postoperative observation period in all the cases.

However, it fluctuated within normal physiological limits. These findings were in agreement with the findings of Tembhurne *et al.* (2010), Reddy *et al.* (2021) and Yadav *et al.* (2021).

5.7.4 Serum Biochemical Observations

Biochemical parameters such as serum calcium, inorganic phosphorus, alkaline phosphatase, and C-reactive protein could be used to assess bone growth and pain. Biochemical parameters along with clinical and radiographical examination provide sound knowledge on the degree of bone healing Phaneendra *et al.* (2016) and Kumar *et al.* (2018)

The serum alkaline phosphatase values increased from pre-operative day to 15th day and thereafter, the levels decreased reaching normal by 60th day which did not differ significantly (Maiti *et al.* 1999). Increase in serum alkaline phosphatase level may be due to increased chondroblastic proliferation to cause bone formation during the repair of fractured bone and also maximum contribution was from the periosteum of destructed bone which is a rich source of alkaline phosphatase. These findings were in concurrence with those of Singh *et al*. (1976), Hedge (2010) and Yadav *et al.* (2021).

The serum calcium mean values showed highest value on 15th day followed by decrease in the values and reaching normal at 60th day of post-operative interval period which did not differ significantly. The serum calcium level in all the animals fluctuated within normal physiological range. This could be due to severe trauma with unstable fractures. The present observations are in accordance with those of Bush (1991), Nagaraja *et al.* (2003) and Reddy *et al.* (2021).

The serum phosphorous mean values showed no significant variation post-operatively and the values were within the normal range. The present observations are in accordance with those of Siemesen (1970), Singh *et al.* (1976), Uma Rani and Ganesh (2003) and Mahendra *et al*. (2007).

5.8 POST-OPERATIVE COMPLICATIONS

Among the fixation of tibia fractures with intramedullary interlocking nail in seven dogs, one dog (Case no. 6) had post-operative complication in which in nail bending was observed on 15th post-operative day this might be due to heavy weight and hyperactivity of the animal. Durall and Diaz (1996), Dueland *et al*. (1999), McLaughlin (1999), Suber *et al*. (2002), Duhautois (2003), Durall *et al.* (2003), Horstman *et al.* (2004), Wheeler *et al.* (2004), Patel *et al.* (2007), Raghunath and Singh (2008) and Arican *et al.* (2017)

5.9 IMPLANT REMOVAL

In the present study, no implants were removed during or after the period of evaluation. This is in accordance with Mc Laughlin (1999), Larin *et al.* (2001), Duhautois (2003) and Déjardin *et al.* (2014) who stated that implant removal is not necessary unless complications occur. Raghunath and Singh (2008) stated that dogs with implant in situ had good limb function. However, Muir *et al.* (1993) and Endo *et al.* (1998) recommended implant removal is necessary if they interfere with normal motion of the animal.

5.10 CONCLUSION

Based on the present study, it was concluded that intramedullary interlocking nail was successful in the treatment of tibia fractures and offered remarkable improvement in the limb function with good fracture stability till the completion of the bone healing in six out of seven dogs. Though radiographs on 90th postoperative day revealed complete bone healing in case 6, but animal showed normal weight bearing at rest, favors affected limb while walking (grade II lameness). The use of intramedullary interlocking nail fixation in the treatment of tibial diaphyseal fractures was found to be effective as it provided resistance against axial, bending and torsional forces acting on the bone.

CHAPTER VI

SUMMARY

The present clinical study on the treatment tibial fractures using intramedullary interlocking nailing was conducted in seven dogs presented to, the Department of Surgery and Radiology, College of Veterinary Science, Rajendranagar, Hyderabad. The cases were diagnosed by clinical and radiographic examinations.

The age of these seven dogs ranged from 9 months to 42 months. Out of these dogs, one dog was female and six dogs were male. Among the seven dogs, one was a Labrador Retriever, one was a German Shepherd, one was a Great Dane, one was a Mongrel, one was a Doberman and two were Golden Retriever. The body weight of the dogs ranged from 12-40kg.

The symptoms observed in the dogs presented for treatment were pain on manipulation, abnormal angulation, dangling of the limb, lameness immediately after traumatic injury, non-weight bearing lameness and crepitation at the fracture site.

Pre-operative radiographic examination in two orthogonal views, i.e., cranio-caudal and medio-lateral radiographs revealed tibial fractures. Out of seven dogs in the present study pre-operative radiographs showed 2 dogs had complete short oblique fractures, 3 dogs had complete transverse fractures, one dog had a complete spiral fracture and one dog had a complete communited fracture. All the seven dogs had closed fractures.

Out of seven dogs, three dogs were treated with 120mm, 140mm and 160mm length of 5.0mm diameter interlocking nails, two dogs were treated with 160mm and 180mm length of 6.0mm diameter interlocking nails. One dog treated with 7.0mm intramedullary interlocking nail of length 200mm and 8.0mm diameter interlocking nail of length 220mm was used in one dog. The length and thickness of nail to be used was determined by the length of the bone and diameter of medullary cavity at isthmus region as measured from the medio-lateral radiographs. The lengths of screws were determined by measuring the trans-cortical diameter of the bone at different regions from the cranio-caudal radiographs obtained pre-operatively.

Cranio-medial and parapatellar approach was used, which provided good exposure of the fracture site and enabled good fracture fixation.

Post-operative radiographs taken immediately after the surgery revealed satisfactory fracture reduction and good alignment of the fracture fragments in all the seven dogs. Follow-up radiographs taken on 15th, 30th, 60th and 90th post-operative days revealed either secondary bone healing with periosteal bridging callus or primary bone healing with minimal callus formation.

All the dogs which were diagnosed for tibial fractures showed grade V lameness before surgical management. Post-operatively, four cases progressed to grade I lameness by 30th post-operative day and two cases progressed to grade I lameness by the 60th post-operative day. One case progressed to grade II lameness by the end of 60th post-operative day. Fracture fixation using intramedullary interlocking nail with cortical screws resulted in remarkable improvement with normal limb function. Good implant stability throughout the treatment period without any complications was achieved in six of seven dogs. In one dog nail bending was noticed on 15th post-operative day.

The mean ± SE values of haemoglobin level and packed cell volume did not differ significantly (P >0.05). Haemoglobin level and packed cell volume on the 15th, 30th and 60th post-operative days were higher when compared to pre-operative day before surgery. The total erythrocyte count was elevated by the 60th post-operative day when compared to pre-operative day before surgery which did not differ significantly. The progressive increase of haemoglobin level, packed cell volume and total erythrocyte count post-operatively days indicated erythropoiesis. However, the values were within the normal range.

The total leukocyte count was higher on the day before surgery when compared to the post-operative period which did not differ significantly. Physiological leucocytopenia seen was suggestive of gradual decrease in inflammatory reaction. The differential leucocyte count like neutrophil was decreased on 15th, 30th and 60th post-operative day when compared to the day before surgery in all the cases. Contrary to this, the lymphocyte count was statistically increased on 15th, 30th and 60th post-operative days. This indicated gradual decrease of inflammatory reaction. However, they were within normal physiological limits of different post-operative days in all the cases. The monocyte count was higher on the pre-operative day when compared to post-operative days in all cases. However, it fluctuated within normal physiological limits. Also, eosinophil count between different post-operative days fluctuated within normal physiological limits.

The serum alkaline phosphatase and serum calcium values increased from day before surgery to 15th day and there after reached to normal values by 60th post-operative day which did not differ significantly. The increased serum alkaline phosphatase levels during the first two weeks indicated increased chondroblastic proliferation to cause bone formation during fracture repair. The serum phosphorous values showed no significant variation and the values were within the normal range.

There was complication associated with intramedullary interlocking nail in which nail bending was noticed in case 6 by 15th post-operative day due to heavy weight and hyperactivity of the dog.

Based on results of present study, it was concluded that intramedullary interlocking nail was used successfully in the treatment of tibial fractures and offered good recompense and remarkable improvement in limb function in six out of seven dogs. The intramedullary interlocking nail was found to facilitate a more reliable and function with enhanced conformation to bone. Its biomechanical properties permitted resistance to axial, torsional and bending forces which provided early return to function of dogs affected with tibia fractures with minimal complications were noticed.

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