# Management of Radius Ulna Fracture in Clinical Canine Patients

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*Prakash Chandra Ghadei*

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# CERTIFICATE-I

This is to certify that the thesis entitled **"Management of Radius ulna fracture in clinical canine patients"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Veterinary Science (Veterinary Surgery & Radiology)** to the Orissa University of Agriculture and Technology is faithful record of bonafide and original research work carried out by **Prakash Chandra Ghadei** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by him from various sources during the course of investigation has been fully acknowledged.

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# CERTIFICATE-II

This is to certify that the thesis entitled **"Management of Radius ulna fracture in clinical canine patients"** submitted by **Prakash Chandra Ghadei** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **Master of Veterinary Science (Veterinary Surgery & Radiology)** has been approved/disapproved by the students' advisory committee and the external examiner.

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Ghadei
20.7.16

**(Prakash Chandra Ghadei)**

**Bhubaneswar**

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# ABBREVIATION

| | |
|---|---|
| $^0C$ | degree centigrade |
| $^0F$ | degree farenheit |
| ALP | Alkaline phosphatase |
| ANOVA | Analysis of variance |
| AP | Antero-posterior |
| b.i.d | twice daily |
| B. Wt | body weight |
| Ca | calcium |
| Cm | centimetre |
| CT | computerized tomography |
| Cu | cubic |
| dl | decilitre |
| DLC | differential leucocyte count |
| e.g | example gratia |
| EDTA | Ethylenediaminetetraceticacid |
| et al | Et alibi |
| Fig | Figure |
| g or gm | Gram |
| h or hrs | Hour or Hours |
| Hb | Haemoglobin |
| i.e | id est |
| i.m | Intramuscular |
| Inj | Injection |
| IU/L | International unit per litre |
| i.v | Intravenous |
| IP | Intramedullary pinning |

| | |
|---|---|
| Kg | kilogram |
| Kgf | kilogram factor |
| Lit | litre |
| MRI | magnetic resonance imaging |
| mg | milligram |
| mg/dl | milligram per decilitre |
| mg/kg | milligram per kilogram |
| ML | medio-lateral |
| Min | minutes |
| mm | milimeter |
| no | number |
| P | phosphorus |
| PCV | packed cell volume |
| Rs. | rupees |
| s.c. | subcutaneous |
| S.E | Standard Error |
| s.i.d | once daily |
| TEC | total erythrocyte count |
| TLC | total leucocyte count |
| Viz | namely |
| Vs | versus |

# ABSTRACT

The present research work was carried out in the department of veterinary surgery and radiology in collaboration with teaching veterinary clinical complex and department of veterinary surgery , college of veterinary science and animal husbandry , OUAT , Bhubaneswar. The research work was divided in two parts. In part-a retrospective study was carried out in dogs having long bone fractures presented at the clinic during last three years(201-201), while in part-b include study on clinical cases of radius ulna fracture in dogs. Furthermore , in part-b was divided in three groups in which group I comprised of 6 dogs suffering from radius ulna fractures were immobilized by radius plating. In group-II, 6 dogs suffering from radius ulna fractures were immobilized by pinning of ulna. In group-3, 6 dogs suffering from radius ulna fractures were immobilized by both intramedullary pinning and plating. Different parameters were observed before immobilization of fracture(considered as day '0' then at 30 and 60 day after immobilization).Last three years (2014-2016)retrospective information retrieved by scrutinizing the data bank of the teaching veterinary clinical complex,OUAT, Bhubaneswar. A total of 14,069 new cases were registered outwhich, 3821(27.15%) cases were surgical. The incidences of orthopedic maladies were 24.91 per cent of the total canine surgical cases. Out of 340 orthopedic cases, 177 (52.05%) cases were of fractures. Out of total fracture cases, maximum cases of fracture were in canine followed by bovine, caprine, avian, feline, and other species of animals. Amongst all bones, femur fractures were most common fracture followed by tibia-fibula, radio-ulna and other. In dogs were observed higher incidences of fracture in males and in the age group of below 1 year aged. In canine according to line of fracture mid-shaft fracture were higher in number as compared to proximal and distal third. Majority of fractures occurred due to road accidents followed by fall from height and other etiology. Modified Thomas splint was the choice of treatment for repair of long bone fracture in dogs during three years. The highest numbers of fracture cases in dogs were recorded in mansoon season.In clinical study of dogs with fracture, physiological and haemopathological parameters were found within normal range expect the significance different was noticed in rectal temperature, respiratory rate, neutrophils count and total leucocyte count. No significance variation were observed in the serum calcium and phosphorus values during fracture healing while serum alkaline phosphate level increased upto $30^{th}$ day after immobilization and returned back to normal level by day 60. The radiology union was almost similar in dogs of all the groups. No significant different was observed in time to reach maximum value of callus index between all groups indicating that all methods were equally effective for fracture healing on radiopathic evaluation.

# CHAPTER-1

# INTRODUCTION

# 1. INTRODUCTION

Bone is a dynamic and a specialized connective tissue of the endoskeletal animal which provides support and shape to the body. Bone is considered to be the 2nd hardest tissue of the body after Enamel. But it is also one of the most dynamic and one of the most sensitive tissues (Freemont, 1998). Long bones (e.g. femur, tibia, radius and humerus) are longer in one dimension than in the other and consist of a shaft, distal and proximal ends.

In long bones, the shaft is called the diaphysis and each extremity is called an epiphysis. The metaphysis is the joining point of the diaphysis and epiphysis. Between the diaphysis and epiphysis of growing bones is a flat plate of hyaline cartilage called the metaphyseal plate. The medullary cavity (medulla, "innermost part") is the space in the diaphysis containing bone marrow. The fibrous covering surrounding part of the bone not covered with articular cartilage is called the periosteum.The periosteum by histological examination reveals 2 layers of connective tissue. The lower layer is having osteochondrocytes which benefits to the healing procedure of fracture.The endosteum is the cellular tissue lining of the medullary cavity of the bone. Each bone consists of compact and cancellous part. Compact part is found on the surface of bones forming a protective outer coating. Cancellous part of found on the interior (Constantinescu, 2002).

The most common ailment encountered in routine clinical practice pertaining to the bone is fracture. Fracture is defined as the discontinuity in the connective tissue, bone and/or cartilage (Nunamaker, 1985).

In animal, fractures are mainly caused by the trauma. The history of fracture cases frequently reveals massive trauma like struck by an automobiles, stepping into hole while running, or catching a legs in gate or fence. Mechanical forces such as compression, bending and twisting can also cause long bone fractures (Adams and Fessler, 1996). The fracture in animals invariably causes pain and suffering to them apart from loss of functions of their affected limb.

The evidences of the long bone fractures in dogs were comparatively higher than other species of animals. Canines were affected more (41.40%) followed by bovine (17.10%), feline (11.40%), ovine (15.70%) and caprine (8.50%). Incidences of facture were more in age group of below three months (45.71%). Males (55.40%) were affected more than females (44.60%). Incidence of simple fracture were highest (21.40%) followed by compound (15.70%) and multiple (4.20%). Among all the fractured bones, fracture of

tibia was highest (22.85%) followed by humerus (18.57%), femur (15.71%), radius (12.85%), metacarpal (10.00%) and metatarsal (7.14%) (Abdulrahman *et al.*, 2003).

The primary goal of fracture treatment is to achieve a healed fracture with anatomic reduction, stable fixation, and early function (weight bearing) of the affected limb (Dudley *et al.*, 1997). In treating a fractured bone the ultimate aim of an orthopaedic surgeon is to realign fragments, maintain the anatomical structure and retain the fragments in position for longer duration for initiation of healing processes aligned by simplest effective fixation technique, resulting into early return to normal locomotory function.

The various fracture fixation techniques are being used in small animal practice which includes both internal and external immobilization of fractured bone. Each technique has its own merits and demerits.

External fixation is a very useful method of treating the bone fracture. The economy and availability of this technique continue to make external fixation as the most frequently used method for fracture repair of long bones (Tulleners, 1986) and most of lower limbs fractures heal with normal casting (Merck, 2006).

Plaster of Paris in bandage form or slab form is still the most common material used for immobilization of injured limbs. It is inexpensive and can be used with ease to produce a smooth, conforming and safe cast (Parsons, 1991). Increased setting time, hygroscopic nature, increased break-down rate and heavy weight of casted limb are the disadvantages of Plaster of Paris cast (Wilson and Vanderbay, 1995; Avasthi *et al.*, 2012).

The introductions of polyurethane (PU) resin impregnated fiberglass bandages are likely to have a significant effect on modern orthopedic practice. The fibre glass casts have many improved properties compared to Plaster of Paris bandages, such as high strength to weight ratio, rapid setting time and high radiolucency. The fiberglass bandages are mechanically superior and offer numerous advantages over Plaster of Paris for use as the definitive casting material for both weight-bearing and non-weight bearing casts (Wytch *et al.*, 1987). A stokinette must be used while applying a fiber glass cast and the surgeon should wear a protective gloves.

Internal fixations of fractures with intramedullary pins achieve early stability at the cost of bone vascularity and open fractures, increases the risk of infection. Early motion of the joints is allowed but weight bearing is not permitted. Theintramedullary pinning

methods do not protect fracture sites from rotational forces though they are good in resisting bending forces.

**OBJECTIVES :**

Present work was proposed with following objectives :

- To study incidences of long bone fractures in dogs presented to the department of Surgery &Radiology and to the TVCC.
- To evaluate the comparative efficacy of internal and external immobilization technique for radius-ulna fractures in dog.
- Radiographic evaluation of clinical union of fracture fragment.

# CHAPTER-2

# REVIEW OF LITERATURES

# II. REVIEW OF LITERATURE

Bone is a rigid form of specialized connective tissue that serves as a supportive, protective and locomotive system for the body. Bone is considered to be the hardest tissue of the body. But it is also one of the most dynamic and one of the most sensitive tissues. Bone is comprised of a cortex with the majority of the tissue being bone matrix (Freemont, 1998). The factor that distinguishes bone from the rest of the body tissues in the body is the process of mineralization that the matrix undergoes (Ross *et al.,* 1995). Bones of the body are furthermore classified in five categories based on its structure and shape, such as long bones, short bones, irregular bones, flat bones and pneumatic bones (Freemont, 1998). Long bones (e.g. femur, tibia and humerus) are longer in one dimension than in the other and consist of a shaft (diaphysis), distal and proximal ends known as epiphysis.

## 2.1 Anatomy of long bone

Long bones are bones that are longer than they are wide. Long bones are characterized by an elongated shaft and somewhat enlarged extramities that bear articular surfaces. Examples of long bones include the humerus, radius, femur, tibia, metacarpal and metatarsal (Marieb, 2003).

In long bones, the shaft is called the diaphysis and each extremity is called an epiphysis. The epiphysis consist mostly of cancellous bone with a thin outer coat of compact bone. It is generally enlarged relative to the diaphysis. The metaphysic is the joining point of the diaphysis and epiphysis. Between the diaphysis and epiphysis of growing bones is a flat plate of hyaline cartilage called the epiphyseal plate. After growth is complete, the plate is replaced by the epiphyseal line. The medullary cavity (medulla, "innermost part") is the space in the diaphysis containing bone marrow. At the joint surface on the bone is an articular surface consisting of a smooth layer of hyaline cartilage that covers the epiphysis where one bone forms a joint with another bone (Constantinescu and Constant inescu, 2004).

The fibrous covering surrounding part of the bone not covered with articular cartilage is called the periosteum. It consists of dense irregular connective tissue. Its innermost layer consists of an osteogenic layer containing osteoblasts (bone germinators) that make new bone, and osteoclasts that break down bone. The periosteum contains nerve fibers, lymphatic vessels, and blood vessels that supply the bone. The periosteum is attached to the underlying bone by Sharpey's fibers extending from the fibrous layer into

the bone matrix. There is a high density of Sharpey's fibers where tendons and ligaments attach to the periosteum. The endosteum is the fibrous and cellular tissue lining the medulary cavity of the bone. The internal surfaces of the bone are covered with the endosteum. The endosteum lines the medullary cavity in long bones and covers the trabeculae of spongy bone (Constantinescu, 2002).

Each bone consists of compact and cancellous part. Compact part, also called dense or cortical, is a term describing solid-looking bone. Compact part is found on the surface of bones forming a protective outer coating. Cancellous part is found on the interior. Cancellous bone, also called spongy bone, consists of a network of pieces of bone called trabeculae or spicules. Interspersed with spaces filled with red or yellow bone marrow. Spongy bone predominates in short, flat and irregular bones, as well as in the epiphysis of long bones. It is also found as a narrow lining of the medullary cavity of the diaphysis of long bones. The epiphyses consist mostly of cancellous bone with a thin outer coat of compact bone (Constantinescu, 2002).

## 2.2 Part :A (Retrospective study)

Singh *et al.* (1983) studied incidence and anatomical location of fractures in 511 clinical cases of canine, caprine, bovine, equine and camels. Most of the fractures were recorded in the age group of one to three years in bovine and caprine while in canine and equine occurrence of fractures were more in young animals below one year of age. There were high incidences of humerus (7.30%), radius and ulna (18.70%) and femur (19.00%) fractures in different animals.

Aithal *et al.* (1999) carried out epidemiological survey of fractures in 402 dogs. They found that number of males affected (63.00%) were significantly more than the females (37.00%). Majority of the fractures (54.00%) were recorded in young animals aged below one year. The occurrence was highest in non-descript indigenous breeds. The causes of trauma were mainly automobile accidents (46.86%) and fall from height (39.11%). Among different types of fractures, oblique/spiral fractures (54.46%) were significantly higher than comminuted (16.57), transverse (14.86%), incomplete (6.57%) and multiple (5.14%) fractures. Of all the long bones, the highest number of fractures were seen in femur (38.56%) followed by tibia-fibula (17.16%), radio-ulna (16.92%) and humerus (7.71%). In all long bones, incidence of diaphyseal fractures was more than

epiphyseal/metaphyseal fratures. Middle and distal third of the diaphysis were more commonly affected in radius-ulna, tibia-fibula and femur and radio-ultra.

Rao *et al.* (1999) conducted a survey of 5,328 cases of canine fractures and reported that, approximately 83 per cent of fractures were seen in dogs of 3 years age. Among the different breeds German Shepherd (26.80%), Doberman (11.20%), Great Dane (7.10%), Labrador Retriever (6.60%), Pomeranian (9.70%), Dechshund (8.20%), Cocker spaniel (3.60%) and Non-descript (27.10%) per cent were recorded. They also reported that, the fracture was more in males (66.12%) compared to females (33.88%). In their survey, they reported higher incidence of female fracture (21.39%) followed by tibia and fibula fractures (17.69%) and radius fracture (14.58%), respectively.

Dvorak *et al.* (2000) studies the incidence of long bone fractures in 200 dogs and reported that the Mongrels (21.79%) were the most commonly affected, followed by German Shepherd (5.13%), Yorkshire Terrier (3.21%). Dalmatian (3.85%), Staffordshire Terrior (3.21%), Fox Terrier (1.92%). Miniature Pincscher (1.92%), Piccolo Levriero Italiano (1.28%), Papillon (1.28%). The age of the dogs varied from two months to 14 years with an average of 2.03 ± 2.52 years. Ninety-five dogs (60.90%) were males and sixty-one (39.10%) were females. The most commonly broken bones were radius and ulna (28.66%), followed by tibia and fibula (28.05%), femur (25.00%) and humerus (18.29%). One hundred and fifty long bone fractures were closed (91.46%) cases) and fourteen fractures were open (8.54% cases). These 164 long bone fractures from 200 fracture cases were classified based on localization and type of fracture line: diaphyseal complex (26.83%), diaphyseal transverse (25.61%), metaphyseal and/or physeal and/or epiphyseal extraarticular (17.07%), metaphyseal and/or physeal and/or epiphyseal intraarticular (15.85%), and diaphyseal oblique or spiral (14.64).

Harsen (2003) carried out analysis of long bone fractures in 282 dogs. He reported that femur was the most often fractured bone accounting for 45 per cent of the total fracture cases whereas 26 per cent cases were that of tibia-fibula. It was observed that almost 3 of every 4 long bone fractures occur in hind limb. Fractures of radio-ulna accounted for 16 per cent whereas humerus was the least fractured bone accounting for only 13 per cent of the total cases.

Rani *et al.* (2004) studied 85 cases of fracture in dogs and observed that the incidences of fracture were more common in younger animals group less than one year of

age (58.82%). Fracture incidences were highest in the age group between and 9 months (22.35%) followed by 4 and 6 months (16.47%). Incidences of fracture were higher n males (71.76%) than in females (28.24%) and maximum fractures were recorded in radius and ulna (29.41%) followed by femur (28.23%) and tibia (24.5%).

Kumar *et al.* (2007) conducted a study among a total of 310 fractures cases in growing dogs. It was reported that in 35 per cent cases of fractures was caused by a fall/jump from a height and in 15 per cent cases a traffic accident was cause of the fracture. Among the different breed of growing dogs affected with fractures, 35 per cent were spitz and 28 per cent were indigenous dogs. Fractures were significantly more frequent in males than in females, 63 per cent of the fractures involved pelvic limbs and 37 per cent involved pectoral limbs.

Bhatia (2010) reported clinical epidemiology of orthopaedic maladies in dogs based on breed sex, age and nature of pathology. Out of 486 orthopaedic cases which were reported at Teaching Veterinary Clinical Service Complex, Anand during 2007-2009, 378 (77.78%) cases were of fractures followed by 42 (8.65%) cases of rickets, 36 (7.40%) cases of hip dysplasia, 18 (3.70%) cases of osteoarthritis and 12 (2.47%) cases of dislocations. The age wise study revealed that majority of the orthopaedic maladies were seen in dog aged below 1 year of age accounting for 234 cases (48.14%). Followed by a high number of cases of 114 (23.45%) between 1 to 3 years. Then a gradual decline was seen in cases of orthopaedic maladies as the age of the dog increased. Breed wise incidence showed maximum cases of orthopaedic maladies in non-descript dogs, i.e., (186; 38.27%) followed by German Shepherd (102; 20.98%), Spitz (84; 17.28%), Doberman (48; 9.87%) and Labrador Retriever (36; 7.40%), whereas in other breeds the incidence was much less (30; 6.17%). Sex wise incidence showed majority of the cases, i.e., (294; 60.49%) were of males, whereas those of females accounted for (192; 39.51%). Among different bones, the highest number of fractures were seen in radius-ulna (29.36%) followed by femur (28.30%), tibia-fibula (23.80%) and humerus (14.55%) whereas incidence of fractures was very less in metacarpals/metatarsals (3.96%).

Kushwaha *et al.* (2011) recorded incidence of fracture and their management in dogs presented with the history and signs of fractures to Veterinary Referral Clinic and Teaching Hospital from September, 2007 to August, 2009. Data were recorded on the basis of breed, sex, age, duration and cause of fractures, limb and bone involved, type of fracture (closed/open), fracture line (transverse/oblique/multiple/comminuted) and the

technique of fixation in each case. Fractures were recorded in 77 dogs out of 1050 surgical cases with an overall incidence of 7.33 per cent. Overall, males were affected more (43; 55.84%) than the females (34; 41.56%). The incidences of fractures were more in Spitz (35.14%) followed by non-descript dogs (27.03%), German shepherd (21.62%), Labrador (5.40%) and other breeds (10.81%). A high incidence of fractures in Spitz dogs could be correlated with their population in this locality. The duration of fractures was 0-2 days in 32 cases (41.56%), 2-4 days in 18 cases (23.37%), 4-6 days in two cases (2.6%), 6-8 days in four cases (5.19%) 8-15 days in five cases (6.50%), and >15 days in cases (18.18%). Young gods (up to two years) were affected more (44; 57.14%) than adults (33; 40.30%). In dogs, fall or jump from height (16; 43.24%) was the main cause of fracture followed by road traffic accident (10; 27.03%). In four dogs, fractures were due to hit by some object; whereas, the cause of fracture was not known in 10 cases. Among different bones, the highest number of ractures were seen in femur (65.00%), followed by radius-ulna (12.5%), tibia-fibula (12.50%), and humerus (10.00%). All fractures were closed except one, which was in humerus due to gunshot (bullet) injury.

Tambe *et al.* (2012) carried out a retrospective study of fracture cases. Out of 200 cases reported, maximum cases were in dogs (26.50%) followed by cattle (25.50%), camels (15.00%), buffaloes (12.50%), horses (8.00%), goats (5.50%), birds (4.50%), rabbits (1.50%) and monkeys (1.00%). Out of total fracture cases, tibial fractures were the major affection amongst all species viz. tibia (27.50%), mandible (15.50%), femur (13.50%), radius and ulna (12.50%), metatarsal (10.50%), humerus (16.00%) and metacarpal (4.50%). Most of the left femur, tibia, metatarsal and humerus bones were affected as compared to right side. Amongst all bones mid shaft diaphyseal fractures (64.00%) were more as compared to proximal third (10.00%) or distal third (18.50%).

Kumar *et al.* (2013) studied the occurrence and pattern of simple and compound fractures of limb bones in different domestic animals. Among the toal 986 fracture cases, more number of compound fractures were observed in dogs, followed by cattle, goats, horses and buffaloes; however, the per cent compound fractures in a particular species was more in cattle (44.00%), followed by horses (32.00%) and buffaloes (24.00%). In cattle, buffaloes, horses and sheep/goats also maximum fractures were recorded up to two years of age.

Singh *et al.* (2005) reported that 0.95 per cent incidence of fracture out of total case in all species of animals. Among them incidences of fracture in dog were 0.76 per cent. Dog was observed as the most common species presented with a fracture followed by goat and other species. The mean age was recorded to be 26.32±5.14 months. Fifteen animals (78.95%) were noticed in age group of 12-36 months. Majority of animals were non-descript (42.10%). Fracture was recorded more in male animals (77.78%). The femur was found to be the most common bone (47.37%) involved in the fracture, seconded by tibia-fibula (36.84%), which was followed by radius-ulna (15.79%). The radiographic examination conducted in two orthogonal views revealed that 14 (73.68%) fractures were multiple whereas, 5 (26.32%) fractures were comminuted.

## 2.3 Fracture diagnosis and classification

Whittick (1974) reported non-weight bearing, limb swelling, pain, crepitus, abnormal proprioception and reluctance to move the limb were the clinical signs in dogs. The author also reported that radiography was extremely useful for the detecting and evaluating fractures, joint diseases, osteoarthritis, neoplasia and congenital joint conditions. The author also opinioned that two orthogonal views were helpful for the diagnosis of fracture as well as fracture healing.

Ozsoy and Altunatmaz (2003) reported that out of six cases of radius fracture three were fractured at the mid-diaphysis and other three were fractured at distal diaphysis in dogs.

Rani *et al.* (2004) recorded 45.88 per cent of transverse fractures followed by 42.35 per cent of oblique fractures among the fractures of radius and ulna. Diaphyseal fractures were common in the distal shaft (40.0%) of radius and ulna in dogs.

Aithal *et al.* (1999) reported 50 per cent oblique fractures, 20.61 per cent comminuted fractures, 33.33 per cent transverse fractures, 4.55 per cent incomplete fractures and 1.52 per cent others among the 402 cases of fractures of radius and ulna in dogs.

Mahesh and Ranganath (2011) evaluated the efficacy of different configurations of external skeletal fixation in 18 clinical cases of dogs with radial fractures; Based on fixator stability, pain evaluation, weight bearing, patient tolerance and radiographic assessment of fracture healing, it was found that external skeletal fixator frames could be easily applied for the treatment of radial fractures. Common orthopaedic affections

encountered in dogs were long bone fractures. Among the long bones, radius and ulna (antebrachium) were predisposed for external trauma as they were the major weight bearing bones and have minimum amount of soft tissue covering. The highest incidences of fractures have been reported in radius and ulna constituting about 29.36 per cent of the cases.

Rovesti *et al.* (2007) studied 49 cases of radial fracture and observed that 20 were open and 29 were of closed type. 17 cases had comminuted type of fracture in dogs.

Henry (2002) described fractures according to location, direction, complete or incomplete status, number of fracture lines, displacement and open or closed status in dogs. Diaphyseal fractures of the long bones were described by dividing diaphysis into 1/3 proximal, distal or mid-diaphyseal. Metaphyseal fractures were described as involving the proximal or distal metaphysic. Direction of the fracture were described as transverse, oblique or spiral depending on the angle of the fracture lines relative to the long axis of the bone. According to the number of fracture lines, the fracture can be classified as simple having only one fracture line and dividing bone into two main fragments or comminuted which has more than one fracture line that communicates to a single point or pane and divides the bones into three or more fragments.

Grant and Olds (2003) classified open fractures according to the mechanism of puncture and the severity of soft tissue injury in dogs. Type 1 (First Degree) fractures were bone penetrating the skin from within, minimal muscle damage, and the fracture was usually simple (two piece), but not always. Type II (Second Degree) fractures were more extensive than type I, with a wound longer than one centimeter that communicates with the fracture. These fractures were cause by high energy force and therefore usually have moderate soft tissue and muscle damage. Type III (Third Degree) fractures were caused by high energy trauma resulting in a severe wound. There was massive soft tissue damage that often has accompanying los of bone and soft tissue. Type IIIa fractures requires no major plastic reconstructive surgery to cover bone or to close the wound. Type IIIb fractures do require reconstructive surgery because remaining viable soft tissue were insufficient for primary closer. Type IIIc open fractures were a major arterial injury that requires repair. Type IV (Fourth Degree) was an open fractures involving amputation or near amputation of the limb. Severe soft tissue damage and neurovascular injury were present.

Denny and Butterworth (2006) described classification of fracture based on anatomical location, external wounds, extent of bone damage, direction of fracture line, relative displacement of the bone fragments and stability in canine and feline. According to the anatomical location fracture might be proximal, distal or diaphyseal. The proximal or distal fractures were further subdivided into articular, epiphyseal, physeal or metaphyseal fractures. Fractures of the physis were divided into six types. Diaphyseal fractures could be further classified according to the direction of the fracture line or the number of fragments, According to the external wounds fracture might be open or closed, an open fracture was one in which there was a communication between the fracture site and a skin wound. Open fractures were classified as first, second or third degree according to the severity of soft tissue injury and contamination. According to extent of bone damage fracture might be incomplete or complete. According to the direction of fracture line fracture might be transverse, oblique, spiral, comminuted or segmental. According to the relative displacement of the fragment fracture might be avulsion, impacted, compression or depression. According to the stability fracture might be stable or unstable.

Kushwaha *et al.* (2011) conducted a study on the basis of location of fractures in long bones in dogs and reported that it was proximal in 14 cases (17.30%), middle in 28 cases (34.50%) and distal in 39 cases (48.20%). The location of the fracture was more in distal one third (52.50%) followed by midshaft (30.00%) and proximal third (17.50%) of shaft, respectively. Three fractures were incomplete and seen in growing dogs and 74 fractures were complete. The types of fractures on the basis of fractures line, majority of fractures were transverse fractures (60.00%), oblique (35.00%), whereas comminuted fractures accounted for only (5.00%) of the total fractured cases.

## 2.4 Immobilization techniques

### 2.4.1 Premedication and anaesthesia

Dwivedi *et al.* (2009) carried out a management of compound fracture of radius-ulna and tibia-fibula using Hizarov's ring fixator in dogs. In which dog was premedicated with atropine sulphate at the rate of 0.04 mg/kg body weight, i.m., followed by xylazine hydrochloride at the rate of 1 mg/kg body weight, i.m., and diazepam at the rate of 0.2 mg/kg body weight, i.v. General anaesthesia was induced by ketamine hydrochloride at the rate of 10 mg/kg body weight, i.v., and maintained by ketamine hydrochloride using half of the initial dose as and when required via intravenous route.

Mahesh and Ranganath (2011) reported that the dogs were restrained under xylazine hydrochloride sedation (at the dose rate of 0.5 mg/kg body weight) and thiopentone sodium anaesthesia at the dose rate of 25 mg/kg body weight for comparison of three different external skeletal fixators for radius fracture treatment. Preoperatively, ceftriaxone was administered at the dose rate of 20 mg/kg body weight, i.v.

Fizili *et al.* (2008) used trifluprомazine (1.0 mg/kg intramuscular) and atropine sulphate (0.02 mg/kg subcutaneously) for premedication. Anesthesia was induced and maintained with thiopentone sodium (2.5% or 5% intravenously) for dogs undergoing long bone fracture repair.

Pardeshi and Ranganath (2008) premedicated dogs with atropine sulphate at the rate of 0.04 mg/kg body weight, after 10 min, xylazine HCL was administered i.v. 0.5 mg/kg body weight for comparison of external skeletal fixation for tibial fracture repair in dogs. General anaesthesia was induced and maintained by i.v. administration of 2.5 per cent thiopentone sodium given to effect.

Raghunath and Singh (2008) premedicated dogs with butorphanol at the rate of 0.2 mg/kg body weight, acepromazine at the rate of 0.05 mg/kg body weight and glycopyrrolate at the rate of 0.01 mg/kg body and anaesthesia was induced with thiopental sodium (5%) administered, i.v., till effect and maintained on 1-2 percent halothane in oxygen using Boyle's apparatus for intramedullary nailing for management of long bone diaphyseal fractures in 17 dogs.

Ayyappan *et al.* (2009) used atropine sulphate and xylazine HCL at the rate of 0.02 mg/kg and 1.0 mg/kg body weight i.m. respectively, at 10 min interval as preanaesthetics for external fixators for long bone fracture management in dogs. General anaesthesia was induced by administration of ketamine HCL and diazepam intravenously 5mg/kg and 0.1 mg/kg body weight, i.v., respectively, and anaesthesia was maintained by administering sevoflurane.

Bhagat (2009) advocated the use of buprenorphine at the rate of 0.02 mg/kg, i.v., at least 30 minutes prior to surgery for dynamic compression plating for correction of diaphyseal fractures of long bones in dogs. He also used atropine at the rate of 0.04 mg/kg body given, s.c., as a prenaesthetic followed by xylazine at the rate of 1.0mg/kg body weight after a lapse of 5 minutes. Fifteen minutes later, dogs were sedated with diazepam at the dose rate of 0.3 mg/kg body weight to produce muscle relaxation. Immediately,

anaesthesia was induced with ketamine at the rate of 5mg/kg body weight, i.v., to the effect and was maintained on 2 per cent isoflurane in oxygen.

### 2.4.2 External coaptation technique

Wytch *et al.* (1987) demonstrated that the fiberglass bandages were mechanically superior and offer numerous advantages over the plaster of Paris for use as the definitive casting material for both weight-bearing and non-weight-bearing casts. The rate of strength built up of the fiberglass material was rapid enough to allow weight bearing often only 30 minutes.

Kumar *et al.* (1997) conducted clinical study to assess the efficacy of Polyvinyl Chloride (PVC) splints as immobilization material for fracture treatment of metacarpal, radius and ulna, metatarsal and tibia in small ruminant. The splints were applied over the fractured area on the anterior aspect in forelimb and posterior aspect in hind limb for better immobilization and maintained for three weeks.

Manjulkar *et al.* (2004) studied utility of different immobilization materials based on cast and availability of material in the field, plaster of Paris bandage, Newtech cast plaster with slab technique and PVC sheets were used as immobilizing material on fracture area of metacarpal bone in goats. The weight bearing and radiographic studies showed better healing and large callus in PVC sheet treated animal. PVC sheet was best among all with minimum cast, easily available, less time required for application and removal of bandage.

Avasthi *et al.* (2012) compared fibre glass cast and plaster of Paris in 12 goats with closed long bone fracture under sedation with xylazine hydrochloride (0.1 mg/kg body weight, intramuscularly) and stated that fibre glass cast as external immobilizing technique was considered as a better orthopedic modality than plaster of Paris as it provided rigid fixation, despite being light in weight and less time consuming with less complications.

### 2.4.3 Intramedullary panning

#### 2.4.3.1 Preparation and positioning

Gupta (2005) repaired humeral and tibial shaft fractures under image intensifier in dogs, dogs were withheld feed and water for 12 hours prior to surgery and the site was prepared for surgery by clipping and shaving hair.

Raghunath and Singh (2008) withheld feed for 12 hours and water for 6 hours before surgery for intramedullary pinning for management of long bone diaphyseal fractures in 17 dogs. The operative site was prepared aseptically in routine manner.

Rani (2008) repair of canine femoral fracture in which withheld food and water 12 and 8 hours respectively before anaesthesia to prevent anaesthesia complications.

Bhagat (2009) managed a case of dynamic compression plating for correction of diaphyseal fractures of long bones in dogs. In which withholding of feed for 12 hours and water for 8 hours which prevented anaesthesia complications of regurgitation, aspiratory pneumonia as well as contamination of surgical field by faeces and urine. The author also advocated use of buprenorphine at the dose rate of 0.02 mg/kg body weight, i.v., at least 30 minutes prior to surgery for pain management.

Dwivedi *et al.* (2009) withheld feed for 24 hours and water for 6 hours prior to anaesthesia for management of compound fracture of radius-ulna and tibia-fibula using Ilizarov's ring fixator in digs. The forelimb to be operated was ahved from elbow joint to paw and prepared aseptically for surgery.

Bhatia (2010) carried out a clinical studied on application of Ilizarov's technique for immobilization of tibial fractures in dogs. In which 12 hours off-feeding and 6 hours off-watering prior to anaesthesia induction. All dogs were given preoperative antibiotic amoxicillin clavulanate at the rate of 20 mg/kg body weight, i.m., 30 minutes before induction of anaesthesia.

Vedpathak *et al.* (2011) withheld feed for 12 hours and water for 8 hours prior to operative procedure for intramedullary pinning for stabilization of femoral fractures in digs. The site for surgery was prepared by clipping and shaving of hairs from hip joint to stifle joint.

### 2.4.3.2 Surgical technique (Intermedullary pinning)

Hurov and Seer (1968) carried out intramedullary Steinmann pinning of the radius in radial-ulner fractures in the dogs and advocated that retrograde intramedullary pining was best for immobilization of the radial fractures. The purpose of this report has been to indicate that the accepted practice of retrograde intramedullary bone pinning was also quite feasible in the radius. Intramedullary Steinmann pin or Kirschner wire pinning was straightforward when applied to the radius.

Piemattei (1993) suggested that the shaft of the fractures were approached from lateral of the radius-ulna bones in the dog and cat.

Brinker *et al.* (1997) showed that it was advantageous to have the stifle flexed at a right angle and the dog in dorsal recumbency. The pin was to be inserted through the skin and along the medial border of the patellar ligament, entering the proximal end approximately one third to one half the distances from the cranial surface of the tibial tubercle to the medial condyle of the tibia.

### 2.4.3.3 Selection of Steinmann's pin

Hurov and Seer (1968 advocated the use of intramedullary pin in the radial fracture that fills at least 60 to 70 per cent of the medullary cavity of the radius in the dogs. Pins of large diameter which tend to fill the medullary cavity contribute to the stability of the reduced fracture fragments.

Jackson (2004) recommended filling of at least 70 per cent of the medullary canal when pin is used as the only fixation device in the dogs. The larger intramedullary pin gives better fracture stability and implant strength.

Simpson and Lewis (2004) advocated use of intramedullary pin in the radial fractures that fills at least 60 to 70 per cent of the medullary cavity at the isthmus of the diaphysis in the canine and feline.

Piermattei *et al.* (2006) suggested use of intramedullary pin the fills about 50 to 60 per cent of he medullary cavity of tibia in dogs and cats. If the pin was too large it would straighten the S shaped curve of the tibia and cause valgus angulation of the distal tibia and hind paw.

### 2.4.3.4 Reduction of fragments

Kraus *et al.* (2003) observed that hanging the limb was tend to reduce the fracture, of properly performed in the small animals. As the limb extended, the fracture was distracted, the soft tissues of the limb tighten, and the bone fragments were pulled into alignment. The joints proximal and distal to the fracture tended to be brought parallel to each other as well. Pointed reduction forceps could be used to reduce the fracture without crushing or elevating the periosteum or soft tissues. Transverse fractures could be reduced by using periosteal elevator to lever the two fracture fragments into apposition. It was also

possible to place a small temporary K wire across a transverse or short oblique fracture to hold it in alignment.

Piermattei *et al.* (2006) opined that if the goal of fracture treatment is rigid, uninterrupted stabilization of the main fracture fragments, auxiliary fixation (which may include use of lag screw, intramedullary pins, kirshener wires and cerclage or interfragmentary wire configurations) may be helpful in maintaining reduction during insertion of the fixation pins and in aiding rigid stabilization in the small animals.

## 2.5 Cast and intramedullary pin removal and complications

Hurov and Seer (1968) opined that when intra-medullary pin was used as a sole means of fixation, there were increased chances of development of rotationaland axial instability for immobilization of the radial fractures in the dogs. The instability after intra-medullary pinning could lead to non-union and predisposes to osteomyelitis and chances of anchylosis of the carpal joint, there were increased chances of pin tract infection through the protruded pin point.

Simpson and Lewis (2004) reported that when intra-medullary pin was used as a sole means of fixation, there were increased chances of development of rotational and axial instability in small animals. The authors also stated that instability after intra-medullary pinning could lead to non-union and predisposes to osteomyelitis.

Piermattei *et al.* (2006) opined that any instability at the fracture site would invariably cause pin to loosen because of bone resorption and to migrate proximally, sometimes completely out of the bone for repair of long bones in dogs.

Singh *et al.* 2008) observed that complications were more in plaster of Paris cast as compared to fiber glass cast for long bone fracture repair in goats. Erosion of cast at foot exposing the hoof, rope gall and pressure point bites were found in some animals with plaster of Paris cast while only pressure point sore were seen in one animal with fiber glass cast.

Boyd *et al.* (2009) stated that compartment syndrome was the most serious complication of casting or splinting in different species of animals. It was a condition of increased pressure within a closed space that compromises blood flow and tissue perfusion and causes ischemia and potentially irreversible damage to the soft tissues within that space. Thermal injuries to the skin can occur as a result of the casting or splinting process. Skin breakdown was the most common complication, often caused by focal pressure from

a wrinkled, unpadded or under padded area over a bony prominence or underlying soft tissue. Bacterial and fungal infections or pruritic dermatitis can develop beneath a splint or cast.

Avasthi *et al.* (2012) carried out the clinical study on efficacy of plaster of pans and fiber glass casts for repair of long bone fractures in goats. They observed complications were more in plaster of Paris cast as compared to fiber glass cast. The incidence of breakage of the cast in four cases and displacement of bamboo splints in two cases were seen only with plaster of Paris cast whereas the fiber glass cast remained intact during the clinical study. Stiffness of joint in three cases and shortening of limb in one case were seen in plaster of Paris cast whereas only in one case shortening of limb was observed in fiber glass cast.

## 2.6 Parameters investigated in fractures

### 2.6.1 Etiology of fracture

Aithal *et al.* (1999) reported that the major cause for fracture of radius and ulna was falling from a height (53.1%) and automobile accidents (34.69%).

Rao *et al.* (1999) recorded the cause for long bone fracture in canines, which included road traffic accidents (22.66%), fall from height (43.06%), animal interaction (11.73%) and crush injury (22.54%).

Abdulrahman *et al.* (2003) carried out a retrospective study of fracture cases of 19 years during 1984-2002 at University of Maiduguri, Nigeria. Total 70 cases of fracture were recorded in species of animals. The associated causes of the trauma resulting in the fracture cases included; automobile accident, (25 cases; 35.70%), falling from height, (2 cases; 2.80%), hit by object (4 cases; 5.70%), and trauma (5 cases; 7.10%).

Rani *et al.* (2004) observed 68.24 and 31.7 per cent of cases of fractures in dogs due to automobile accidents and falling from a height, respectively.

Tambe *et al.* (2012) carried out the retrospective study on the incidence of fractures in 200 different species of animals. The fracture occurred mainly due to read accidents in 103 animals (51.50%) which was followed by other reasons viz. due to falling down in 50 animals (29.50%), dog bite in 15 animals (7.50%), fighting in 14 cases (7.00%), extra pulling in three cases (1.50%), improper transport and struggling in two

cases each (1.00% each) while trap device and hit with stick in one case each (0.50% each).

Kommayer *et al.* (2014) carried out a retrospective study on long term prognosis of metacarpal and metatarsal fractures in 100 dogs. The most common histories of the dogs included in the study were motor vehicle accidents (33.00%) followed by jumps or falls (21.00%), unknown trauma (21.00%), falling objects (11.00%), dog interactions (6.00%), being stepped on by a horse or owner (5.00%), and bites (3.00%).

Singh *et al.* (2015) reported that 0.95 per cent incidence of fracture out of total case in all species of animals. Among that incidence of fracture in dog was 0.76 per cent. An automobile accident (42.10%) emerged to be the major cause of fracture, whereas a fall from height (31.58%) was second common cause of fracture.

### 2.6.2 Clinical parameters

Aithal *et al.* (1998) observed the elevated heart rate and respiratory rate post-operatively in dogs undergoing supracondylar femur fracture treatment.

Chandy (2000) reported that the treatment of femur fractures with external skeletal fixators resulted in increased rectal temperature along with local warmth of the effected region of the limb. He opined that, the rise in temperature might be due to osteomyelitis.

Srinivasamurthy (2000) reported that there was rise in temperature, heart rate and respiratory rate up to third post-operative day in dogs treated for femur fracture. The author opined that these changes might be due to reparative inflammatory process occurring at the fracture site of surgical wound.

Pardeshi (2007) reported in his study of external skeletal fixation for tibial fracture repair, there was a significant elevation of temperature, heart rate, pulse rate and respiratory rate between first and third post-operative days and subsequently returned to normal.

### 2.6.3 Local parameters (at fracture site)

Nayak *et al.* (2012) carried out the clinical study on a four years old female mongrel dog weighing about 18 kg body weight was presented with a history of accident and lameness on right forelimb. Physical examination by palpation revealed crepitation and pain of right elbow.

Singh *et al.* (2015) carried out the clinical study on a one year old non-descript male dog was presented with the history of non-weight bearing lameness of right hind limb since four days, after accident with car. Palpation of the right thigh region indicated pain, swelling and crepitus.

### 2.6.4 Haematological analysis

Benjamin (1998) reported that neutrophilia and lymphocytopenia might be seen as a response of the body to stress and inflammation.

Julie (2005) noticed no significant variation in white blood cell (WBC), erythrocyte sedimentation rate (ESR), neutrophil, lymphocyte, monocytes and cosinophil counts but found significant increase in heamoglobin (Hb) by fourth post-operative week in dogs undergone radius and tibial fracture treatment using external skeletal fixator.

Pardeshi (2007) evaluated the physiological parameters in dogs and reported that, there was no significant variation in haemoglobin (Hb) and total erythrocyte count (TEC). Monocyte, eosinophil and basophil counts were within the normal range but there was a significant neutrophilia, leuocytosis and lymhocytosis upto third post-operative day of fracture repair which could be due to inflammatory process originated at the fracture site.

Singh *et al.* (2008) conducted the study on correction angular deformities after wedge osteotomy and stabilized with circular external skeletal fixator. The authors recorded in their study the haemoglobin (Hb), total protein (TP), packed cell volume (PCV) and calcium did not show any significant variation from the base values and there was increase in phosphorous and alkaline phosphatase levels in the plasma.

Tembhurne *et al.* (2010) studied management of femoral fracture with the use of horn peg in canine. The hematological parameters viz. Hb, TEC, TLC, PCV and DLC were recorded on 0 day, 1$^{st}$, 10$^{th}$, 20$^{th}$ and 45$^{th}$ post operative day. The hematological parameter viz. Hb, TEC, TLC, PCV, eosinophils, monocytes and basophils were within normal physiological range throughout the study. How ever there was a non significant increasing trend of neutrophillia and a significant lymphocytopenia on 10$^{th}$ day.

Avasthi *et al.* (2012) carried out the clinical study on efficacy of plaster of paris and fiber glass casts for repair of long bone fractures in goats. The hematological parameters viz. Hb, TEC, TLC, PCV and DLC were recorded on 0, 15$^{th}$, 30$^{th}$, 45$^{th}$ and 60$^{th}$ post operative day. The hematological parameter viz. Hb, TEC, TLC, PCV and monocytes

were within normal physiological range. Significant increase in neutrophils, lymphocytes and eosinophils were observed at 15$^{th}$, 30$^{th}$, 45$^{th}$ and 60$^{th}$ day when compared with 0 day.

Manjunatha and Raghunath (2012) treated six dogs of different breeds, between age groups of 1 to 7 yrs with diaphyseal femur fractured by using c-arm guided interlocking nailing technique. The mean values of haemoto-biochemical parameters during the study were within the normal range in all the stages and changes in values were non significant. This indicates that fixation technique used in the group could not have any influence no haemato-biochemical parameters.

### 2.6.5 Biochemical parameters

Bone contains nearly all of the body's source of calcium and 80 per cent of the phosphorus (Banerjee, 1998). The normal ratio of Ca to P in animals is approximately 2:1 in the blood stream. The levels of calcium, phosphorous as well as alkaline phosphotase vary during the process of bone healing.

Pandey and Udupa (1980) reported that there were no significance changes in serum calcium level after fracture in dogs, while serum phosphorous and alkaline phosphatase level showed significant rise from 5-23 days and 7-30days after fracture, respectively.

Akhare (1997) reported that no significant alternations were observd in serum calcium and alkaline phosphatase levels in healing process of long bone fracture in goats. However, serum alkaline phosphatase level increased initially and then decreased gradually. He also opined that biochemical studies did not give the firm base for faster healing process.

Manjulkar (2000) observed serum calcium, phosphorous and alkaline phosphatase level in the long bone fracture in the goats. Progressive elevation of level of calcium was seen from day 0-30 days, while phosphorous and alkaline phosphotase levels increased up to 15 day after fracture. All the three parameters showed a declining trend till 45$^{th}$ day after fracture.

Chaudhary *et al.* (2000) studied biochemical changes during compound tibial fracture managemet using lizarov's circular external skeletal fixature in dogs. They observed no significant differences in serum calcium and phosphorus level. There was gradual increase in serum alkaline phosphates level from the pre-operative day to 30-34 post operative day followed by decline up to 60 days.

Saraswathy *et al.* (2004) evaluated biochemical changes in experimentally created fracture in dogs. The result showed no significant change in serum calcium and phosphorous level during different stages of fracture healing. But there was a highly significant elevation in serum alkaline phosphatase level in all the animals up to third post-operative week.

Hegade *et al.* (2007) studied biochemical parameters during fracture healing in 24 dogs at 0, 15, 30, 45 and 60 days interval. They concluded that biochemical parameters like serum calcium and inorganic phosphorus levels fluctuated within normal limits. Except serum alkaline phosphatase which was significantly increased on operative day when compared to post-operative days.

Singh *et al.* (2010) estimated serum calcium, phosphorus, vitamin A and alkaline phosphatase in plaster of Paris and fibre glass group in long bone fractures of goats, the serum calcium level increased up to 30 days then returned to 0 day value at 45 days, the phosphorus level elevated up to 15 day and declined up to 45 days. Alkaline phosphatase increased on 15 day then returned close to 0 day value on 45 day in both groups.

Avasthi *et al.* (2012) estimated serum calcium, phosphorous and alkaline phosphatase during clinical study on efficacy of plaster of paris and fiber glass casts for repair of long bone fractures in goats. Significant increase in serum calcium values were observed on $15^{th}$, $30^{th}$, $45^{th}$ and $60^{th}$ days compared to '0' day in both the groups. Non-significant differences were observed when values of '0' day was compared with values of corresponding post operative days in both the groups. Significant increase in serum alkaline phosphatase values were observed on $15^{th}$, $30^{th}$, $45^{th}$ and $60^{th}$ days in Group I whereas non-significant differences were noticed when values of '0' day was compared with values of corresponding post operative days in Group II.

## 2.7 Evaluation of fracture healing

Evaluation of fracture healing in all group was carried out clinically (amount of weight bearing) and radiographically on 0, $10^{th}$ and $30^{th}$ day after immobilization.

### 2.7.1 Clinical evaluation of fracture healing

Aron *et al.* (1986) reported a five scale grading for functional limb usage as,

I : Non weight bearing

II : Weight bearing less frequent than non weight bearing

III : Weight bearing more frequent than non weight bearing

IV : Constant weight bearing with perceptible lameness.

V . No perceptible lameness

Anderson *et al.* (2002) reported five scale lameness grading system in dogs stabilized with external skeletal fixation which included,

Grade 0 : Normal limb function

Grade I : Subtle, intermittent weight bearing lameness

Grade II : Subtle, consistent weight bearing lameness

Grade III : Obvious weight bearing lameness

Grade IV : Intermittent non weight bearing lameness

Grade V : Consistent non weight bearing lameness

### 2.7.2 Radiographic evaluation

Morgan (1972) observed healing of fractured bones radiographically in canine. He found that in nine to ten days time, fracture line become prominent immediately above the injury. Periosteal callus first occurred as a faint hazy area developing adjacent and directly overlapping the seat of fracture. The amount of callus formation depends upon restoration of state of the patient. He suggested that healing of fracture could be better ascertained clinically and radiographically.

Bommaiah *et al.* (1976) carried out treatment of nonunited tibial diaphyseal fracture in dogs and reported that fracture line was discrernible clearly but the radiolucency of the fracture line was reduced on lateral aspect by $2^{nd}$ week. By $3^{rd}$ week the fracture line revealed a slight increase in radio capacity which was more evident at $4^{th}$ week. At $5^{th}$ week, the fracture line could hardly be demarcated, whereas at sixth week the fracture line was obliterated with ossified tissue in ununited tibial diaphyseal fracture.

Kraus *et al.* (1998) conducted a study on type II fixation in 23 dogs for radial and tibial fracture and reported that, the time required for radiographic evidence of a bridging callus and removal of the fixators was 80 to 154 days.

Beck and Simpson (1999) reported that radiographs of dogs taken post-operatively at sixth week which were stabilized with Type 1-2 hybrid external skeletal fixator for

distal humeral fracture with tied in intramedullary pins, showed a significant bony callus formation at the fracture site.

Gul and Yanik (2006) observed periosteal callus formation from second week onwards post-operatively. They also reported clinical union in simple and closed fractures of tibia at 45$^{th}$ day, reduced with unilateral uniplanar external skeletal fixator but for the polytraumatized open fracture it was 65$^{th}$ day and for comminuted fractures it was 75$^{th}$ day and fixators were removed on these respective days.

Eastaugh-Waring *et al.* (2009) studied the quantification of fracture healing from radiographs using the maximum callus index in which three groups of 15 consecutive patients with tibial fractures treated by external fixation (ExFix), intramedullary nailing (IMN) and plaster cast (POP). Callus was first seen after an average of 5.4 and 6.7 weeks (antero-posterior (AP) and medio-lateral (ML) radiographic projections respectively) in the POP group, after 10.2 and 11.4 weeks in the IMN group, and after 6.5 and 7.8 weeks in the ExFix group. There was no significant difference with the sole exception of the POP and IMN groups in the ML projection ($p < 0.05$), and this may partly be a reflection of the frequency of the postoperative radiographs. The time taken to reach the maximum callus indices was substantially different for each group for both AP and ML callus indices. The peak value of callus index reached in all three groups was not found to be significantly different between the groups on antero-posterior films and the only significant difference in the ML callus index was for the POP group and the ExFix group ($p < 0.01$).

Patil *et al.* (2010) managed a case of four months male spitz pup was diagnosed avulsion fracture of the proximal tibial epiphysis and fracture of the fibula at its upper third after taken a medio-lateral view radiograph.

Sharma *et al.* (2011) examined two ears old male Alsatian dog weighing 40 kg which was presented with a history of automobile accident leading to non-weight bearing on the right hind limb. Radiographic examination evealed complete oblique condylar fracture involving maximally the medial condyle than the lateral condyle in right femur.

Bishnoi and Raghunath (2012) managed a case of Labrador dog of 30 kg body weight which was diagnosed with bilateral tibia fracture, having fractures in the left and right hind limbs, respectively (AO/ASIF classification). The closed comminuted fracture of left tibia was stabilized by open reduction and internal fixation with static intermedullary interlocking nailing. While the simple, complete spiral fracture of right

tibia was stabilized by applying full limb POP cast. Post fracture stabilization, early weight bearing was found in the statically interlocked fractured limb than in the externally casted limb. Complete radiographic and clinical union was found in both the hind limbs after 3 months of fracture fixation.

Manjunatha and Ranganath (2012) treated six dogs of different breeds, between age groups of 1 to 7 years with diaphyseal femur fractured by using c-arm guided interlocking nailing technique. Radiographic evaluation was made preoperatively, immediate post-surgically, on $7^{th}$, $14^{th}$, $28^{th}$ and $42^{nd}$ post-operative days respectively. The pre-operative radiograph helped for the selection of length and diameter of the interlocking nail for the fracture repair, immediate post-operative radiograph helped in assessment of the fracture alignment and proper implant in situ, the forty second day radiograph depicted more callus at the fracture site with visibility of faint fracture line.

## 2.8 Post-operative care

Mathews (2000) suggested the use of meloxicam at the dose rate of 2mg/kg intravenously, subcutaneous once, followed by 0.2 mg/kg every 24 hrs for the treatment of moderate to severe pain.

Johnson and Hulse (2002) recommended the usage of cefazolin 22mg/kg intravenously, intramuscularly or subcutaneously at six to eight hour interval as a prophylactic antibiotic for controlling orthopedic infections.

Perscott *et al.* (2002) reported that staphylococci showed 18 per cent resistance to first-generation cephalosporins, although they were the commonly used antibiotic as the first line of defense against bone and joint infections.

Roush (2005) recommended one time administration of a first generation cephalosporin at a dose of 20 mg/kg body weight intravenously, followed by 20 mg/kg body weight administered intramuscularly to provide prophylactic antibiotic coverage for up to five hours in fractures patient for open orthopedic procedure.

Julie *et al.* (2007) used the ceftriaxone sodium at the dose rate of 20 mg/kg body weight intravenously to prevent post-operative infection. They also advised the owner to restrict the movement of animal for two weeks after surgery and then allowing leash walk.

Rani (2008) used povidone iodine solution for surgical wound cleaning and dressing before bandaging the operated site of intramedullary pinning in fracture of bones

in dogs. The author used amoxicillin and cloxacillin at the dose rate of 10mg per kg body weight b.i.d. for five days post-operatively.

## 2.9 Economic parameters

Leathern *et al.* (1991) examined 180 human patients comprising 90 upper limbs and 90 lower limb with 30 in each of the three group viz. traditional gypsum, fiberglass and new polypropylene. The gypsum cast remains the cheapest at an average cost of £3.51 per patient compared to £7.18 for fiberglass and £7.45 for polypropylene (upper limb).

Kowalski *et al.* (2002) conducted a prospective randomized study comparing the costs, comfort and effects on fractures managed in plaster of Paris (POP) and fiber glass (FG) in human. They observed that fiber was superior in terms with lower break down rate. The average cost per fracture immobilized in a short arm cast was $12.90 for POP and $15.45 for FG. For short leg casts, the average cost of immobilization was $49.06 for POP and $47.85 for FG, FG had a significantly lower breakdown rate in short leg casts (17.00% vs. 66.00%) but not in short arm casts.

Singh *et al.* (2008) observed that the material cost was found higher immobilizing the fractures of goats with fiber glass cast then plaster of Paris cast. The time taken for application of plaster cast was approximately double as compared to that required for fiber glass cast. The time taken in setting of the plaster of Paris cast was 15-20 minutes as compared to the fiber glass cast which sets within three-five minutes. The breakage of the cast seen in the plaster of Paris cast where as the fiber glass cast remained intact during the healing period. The moulding of plaster cast was easy and less cumbersome than fiber glass cast.

Avasthi *et al.* (2012) carried out the clinical study on efficacy of plaster of Paris (Group I) and fiber glass casts (Group II) for repair of long bone fractures in goats. The material cost was found higher in immobilizing the fractures of Group II (MRP Rs. 645) than Group I (MRP Rs. 120). The time taken for application of plaster of Paris cast was approximately double as compared to that required for fiber glass cast. Similarly, the time taken in setting of the plaster of Paris cast was 20-25 minutes as compared to fiber glass cast which sets within three-five minutes.

## 2.10 Statistical analysis and success rate

Hurov and Seer (1968) treated two dogs having compound radio-ulnar fractures with retrograde intra-medullary pinning method of which all dogs showed fracture union and final limb function within 6 weeks of postoperative surgery.

Lewis et al. (1999) treated 17 cases of tibial and radial fractures out of which all cases showed fracture union and final limb function within 4-23 weeks pet operatively by use of circular external skeletal fixation.

Marcellin-Little (1999) documented 13 cases of radial and tibial fractures, of which all cases 100 per cent showed fracture union and final limb function within 14 weeks with use of intramedullary nailing.

Rahal *et al.* (2005) performed intramedullary pinning in two dogs for immobilization of nonunion radial fractures of the distal aspect of the radial diaphysis. The intramedullary pin and one of the cerclage wires have provided proper reduction and stability to the fractures.

Rudy (2008) stated that round Steinmann pin alone or in combinations with additional pins, orthopedic wire, is a very versatile method of skeletal fixation which is applicable to tiny or large breeds and to the very young or mature dogs. The objective of rigid skeletal fixation can be achieved if principles of auxiliary skeletal fixation are used in complicated fractures. For uniform success with intra-medullary pinning, it is essential that the principles of accurate reduction and rigid fixation be followed. The Steinmann (round) intra-medullary pin is the most versatile.

# CHAPTER-3

# MATERIALS & METHODS

# III. MATERIALS AND METHODS

The present study was carried out at Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, OUAT, Bhubaneswar, Odisha, during August 2015 to July 2016. Last three years (2014-2016) retrospective data on age, breed, sex, season, etiology, type of fracture, post-operative complication, weight bearing, management of fracture and immobilization technique pertaining to the cases registered in the Teaching Veterinary Clinical Complex (TVCC) were collected and analyzed to study the clinical epidemiology of osteopathy in dogs. Total 18 dogs suffering from fracture of radius ulna were included in the present study and three different methods for immobilization were studied.

## 3.1 Part: A (Retrospective study)

Analyses of fracture cases presented to the Teaching Veterinary Clinical Complex during last three yeasr (2014-2016) were carried out and incidences of fractures in all species of animals presented at the TVCC were studied. The incidence of fractures in dogs were further studied based on age, breed, sex, season, etiology, type of fracture, bone involved, weight bearing, management of fracture, immobilization technique and treatment given.

## 3.2 Part: B (Clinical Study)

### 3.2.1 Selection of animals

The clinical study was carried out in 18 clinical cases of dogs. These animals were divided in three groups as under.

**Group-I: Radius plating (n=6)**

In dogs of group I, fractures were immobilized by radius plating and bandaging.

**Group-II: Ulnar pinning (n=6)**

In dogs of group II, fractures were immobilized by ulnar pinning with Robertjone's bandaging.

**Group-III:Radius plating & Ulnar pinning (n=6)**

In dogs of group III, fractures were immobilized by both radius plating & ulnar pinning technique.

### 3.3 Fracture diagnosis and classification

All dogs presented due to trauma were first examined routinely. The dogs were then examined for loss of function, abnormal mobility, deformity or change is angulation of the affected limb, pain and crepitation at the fracture site, signs of local swelling, infection and exudates from the fracture site. Soft tissue and neurological status were assessed during clinical examination of the patient.

The affected limbs in all the dogs of all groups were subjected to radiological examinations. Mediolateral and craniocaudal radiographic views were taken to confirm and define the type of fracture. The fractures were classified clinically as open/closed and radiographically depending on the fracture line.

### 3.4 Immobilization techniques

#### 3.4.1 Premedication and anaesthesia

Some dogs were completely off fed due to injury hence further fasting was not required, rest were advised to kept off fed for atleast 12 hours. All the dogs were premedicated with atropine sulphate at the dose rate of 0.04 mg/kg body weight intra-muscularly, anaesthesia were induced with ketamine hydrochloride and zylazine combination at the dose rate of 10 mg/kg, i.m. and 1mg/kg body weight, i.m. respectively and were maintained on ketamine intravenously during surgery.

#### 3.4.2 External coaptation technique

The external coaptation technique for treatment of fracture in group I and group II was adopted as under:-

The affected limb was kept uppermost after securing the animal in lateral recumbency. Povidone Iodine powder was dusted liberally on the fractured limb, followed by padding with cotton. The limb was bandaged with Robert Jones bandage and was applied in group I&group II.

#### 3.4.3 Intramedullary pinning

##### 3.4.3.1 Preparation and positioning

The affected limb of the animal was prepared for aseptic surgery by clipping, shaving and scrubbing with Povidone iodine scrub, circumferentially of the affected limb including the portion around the fracture bone.

### 3.4.3.2 Surgical technique (Intramedullary pinning)

A normograde/retrograde approach was followed for intramedullary pinning in radius ulna fractures. A Mediolateral and craniocaudal radiographic position of the fracture was taken under image intensifier with C- arm and exact point of entrance was decided in normograde technique. A small vertical incision was given and a curved bone awl was used to open the bone cortex. Fracture was reduced by traction, angling and toggling under the guidance of image intensifies. Steinmann pin of diameter that filled at least 60 to 70 per cent of the medullary cavity. The Steinman pin was cut as close to the bone as possible to avoid seroma formation and also to avoid irritation of the soft tissues around the joint. Last few millimeters of the pin were advanced with the help of pin tapper and hammer. Loose bone fragment if present was immobilized using orthopaedic wire in full circular manner. The points of entry of the pin and the incision at the fracture site were sutured with silk thread. A retrograde approach was followed for intramedullary pinning in long bone fracture at fracture site. The closure consisted of suturing the muscles by continuous lockstick pattern using catgut no. 1-0 in one tier and the subcutaneous fat and fascia in a second tier using subcuticular pattern after fracture stabilization. Skin was opposed using silk by horizontal mattress pattern. Lead aprons and lead collars were worn for protective wear.

### 3.4.3.3 Surgical Technique (radius plating)

Thedogs were restrained properly after giving anaesthesia and wre aseptically prepared for surgery. Then incision was given and fractured fragments were exposed. The fractured fragments were reduced and temporarily fixed with bone holding forcep. The plates were selected of proper size and length prior to surgery. The plate was then placed on the fracture site and centered over the fracture so that a hole can be drilled through the bone approx. 1cm from its fractured end. The plate was placed over this hole in order that the screw length can be measured taking into account the thickness of the plate. The hole is then measured and tapped through both cortices. The correct length of screw was chosen and inserted. The fracture was then secured with bone holding forcep after the plate was aligned with long axis of bone. The tension device was tightened to aligned the plate with

**Fig 1: Restraining and positioning of animal after giving anaesthesia.**

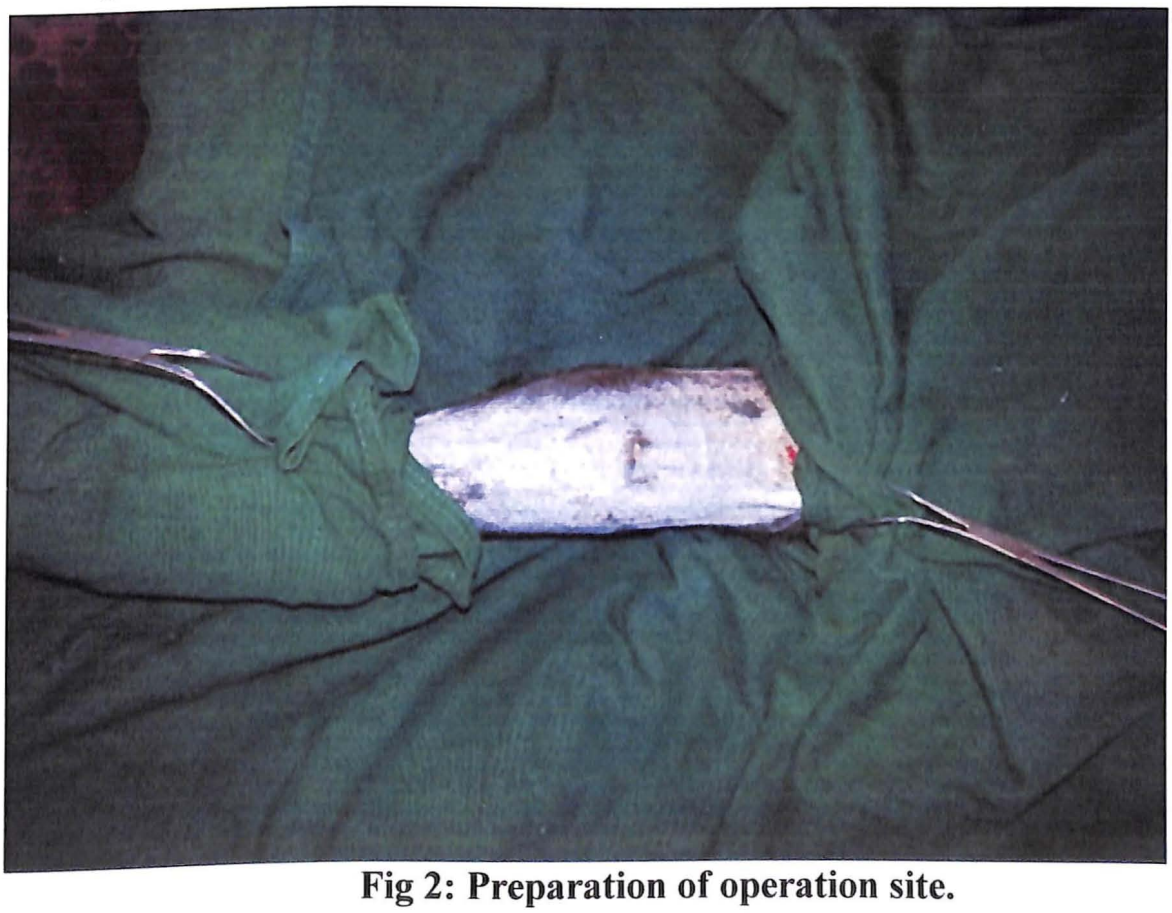

**Fig 2: Preparation of operation site.**

**Fig 3: Incision given on proper site.**

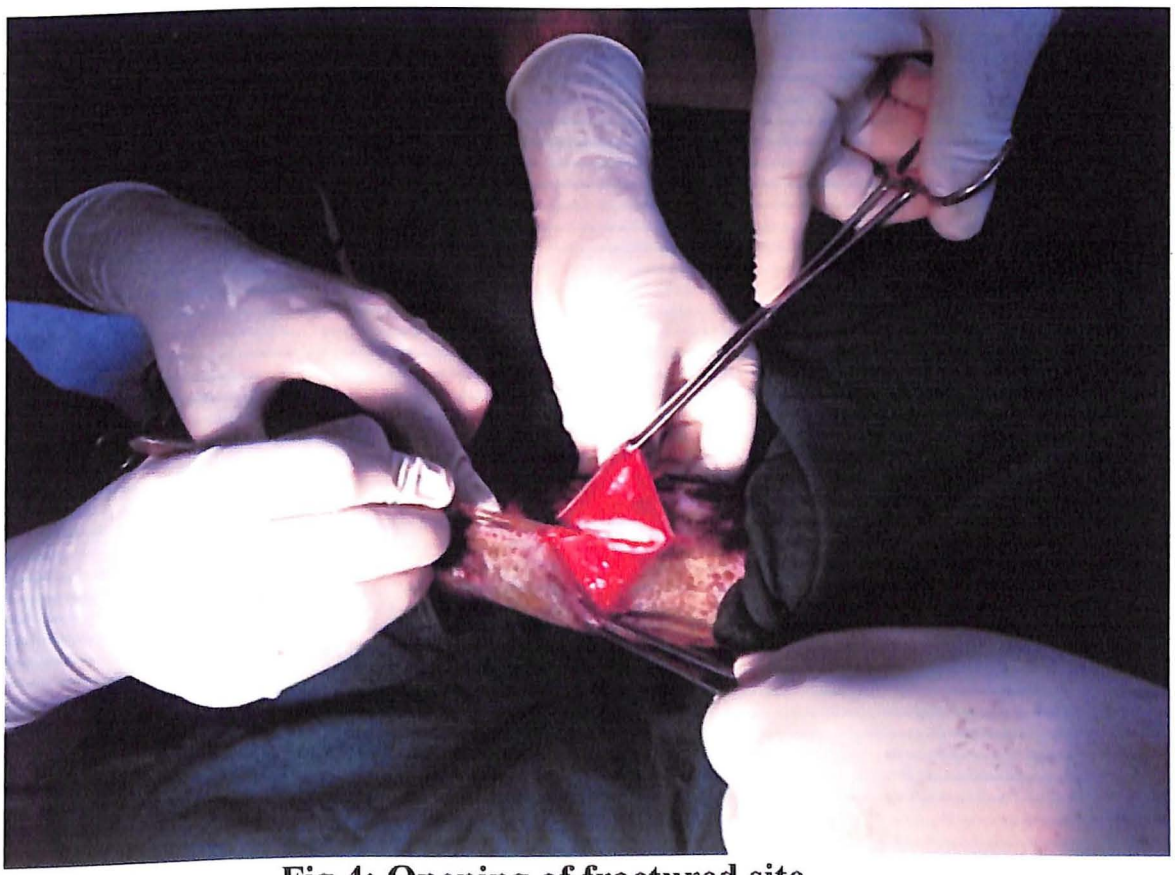

**Fig 4: Opening of fractured site.**

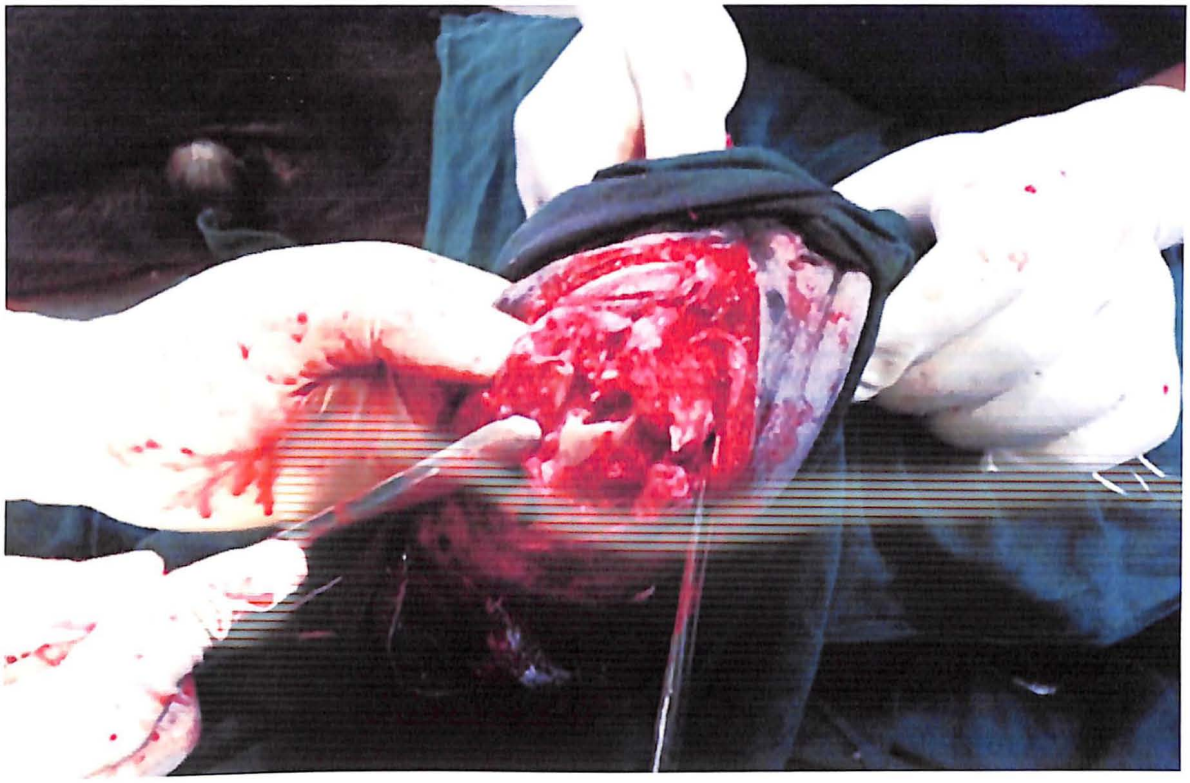

**Fig 5: Exposing fractured fragments.**

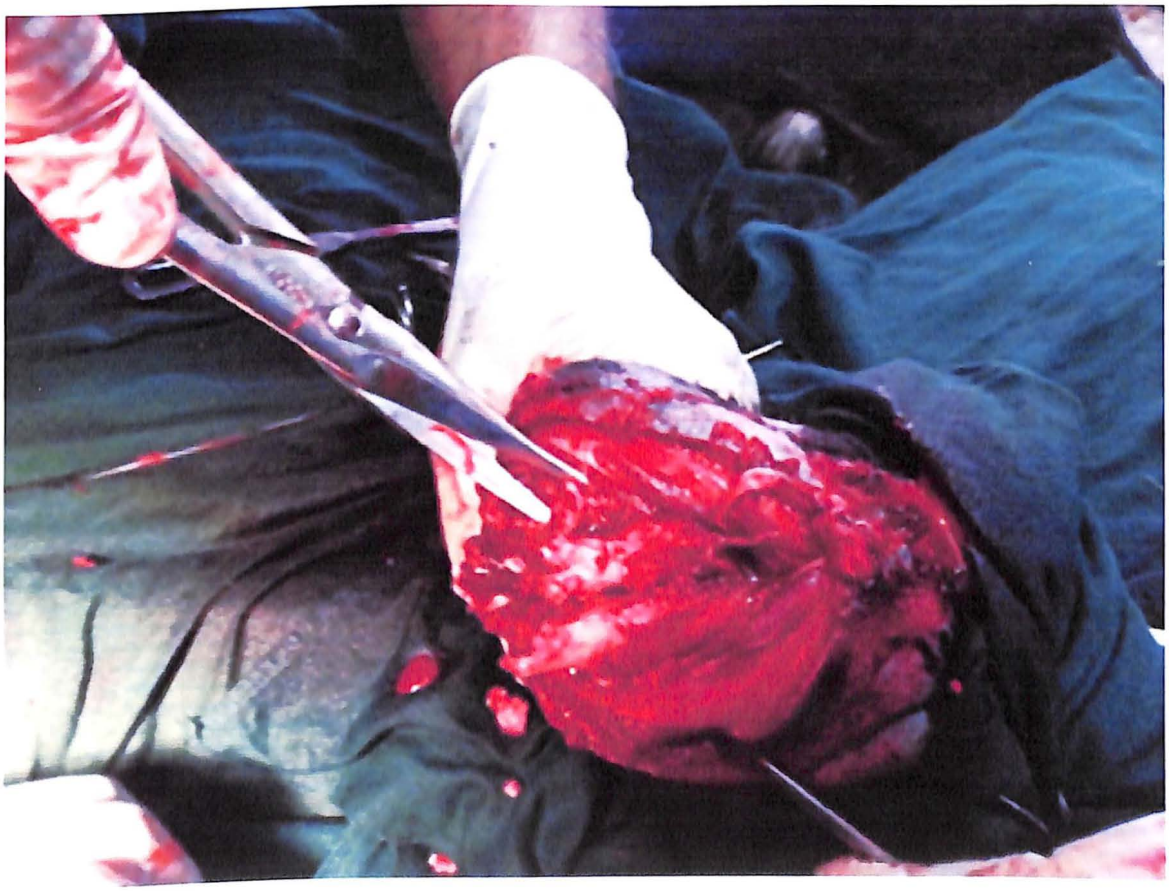

**Fig 6: Refreshing of edges of bones.**

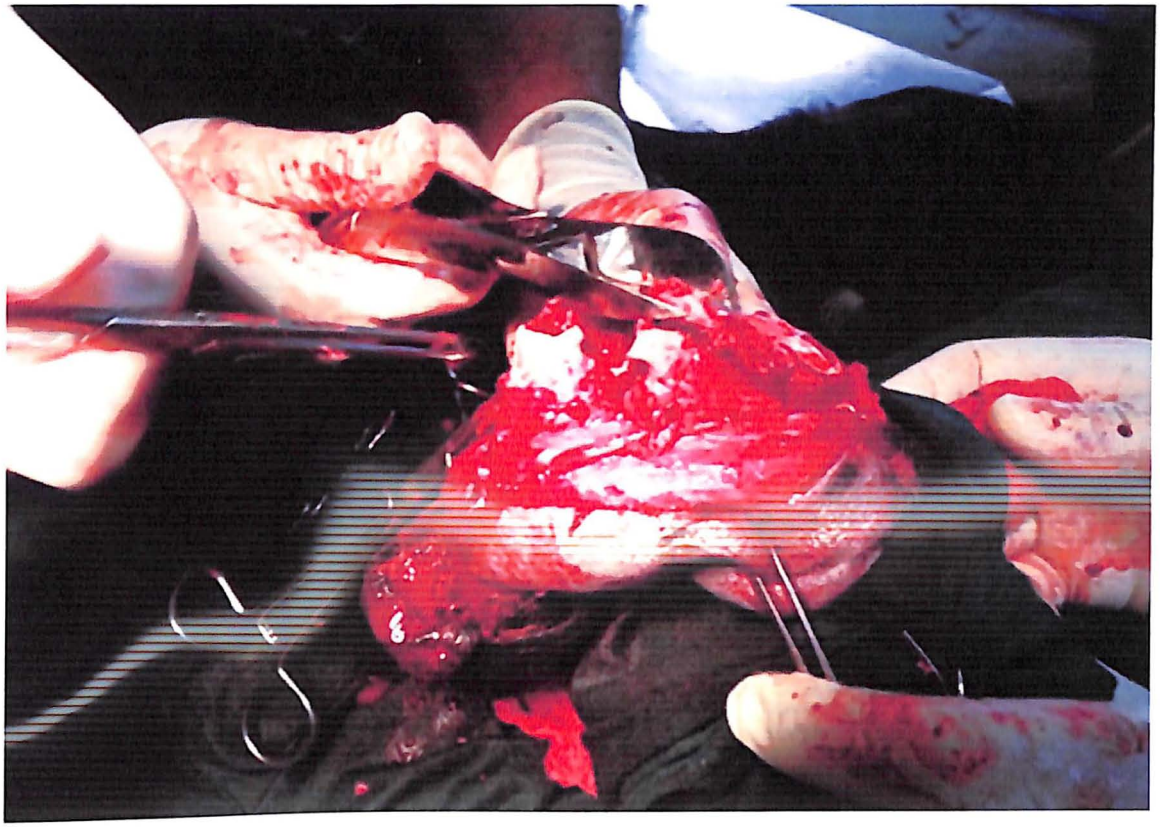

**Fig 7: Cutting of bone edges**

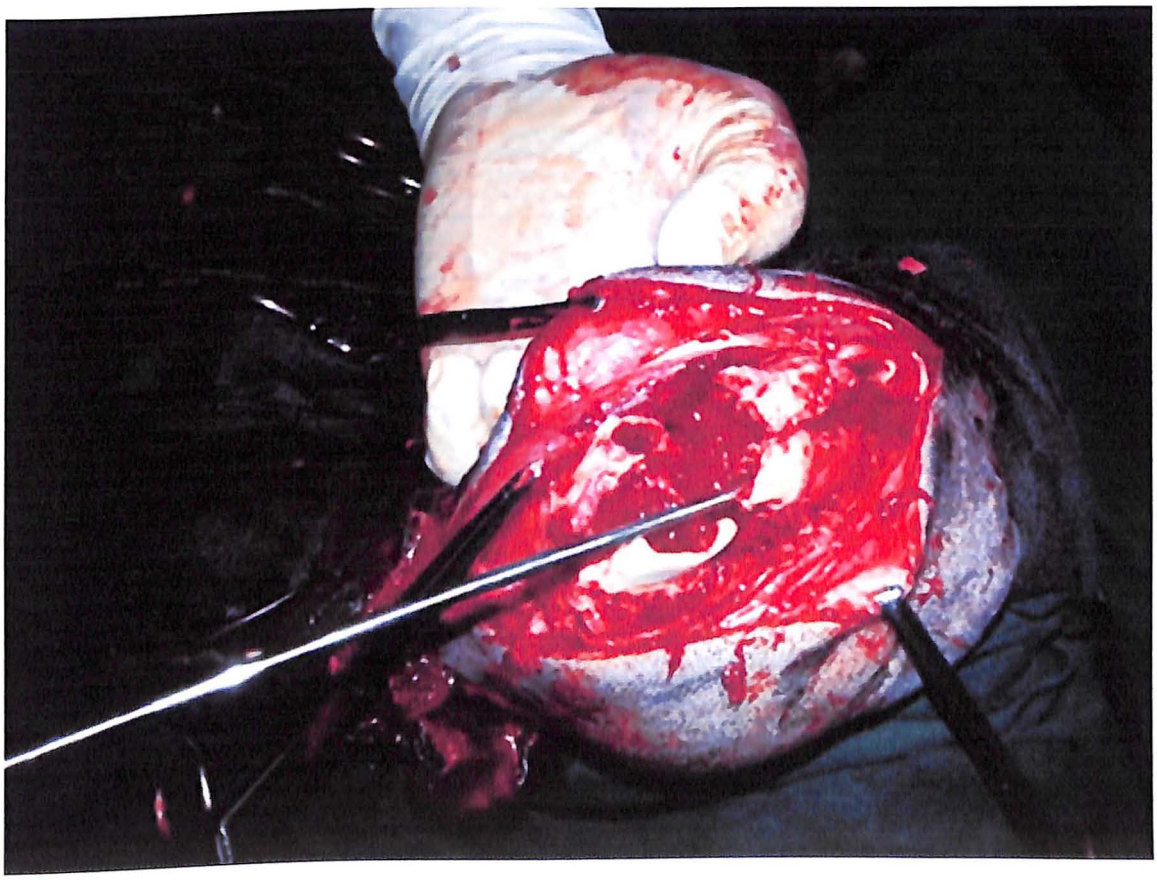

**Fig 8: Insertion of pin into bone.**

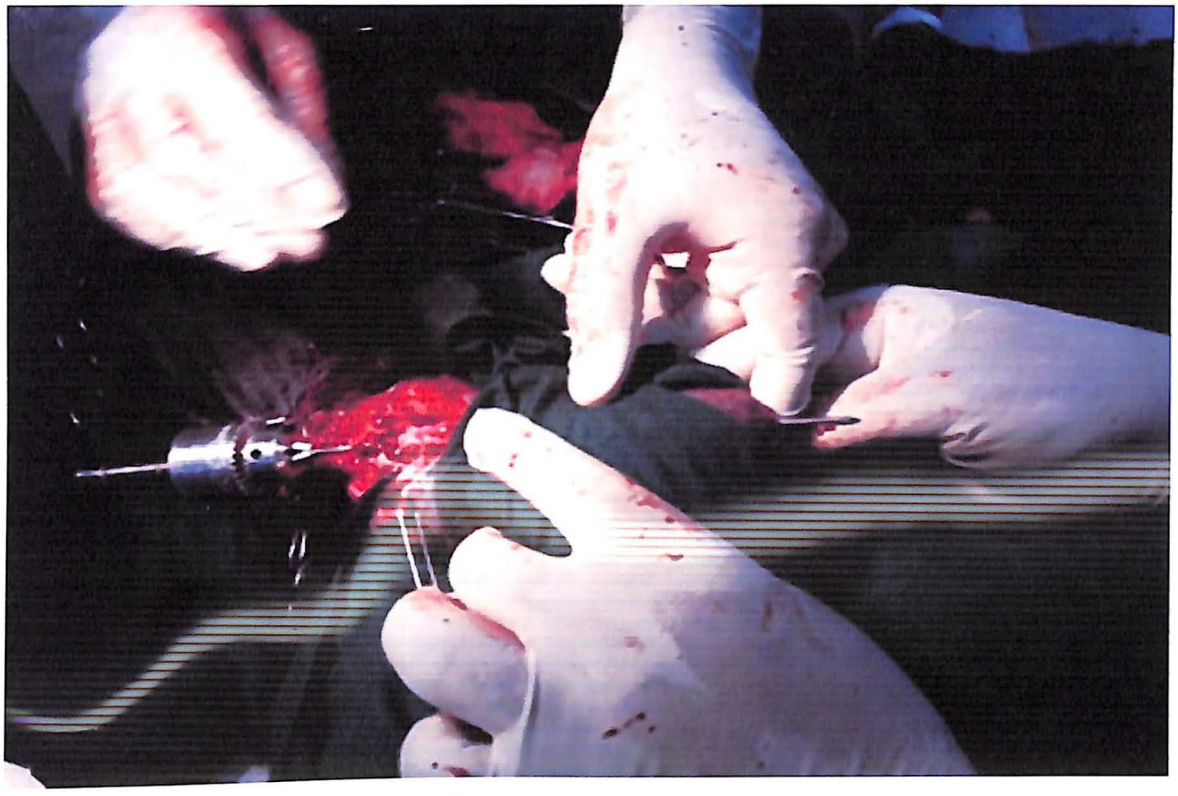

**Fig 9: Drilling of pin through the bone.**

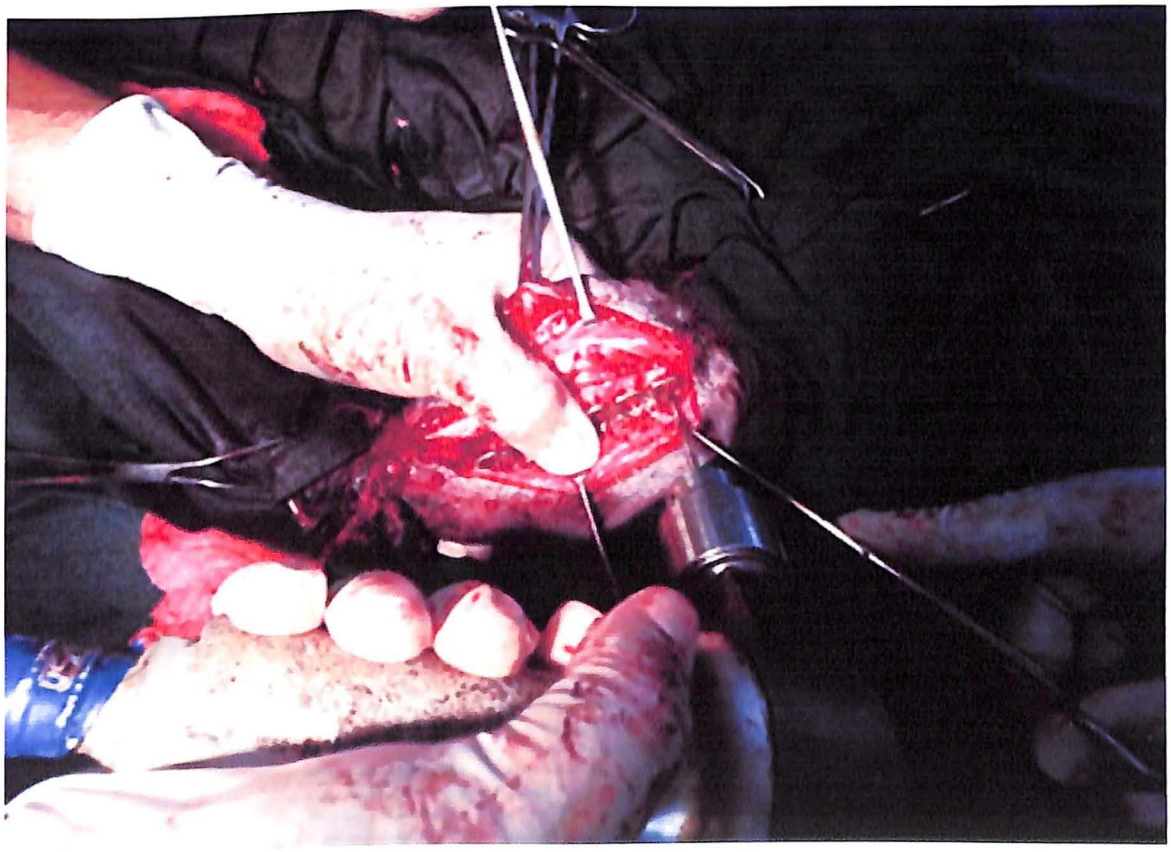

**Fig 10: Drilling of screw through the bone plate.**

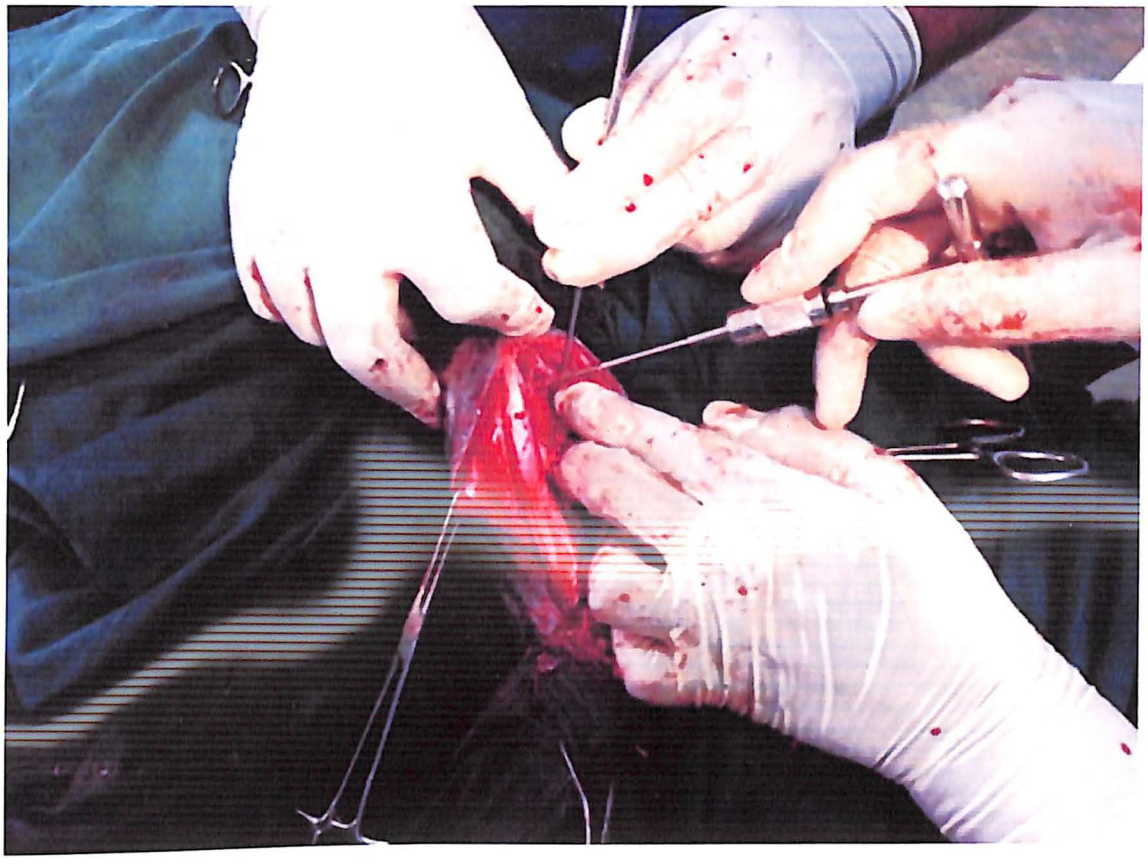

**Fig 11: Drilling of holes using a drill guide.**

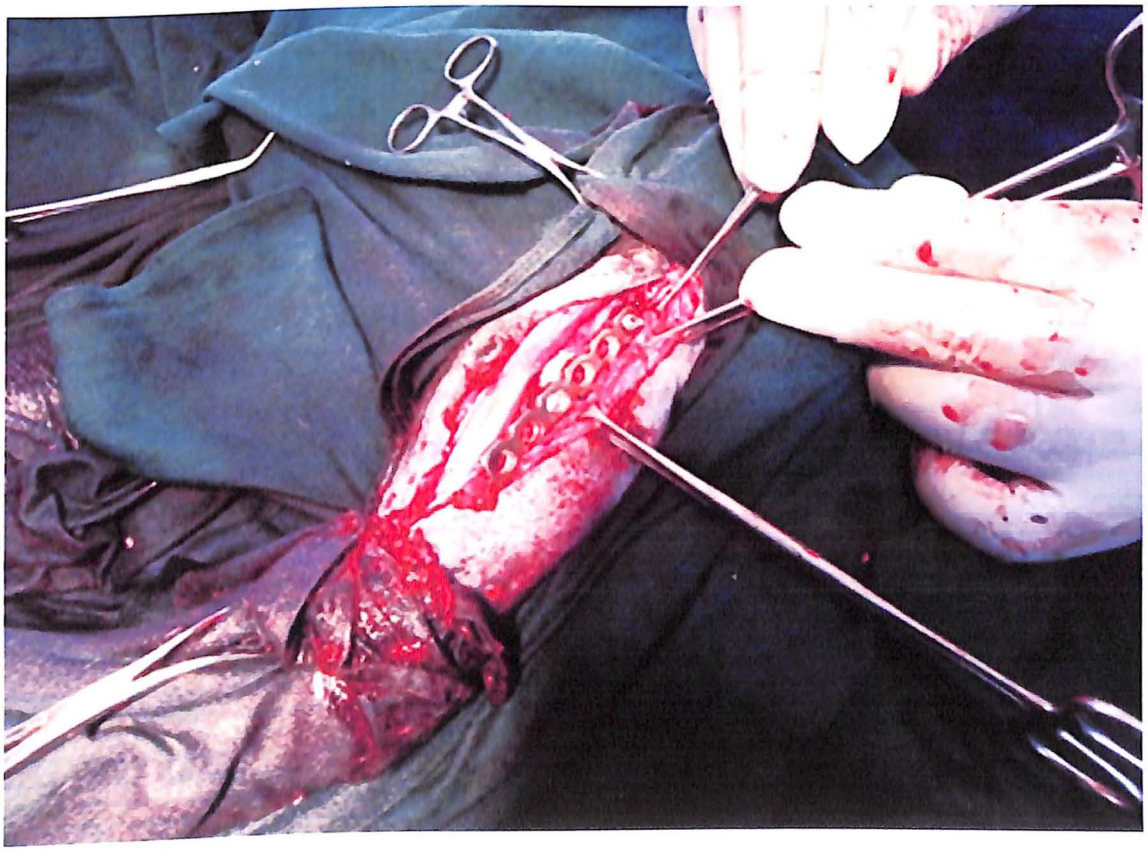

**Fig 12: Complete fixation of bone plate.**

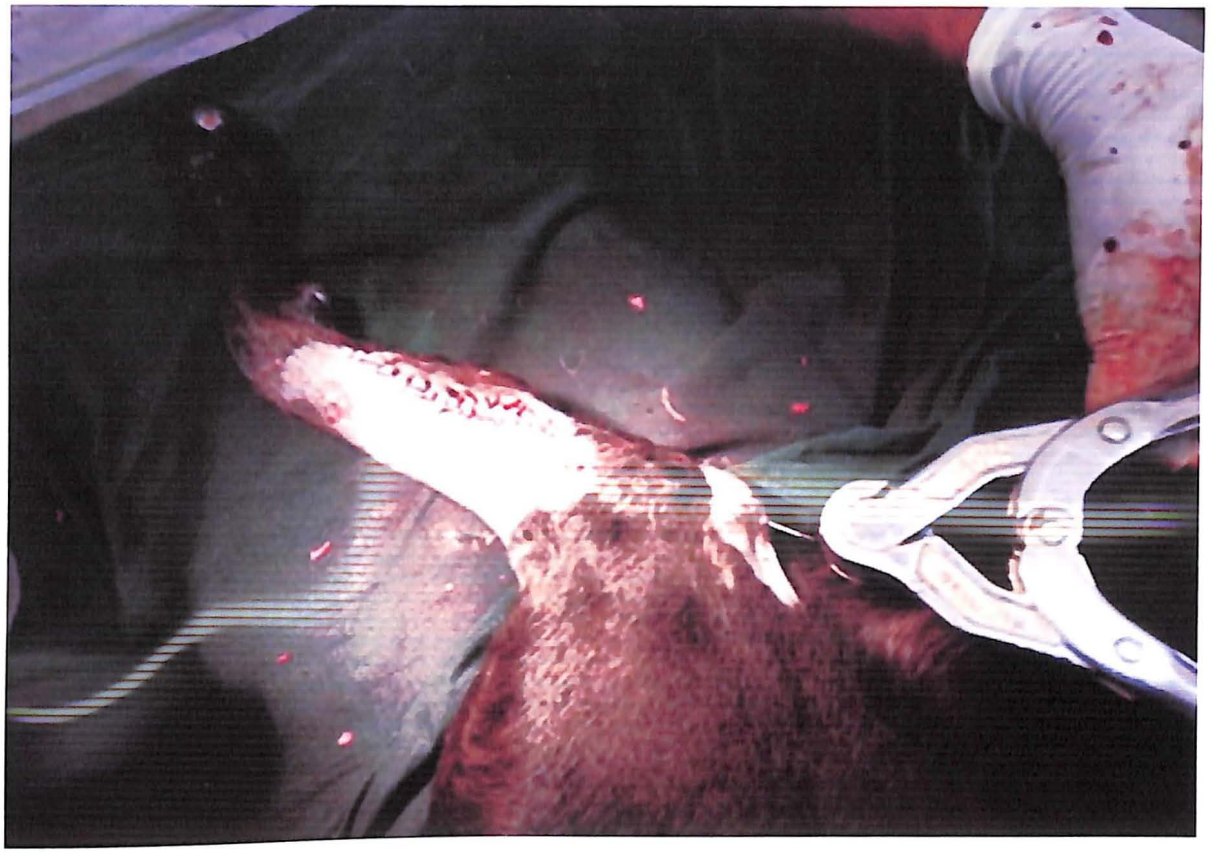

**Fig 13: Cutting of extra part of pin.**

**Fig 14: Suturing of skin.**

**Fig 15: Bandaging after surgery.**

long axis of bone. The remaining holes were drilled through the plate in the fractured fragments where the first screw was placed using a proper drill guide. The screws were inserted and tightened completely. The same procedure was repeated for drilling all the holes to ensure all the screws were tight. Then the tension device was loosened and removed. Then incision site was closed.

### 3.5 Cast and intramedullary pin removal and complications

The bandaging (in group I and II) were removed on 21$^{st}$ day after immobilization. The pins and plates were removed after one month of surgery and complication if any, were studied.

### 3.6 Parameters investigated of fractures

#### 3.6.1 Etiology of fracture

Detail of etiology of fracture was carefully recorded in animals of all groups.

### 3.6.4.2 Packed Cell Volume (PCV)

PCV was estimated by auto blood analyser mindrey (DC-2852) (Jain, 1986) and the results were expressed in per cent.

### 3.6.4.3 Total Erythrocyte Count (TEC)

Total erythrocyte count was estimated by auto blood analyser mindrey (DC-2582) (Jain, 1986). The value of total erythrocyte count was expressed in millions per cubic milliliter of blood.

### 3.6.4.4 Total Leucocyte Count (TLC)

Total Leucocyte count was estimated by auto blood analyser mindrey (DC-2852) (Jain, 1986). The value of total erythrocyte count was expressed in thousand per cubic milliliter of blood.

### 3.6.4.5 Differential Leucocyte Count (DLC)

Differential Leucocyte count was estimated by auto blood analyser mindrey (DC-2852) (Jain, 1986). The value of Differential erythrocyte count was in percent.

### 3.6.5 Biochemical parameters

From the serum samples, enzymes, viz., Alkaline phosphotase (AP)* and macro minerals, viz., Calcium (Ca)* and Phosphorus (P)* were estimated using manufactures guidelines.

## 3.7 Evaluation of fracture healing

All dogs suffering from fracture were observed clinically and radiographically to compare the utility of immobilization techniques and rate of healing immediately after fracture immobilization (day 0) and on 30 and 60 days in all the groups.

### 3.7.1 Clinical evaluation of fracture healing

Clinical evaluation of fracture healing was performed by determining the extend of weight bearing. In dogs of all groups assessment of weight bearing was graded given in table-1.

### 3.7.2 Radiographic evaluation

All dogs under study were subjected to radiography of fracture site before immobilization and during the process of fracture healing at $30^{th}$ and $60^{th}$ days post-operatively.

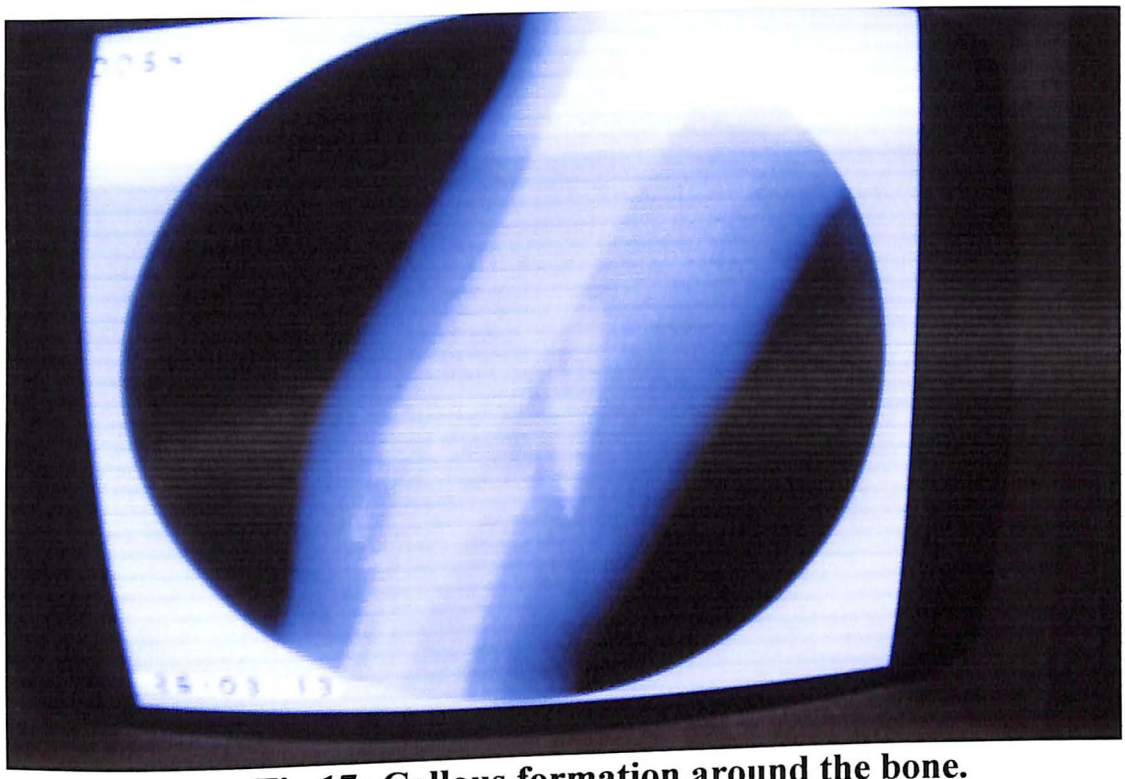

**Fig 17: Callous formation around the bone.**

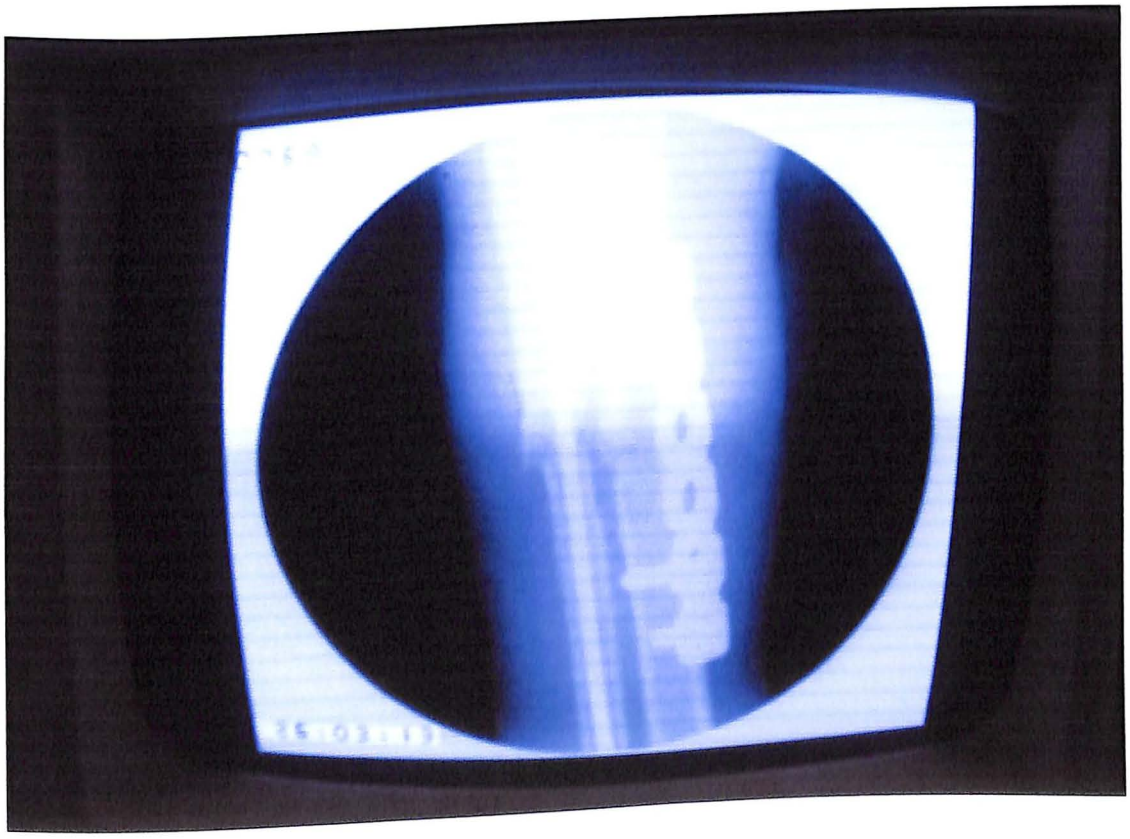

**Fig 18: alignment of bone after pinning & plating.**

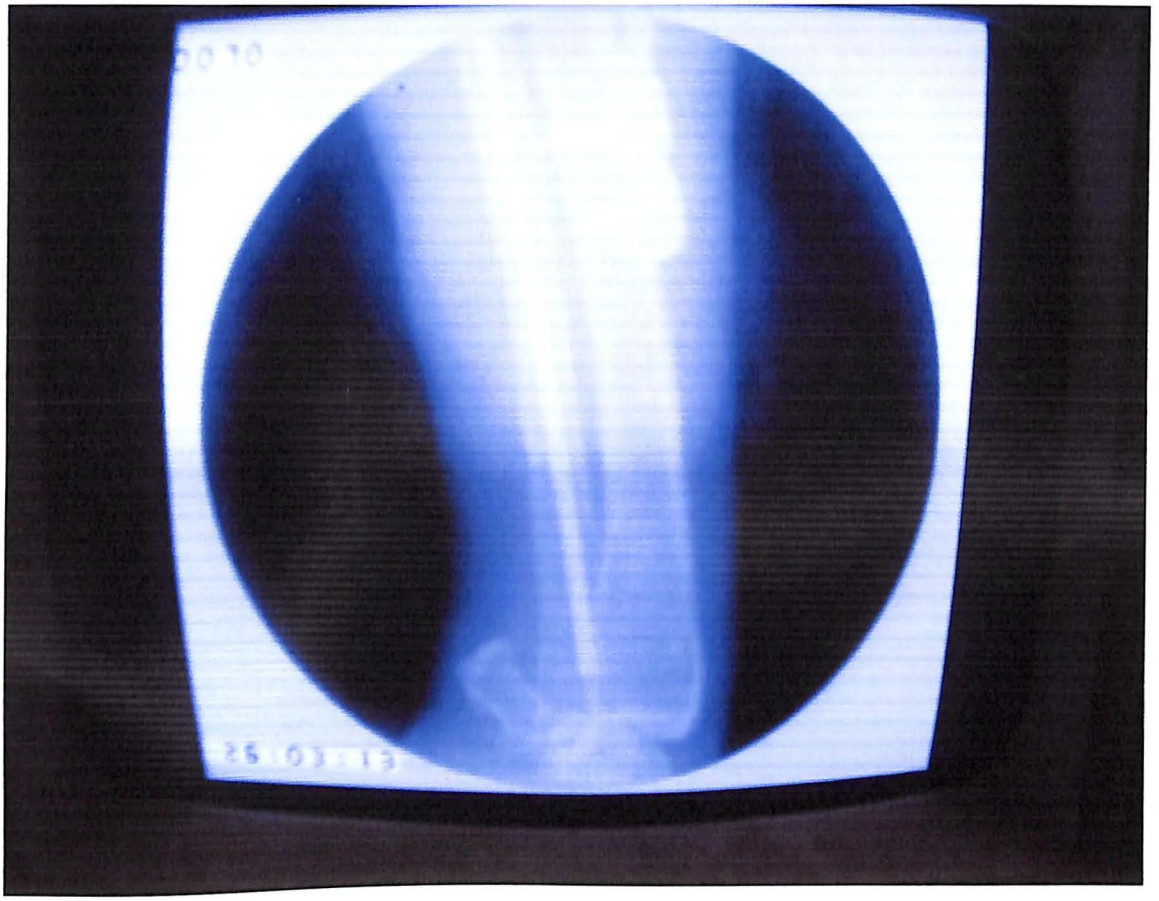

**Fig 19: Radiographic image showing distal position of pin in ulna.**

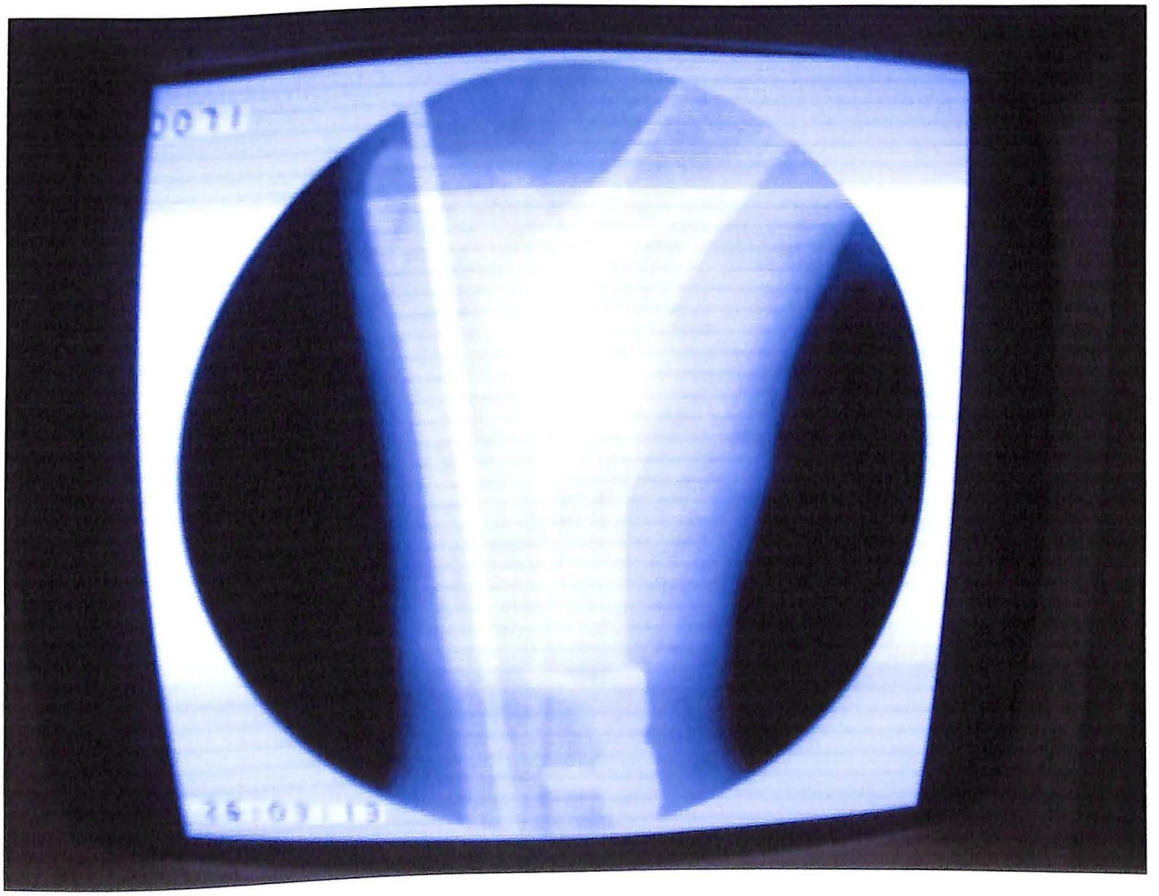

**Fig 20: Radiographic image showing proximal end of pin in ulna.**

### 3.8 Post-operative care

Meloxicam and ceftriaxone were administered at the dose rate of 0.2, 20mg/kg body weight, respectively for 5 days parentrally once a day.

### 3.9 Economic parameters

Cost of materials used for immobilization of fracture fragment was estimated and compared.

### 3.10 Statistical analysis and success rate

The data obtained during the study were statistically analyzed and compared using standard formula given for mean, standard error and T – test. The statistical procedure was use for analysis of above data as per the method described by Snedecor and Cochran (1980).

**Table 1 : Weight bearing criteria for clinical evaluation of fracture healing in dogs.**

| Sr. No. | Weight bearing Criteria | Grade | |
|---|---|---|---|
| 1 | Non weight bearing | 0 | - |
| 2 | Partial weight bearing | 1 | + |
| 3 | Moderate weight bearing | 2 | ++ |
| 4 | Complete weight bearing | 3 | +++ |

# CHAPTER-4

# RESULTS & DISCUSSION

# IV. RESULTS AND DISCUSSION

The present work was divided in two parts. Part A comprised a retrospective study of fracture cases presented at the clinic during threeyears (2014-2016), while part B included study on clinical cases of radius ulna fracture in dogs. Furthermore, in part B Group I (n=6) included dogs with radius ulna fracture immobilized with radius plating, Group II (n=6) included radius ulna fracture treated ulna pinning and Group III (n=6) included radius ulna fracture treated with both intramedullary pinning and plating.

## 4.1 Part : A (Retrospective study)

To know the epidemiological status of orthopaedic maladies in dogs, the information based on breed, sex, age, nature of pathology, etc. pertaining to the cases presented at TVCC were collected and analyzed. In this context, last three years (2014-2016) retrospective information as mentioned above was retrieved by scrutinizing the data bank of the Teaching Veterinary Clinical Complex, Veterinary College, OUAT, Bhubaneswar.

### 4.1.1 Overall incidence

Among the canine cases registered, 31.02 per cent cases were referred to Department of Veterinary Surgery and radiology. The incidences of orthopaedic maladies were 24.91 per cent of the total canine surgical cases. Out of 340 orthopaedic cases, 177 (52.05%) cases were of fractures followed by 38 (11.17%) cases of hip dysplasia, 14 (4.11%) cases of rickets, 06 (1.76%) cases of osteoarthritis and 105 (30.88%) cases of other lameness.

There was not much variation in the year wise incidence of these conditions yet there was gradual increase in the number of cases of orthopaedic maladies reported over the years which could have probably been due to increased pet population as well as increased awareness amongst people about the veterinary services. These findings were in concurrence with those obtained by Bhatia (2010) and Singh *et al.* (2015).

### 4.1.2 Species wise incidence of fractures

Amongst the total 3821 surgical cases, 334 (10.17%) cases of fractures in different species were recorded and analyzed during 2014-2016, out of which maximum cases of fracture were in canine 177 (52.99%), followed by bovine 63 (18.86%), caprine 42 (12.57%), avian 31 (9.28%), feline 12 (3.59%)), ovine 04 (1.19%), laboratory animal 03

(0.89%) and in wild animals 02 (0.59%). The results were in accordance with Abdulrahman *et al.* (2003). Kushwaha *et al.* (2011), Tambe (2012) and Kumar *et al.* (2013) also recorded highest incidence of fractures in canines followed by bovines.

### 4.1.3 Etiology based incidence

Among the total orthpaedic cases referred, automobile accident was the major etiological cause in 114 (64.40%) cases followed by fall from height which accounted for 34 cases (19.60%). This observation was mainly seen in young non-descript pups. A low percentage of orthopaedic cases referred had unknown etiology accounting for 07 cases (3.95%) (Table 5). These findings were in concurrence with those obtained by Aithal *et al.* (1999), Kumar *et al.* (2007), Bhatia (2010) and Singh *et al.* (2015). Whereas Kushwaha *et al.* (2011) found fall from height was the major etiological cause. Substantial number 11 (6.21%) of fracture cases had etiological cause as dog bite followed by fighting which accounted for 07 cases (3.95%) followed by hit with stick which accounted for 04 (2.25%).

### 4.1.4 Age-wise incidence

The incidence of orthopaedic maladies in different age groups was given in Table 6. The study revealed that majority of the orthopaedic maladies was seen in dog aged below 1 year of age accounting for 115 cases (64.97%). This was followed by a high number of cases i.e. 37 (20.90%) in dogs aged between 1-3 years. Then a gradual decline was seen in cases of orthopaedic maladies as the age of the dog increased.

Majority of orthopaedic maladies seen in the dogs less than a year of age were of fractures. This might be due to the fact that young ones are more active and yet to learn to cope with hazards unlike their older fellows. These findings were in concurrence with those obtained by Aithal *et al.* (1999), Kumar *et al.* (2007), Bhatia (2010) and Singh *et al.* (2015). Constaintinescu (2002) reported that, probable reason for high fracture rate in young animals could be that the bones of the young animals.

**Table 2 : Retrospective data of clinical cases (2014-2016)**

| Year | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Total surgical cases | 381 | 1428 | 2012 | 3821 (27.16%) |
| Total Gynaecology Cases | 267 | 480 | 873 | 1620 |

| | | | | |
|---|---|---|---|---|
| | | | | (11.52%) |
| Total Medicine Cases | 961 | 2755 | 4912 | 8628 (61.32%) |
| Total cases | 1609 | 4663 | 7797 | **14069** |

**Table 3 : Nature of orthopaedic maladies in dogs (2014-2016)**

| Year | Fractures | Osteo-arthritis | Rickets | Hip dysplasia | Other lameness | Total |
|---|---|---|---|---|---|---|
| 2014 | 29 | 00 | 01 | 04 | 10 | 44 |
| 2015 | 68 | 02 | 08 | 10 | 44 | 132 |
| 2016 | 80 | 04 | 05 | 24 | 51 | 164 |
| Total | 177 (52.05%) | 06 (1.76%) | 14 (4.11%) | 38 (11.17%) | 105 (30.88%) | 340 |

**Table 4: Species wise incidence of fracture cases in different animals (2014-2016).**

| Year | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Canine | 29 | 68 | 80 | 177 (52.99%) |
| Bovine | 04 | 40 | 19 | 63 (18.86%) |
| Caprine | 04 | 18 | 20 | 42 (12.57%) |
| Ovine | 00 | 02 | 02 | 04 (1.19%) |
| Avian | 01 | 18 | 12 | 31 (9.28%) |
| Feline | 02 | 07 | 03 | 12 (3.59%) |
| Wild animals | 00 | 00 | 02 | 02 (0.59%) |
| Laboratory animal | 00 | 02 | 01 | 03 (0.89%) |
| Total | 40 | 155 | 139 | 334 |

**Table 5 : Etiology of orthopaedic maladies in dogs (2014-2016)**

| Year | Automobile Accident | Fall from height | Dog bite | Fighting | Hit with stick | Unknown | Total |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2014 | 20 | 05 | 02 | 00 | 00 | 02 | 29 |
| 2015 | 38 | 14 | 05 | 05 | 02 | 04 | 68 |
| 2016 | 56 | 15 | 04 | 02 | 02 | 01 | 80 |
| Total | 114 (64.40%) | 34 (19.60%) | 11 (6.21%) | 07 (3.95%) | 04 (2.25%) | 07 (3.95%) | 177 |

### 4.1.5 Breed-wise incidence

Details pertaining to incidence of orthopaedic maladies in different breeds of dogs have been shown in Table 7. Retrospectively, maximum cases of orthopaedic maladies were seen in Non-descript dogs 108 (61.01%) followed by German Shepherd 27 (15.25%), Spitz 17 (9.60%), Labrador Retriever 09 (5.08%) and Doberman Pincher 08 (4.51%) whereas in other breeds the incidence was much less 08 (4.51%).

The incidence of orthopaedic maladies was highest is non-descript dogs which mostly consisted of fractures. This was probably because the population of non-descript dogs is more than any other exotic breed and also the fact that these dogs roam freely, thus making them susceptible to road accidents. These findings were in concurrence with the findings obtained by Aithal *et al.* (1999), Dvorak *et al.* (2000), Bhatia (2010) and Kornmayer *et al.* (2014). Kushwaha *et al.* (2011 reported that high proportion of orthopaedic maladies were recorded in Spitz, German Shepherd and Labrador Retriever breeds of dogs. These findings reflected the breed popularity in the area under study.

### 4.1.6 Sex-wise incidence

In the present study, majority of the cases i.e. 114 (64.40%) were of males whereas those of females accounted for 63 (35.60%) (Table 8). Male dogs were affected more than female dogs because aggressive nature and wandering habits of the male dogs make them more prone to accidents and fractures. These findings substantiate the finding observed by Aithal *et al.* (1999), Bhatia (2010), Kushwaha *et al.* (2011) and Singh *et al.* (2015).

### 4.1.8 Incidence based on fracture site (open/closed)

Majority of the fractures found in the study were of closed by nature 105 (59.32%) while the open fractures accounted 72 (40.68%) (Table 10). Higher incidences of closed fractures indicate that the predominance of bending or compression forces produce less

soft tissue injury and higher bone fracture. This finding was in concurrence with the findings obtained by Aithal *et al.* (1999), Bhatia (2010), and Kushwaha *et al.* (2011).

### 4.1.9 Incidence based on type of fracture line

Among different types of fractures, majority of fractures were transverse 59 (33.33%) followed by comminuted/multiple 55 (31.07%) and oblique/spiral 54 (30.50%) whereas incomplete fractures accounted for only 09 (5.08%) of the total fracture cases (Table 11).

The main force for an oblique fracture to occur was shear and compressive forces, for transverse fracture it was rotational and torsion forces as reported by Kushwaha *et al.* (2011). Whereas, in spiral and comminuted fractures the predominating forces were torsion and high energy forces respectively (Johnson and Hulse, 2002), Similar observations had been made earlier by Aithal *et al.* (1999) who reported the higher incidence of oblique fracture (50%) followed by transverse fracture (33.33%), comminuted fracture (20.61%), incomplete (4.55%) and other fractures (1.5%) of radius and ulna in dogs. However, Rani *et al.* (2004) recorded highest incidence of transverse fracture (45.88%) compared to oblique fractures (42.35%).

### 4.1.10 Incidence based on management of fracture

Various technique were using for management of fractures viz. plaster of Paris 74 (41.80%) followed by intramedullary pinning 39 (22.03%), bamboo splints 19 (10.73%) and wiring 09 (5.08%) (Table 12). In present retrospective study revealed that plaster of Paris cast with bamboo splints was the most common treatment modality in dogs. Wytch *et al.* (1987) suggested coaptation to be simplest and safest technique for fracture repair of long bone fractures in dogs with satisfactory healing.

**Table 6: Bone-wise Incidence of fractures in dogs (2014-2016)**

| Year | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Femur | 07 | 18 | 27 | 52 (29.37%) |
| Radio-ulna | 08 | 11 | 12 | 31 (17.51%) |
| Tibia-fibula | 06 | 16 | 24 | 46 (25.98%) |
| Humerus | 03 | 10 | 03 | 16 (9.03%) |
| Metacarpals/ metatarsals | 01 | 06 | 03 | 10 (5.64%) |
| Mandible | 03 | 01 | 05 | 09 (5.08%) |
| Other bone | 01 | 06 | 06 | 13 (7.34%) |
| Total | 29 | 68 | 80 | 177 |

**Table 7: Incidence of fractures based on fracture site (2014-2016)**

| Year | Open | Close | Total |
|---|---|---|---|
| 2014 | 14 | 15 | 29 |
| 2015 | 27 | 41 | 68 |
| 2016 | 31 | 49 | 80 |
| Total | 72 (40.68%) | 105 (59.32%) | 177 |

**Table 8 : Incidence of fractures based on type of fracture line (2014-2016)**

| Year | Oblique/ Sprial | Transverse | Comminuted / multiple | Incomplete | Total |
|---|---|---|---|---|---|
| 2014 | 06 | 06 | 16 | 01 | 29 |
| 2015 | 21 | 20 | 23 | 04 | 68 |
| 2016 | 27 | 33 | 16 | 04 | 80 |
| Total | 54 (30.50%) | 59 (33.33%) | 59 (31.07%) | 09 (5.08%) | 177 |

**Table 9: Methods used for management of fracture in dogs (2014-2016)**

| Year | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Bamboo splints | 01 | 10 | 07 | 19 (10.73%) |
| Plaster of Paris | 17 | 28 | 29 | 74 (41.80%) |
| Fiberglass cast | 00 | 00 | 03 | 03 (1.69%) |
| Amputation | 04 | 02 | 07 | 13 (7.34%) |
| Intramedullary pinning | 02 | 18 | 19 | 39 (22.03%) |
| Wiring | 03 | 01 | 05 | 09 (5.08%) |
| Plating | 00 | 00 | 02 | 02 (1.12%) |
| Untreated | 01 | 08 | 03 | 12 (6.77%) |
| Thomas splints | 00 | 01 | 05 | 06 (3.39%) |
| Total | 29 | 68 | 80 | 177 |

**Table 10: Season and month wise incidence of fracture cases in dogs (2014-2016).**

| Month | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Summer | 07 | 20 | 25 | 52 (29.37%) |
| Monsoon | 10 | 27 | 31 | 68 (38.41%) |
| Winter | 12 | 21 | 24 | 57 (32.20%) |
| Total | 29 | 68 | 80 | 177 |

### 4.1.11 Season and month wise incidence

The highest number of fracture cases in dogs were recorded in monsoon season (68; 38.41%) followed by winter season (57; 32.20%) and summer season (52; 29.37%) (Table 13). According to Abdulrahman *et al.* (2003) highest numbers of fracture cases in different animals were recorded in monsoon. In present study maximum fracture cases were recorded in monsoon season followed by winter and summer season which was in accordance with above authors.

## 4.2 Part: B (Clinical study)

### 4.2.1 Selection of animals

Selection of dogs for clinical evaluation of fracture was carried out randomly as under.

**Group-I: Radius plating(n=6)**

In dogs of group I, fractures were immobilized by radius platingand bandage for radius ulna fracture repair.

**Group-II: Ulna pinning(n=6)**

In dogs of group II, fractures were immobilized by ulna pining and Robertjone's bandage for radius ulna fracture repair.

**Group-III: Radius plating and ulna pinning (n=6)**

In dogs of group III, fractures were immobilized by both intramedullary pinning and plating technique.

## 4.3 Fracture diagnosis and classification

Mediolateral and craniocaudal views of radiographs of long bone fractures were found adequate for making the diagnosis and classification of the fractures for pre-operative plan and also for post immobilization evaluation in all the dogs. The procedure was in accordance with the methods of Whittick (1974), Henry (2002) and Piermattei *et al.* (2006). Details of the cases are given in table 14, 15 and 16.

In group1, total 6 casesout of which, 2 cases were adults and 4 cases were of young dogs. This might be due to the fact that young ones are more active and yet to learn to cope with hazards unlike their older fellows. These findings were in concurrence with those obtained by Aithal *et al.* (1999), Kumar *et al.* (2007), Bhatia (2010) and Singh *et al.*

(2015). Out of which 5 dogs were male and 1 case of female dogs. Male dogs were affected more than female dogs because aggressive nature and wandering habits of the male dogs make them more prone to accidents and fractures. These findings substantiate the finding observed by Aithal *et al.* (1999), Bhatia (2010), Kushwaha *et al.* (2011) and Singh *et al.* (2015).

As per the breed of the dogs 3 cases were non-descript followed by 1 cases of German Shepherd, 1 cases of Spitz, 1 case of Labrador. The incidences of orthopaedic maladies were highest in non-descript dogs which mostly consisted of fractures. This was probably because of population of non-descript dogs is more than any other exotic breed and also the fact that these dogs roam freely, thus making them susceptible to read accidents. These findings were in concurrence with the findings obtained by Aithal *et al.* (1999), Dvorak *et al.* (2000), Bhatia (2010) and Kornmayer *et al.* (2014).

As per the wound at fracture site 4 cases were closed fracture followed by 2 cases of open fracture. Higher incidences of closed fractures were also observed by Aithal *et al.* (1999), Bhatia (2010), and Kushwaha *et al.* (2011). As per the type of the fracture 4 cases were short oblique followed by 2 cases of transverse fracture. Aithal *et al.* (1999) reported the higher incidence of oblique fracture (50.00%) followed by transverse fracture (33.33%), comminuted fracture (20.61%), incomplete (4.55%) and other fractures (1.50%) in dogs.

In group II, a total 6 cases were treatedout of which, 5 dogs were young and 1cases were of adult dogs. These findings were in concurrence with those obtained by Aithal *et al.* (1999), Kumar *et al.* (2007), Bhatia (2010) and Singh *et al.* (2015). Out of which 3 dogs were males and 3 cases were of female dogs. These findings substantiate the finding observed by Aithal *et al.* (1999), Bhatia (2010), Kushwaha *et al.* (2011) and Singh *et al.* (2015).

**Table 11: Details of clinical cases of dogs belonging to group I.**

| Sr. No. | Breed | Age (month) | Sex | Limb | Bone fractured | Type of fracture | Open / Close |
|---|---|---|---|---|---|---|---|
| 1. | Non descript | 48 | M | R | Radius-ulna | Incomplete, short oblique at epiphysis | Open |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2. | Non descript | 24 | F | R | Radius-ulna | Incomplete, longitudinal at epiphysis | Closed |
| 3 | German Shepherd | 9 | M | R | Radius-ulna | Complete, short oblique at epiphysis | Open |
| 4 | Labrador | 15 | M | L | Radius-ulna | Incomplete, short oblique at proximal 1/3rd epiphysis | Closed |
| 5 | Non descript | 12 | M | L | Radius-ulna | Complete, transverse at distal 1/3rd epiphysis | Clsed |
| 6 | Spitz | 12 | M | R | Redius-ulna | Complete, short oblique at distal 1/3rd epiphysis | Closed |

M = Male, F = Female, R = Right, L = Left

**Table 12: Details of clinical cases of dogs belonging to group II.**

| Sr. No. | Breed | Age (months) | Sex | Limb | Bone fractured | Type of fracture | Open / Close |
|---|---|---|---|---|---|---|---|
| 1 | Spitz | 4 | M | L | Radius-ulna | Incomplete, transverse at epiphysis | Closed |
| 2 | German Shepherd | 48 | M | L | Radius-ulna | Complete, multiple at epiphysis | Open |
| 3 | Non descript | 3 | M | R | Radius-ulna | Incomplete, short oblique at metaphysic | Closed |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | Non descript | 4 | M | L | Radius-ulna | Complete, short oblique at distal epiphysis | Closed |
| 5 | Labrador | 8 | F | R | Radius-ulna | Complete, transverse at distal 1/3rd epiphysis | Open |
| 6 | Labrador | 12 | F | R | Radius-ulna | Complete, short oblique at epiphysis | Open |

M – Male, F – Female, R – Right, L – Left

**Table 13: Details of clinical cases of dogs belonging to group III.**

| Sr. No. | Breed | Age (months) | Sex | Limb | Bone fractured | Type of fracture | Open / Close |
|---|---|---|---|---|---|---|---|
| 1 | Labrador | 18 | F | R | Femur | Complete, multiple at epiphysis | Open |
| 3 | Non Descript | 24 | M | L | Femur | Complete, short oblique at proximal 1/3rd epiphysis | Closed |
| 4 | Non descript | 18 | M | R | Femur | Complete, short oblique at proximal 1/3rd of epiphysis | Closed |
| 5 | German Shepherd | 1 | M | R | Tibia | Complete, multiple at epiphysis | Closed |
| 6 | Labrador | 4 | M | L | Femur | Complete, short oblique at distal 1/3rd of epiphysis | Closed |
| 7 | German Shepherd | 4 | M | R | Femur | Complete, short oblique | Open |
| 8 | Non descript | 45 | M | L | Femur | Complete, transverse at proximal 1/3rd epiphysis | Closed |
| 9 | German Shepherd | 3 | M | L | Femur | Complete, short oblique at epiphysis | Closed |

M – Male, F – Female, R – Right, L – Left

As per the breed of the dogs 2 cases were Labrador followed by 2 cases of Non descript, 2 cases of Spitz and 1 case of German Shepherd dog. Rao *et al.* (1999) studies the incidence of long bone fractures in different breed of dogs. Among the different breeds German Shepherd 26.80 per cent, Doberman 11.20 per cent, Great Dane 7.10 per cent, Labrador Retriver 6.60 per cent, Pomeranian 9.70 per cent, Dachshund 8.20 per cent, Cocker spaniel 3.60 per cent and Non-descript 27.10 per cent were recorded.

As per the bone affected of the dogs 3 cases were of radius-ulna fractures and 3 cases were of tibia fractures followed by 1 cases of metacarpal and 1 case of femur fracture. Dvorak *et al.* (2000) studies on long bone fractures in dogs in which most commonly broken bones were radius and ulna (28.66%), followed by tibia and fibula (28.05%), femur (25.00%) and humerus 918.29%). 4 cases showed right limb fractures and 4 cases showed left limb fractures. Most of the cases showed right limb fractures (7 cases) followed by left limb fractures (5 cases). These findings were in concurrence with the findings obtained by Aithal *et al.* (1999) and Kornmayer *et al.* (2014).

As per the wound at fracture site 5 cases were closed fracture followed by 3 cases of open fracture. Higher incidences of closed fractures were also observed by Aithal *et al.* (1999), Bhatia (2010), and Kushwaha *et al.* (2011). As per the type of the fracture 3 cases were short oblique and 3 cases of transverse fracture followed by 2 cases of multiple fractures. Aithal *et al.* (1999) reported the higher incidence of oblique fracture (50.00%) followed by transverse fracture (33.33%), comminuted fracture (20.61%), incomplete (4.55%) and other fractures (1.50%) in dogs.

In group III, a total 12 cases were immobilized with intramedullary pinning and modified Thomas splints out of which, 9 cases of dogs were young and 3 causes were of adult dogs. These findings were in concurrence with those obtained by Aithal *et al.* (1999), Kumar *et al.* (2007), Bhatia (2010) and Singh *et al.* (2015). Out of which 9 cases of the dogs were males and 3 cases were of female dogs. These findings substantiate the finding observed by Aithal *et al.* (1999), Bhatia (2010), Kushwaha *et al.* (2011) and Singh *et al.* (2015).

As per the breed of the dogs 6 cases were Non descript followed by 3 cases of German Shepherd, 2 cases of Labrador and 1 case of Great Dance. These findings were in concurrence with the findings obtained by Aithal *et al.* (1999), Dvorak *et al.* (2000), Bhatia (2010) and Kornmayer *et al.* (2014).

As per the bone affected of the dogs 10 cases of fractures were of femur followed by 2 causes of tibial fractures. Aithal *et al.* (1999) observed that incidences of long bone fractures were highest in femur (38.56%) followed by tibia-fibula (17.16%), radio-ulna (16.92%) and humerus (7.71%).

6 cases showed left limb fractures followed by 5 cases of right limb fractures than 1 case of both limb fractures. Most of the cases showed right limb fractures (7 cases) followed by left limb fractures (5 cases). These findings were in concurrence with the findings obtained by Aithal *et al.* (1999) and Kornmayer *et al.* (2014).

As per the wound at fracture site 8 cases were closed fracture followed by 4 cases of open fracture. Higher incidences of closed fractures were also observed by Aithal *et al.* (1999), Bhatia (2010) and Kushwaha *et al.* (2011).

As per the type of the fracture 6 cases were short oblique fracture followed by 4 cases of multiple fracture and 2 cases of transverse fracture. Aithal *et al.* (1999) reported the higher incidence of oblique fracture (50.00%) followed by transverse fracture (33.33%), comminuted fracture (20.61%), incomplete (4.55%) and other fractures (1.50%) in dogs.

## 4.4 Immobilization techniques

### 4.4.1 Premedication and anaesthesia

Preoperative administration of antibiotic ceftriaxone 30 minutes prior to immobilization technique effectively prevented infection in all the dogs belonging to groups I, II and III. Gupta (2005) had also expressed importance of preoperative administration of antibiotics for fracture repair in dogs to combat infections.

Premedication with atropine sulphate prevented excessive salivation in all the dogs belonging to groups I, II and III. Comparable findings have also been reported by Yadav *et al.* (2006), Raghunath and Singh (2008), Bhatia (2010) and Vedpathak *et al.* (2011).

The induction of general anaesthesia with ketamine at the dose rate of 10 mg per kg body weight and xylazine at the dose rate of 1mg per kg body weight combination intramuscularly was adequate for anaesthetic induction. The general anaesthesia maintained with intravenous ketamine in all the dogs provided excellent surgical plane of anaesthesia to carry out fracture immobilization. Comparable finding have also been

reported by Gupta (2005), Raghunath and Singh (2008) and Bhatia (2010) for similar purpose in dogs.

### 4.4.2 External coaptation technique

The fracture site was easily accessible for immobilization when the affected limb was kept on the upper side with animal in lateral recumbency. Proper reduction and alignment of fracture fragments were adequately performed manually under traction and counter traction in group I and II. In Group I and II dusting with povidone iodine powder, padding with cotton and application of gauze bandage was found satisfactory (plate 1 and 2). These finding were described in external coaptation for fracture repair by Manjulkar *et al.* (2004).

### 4.4.3 Intramedullary pinning

#### 4.4.3.1 Preparation and positioning

The affected limb of the dogs was prepared for aseptic surgery by clipping, shaving and scrubbing the entire region of fractured bone with betadine scrub, circumferentially of the affected limb including the portion around the proximal and distal joints. This was found satisfactory to combat transient and residual bacterial infection.

For intramedullary pinning in group II the patient's limb was secured at the paw with bandage. The limb was pulled up sufficiently tight to allow the limb to be suspended by portion of the animal's weight in lateral recumbency. These protocols were followed for immobilization of fractures by Vedpathak *et al.* (2011). Gauge bandage roll was applied over the paw for traction and around the thigh region for counter traction. Draping of the surgical site was carried out using standard procedures and this technique was found satisfactory prevention of surrounding contamination.

#### 4.4.3.2 Surgical technique (Intramedullary pinning)

In group II, Steinmann pins in the range of 1.5 to 3 mm diameter were used to immobilize the fracture fragments. The Steinmann pin used filled approximately 60 to 70 per cent of the medullary cavity of long bone. This was given satisfactory result. This was in compliance with the opinions of Simpson and lewis (2004), Piermattei et al. (2006) and Bhatia (2010).

The intramedullary pin was inserted by normograde method of pinning in 2 cases and 4 cases of fractures immobilized by retrograde method of pinning. These techniques

were found satisfactory. This was in compliance with the opinions of Pardo (1994) and Piermattei *et al.* (2006). For proper reduction lateral incision was taken at the fracture site in retrograde method. These findings were comparable to that reported by Hurov and Seer (1968) and Kumar and Gahlot (2013).

### 4.5 Cast and intramedullary pin removal and complications

In groups I and II the bandages were removed on 21$^{th}$ day after immobilization. In group I, out of 6 cases, ulceration at knee joint in 2 dogs and two time change bandages in 4 dogs due to wet bandage. Ulceration at knee joint was due to rubbing og edges of bandage in 2 dogs was the only major complication noted. These findings were also reported by Boyd *et al.* (2009).

In group II, out of 6 cases only 1 case had complication and 3 cases had joint stiffness which was recovered after milk exercise. Stiffness of joint was noted as the common complication, probably due to weakening of joint and tendons by prolonged immobilization as reported by Singh *et al.* (2008) and Boyd *et al.* (2009).

In groups III, the intramedullary pin and plate was removed on 60$^{th}$ day after intramedullary pinning under general anaesthesia in all 6 cases. In group III, out of 6 cases 3 cases have complication such as occasional limping was observed. This was due to irritation of pin to soft tissue around the insertion site while flexing and extending the limb. Mild rotation of the distal fragment was observed in one case.

**Table 14: Complications of fracture healing**

| **Group I (radius plating)** | | **Group II (ulna pinning)** | | **Group III (plating+pinning)** | |
|---|---|---|---|---|---|
| **Case No.** | Complication | **Case No.** | Complication | **Case No.** | Complication |
| **I-1** | Displacement of bandage | **III** | - | **III-1** | - |
| **I-2** | Ulceration due to injury | **II-2** | Stiffness of joint | **III-2** | Infection at the incision site |
| **I-3** | Displacement of bandage | **II-3** | - | **III-3** | Irritation of pin to soft tissue around the insertion site |
| **I-4** | Displacement of | **II-4** | Shortening of limb | **III-4** | - |

| | | | | | |
|---|---|---|---|---|---|
| | bandage | | | | |
| **I-5** | Ulceration due to injury | **II-5** | Stiffness of joint | **III-5** | Infection at the incision site |
| **I-6** | Two time change in bandage | **II-6** | - | **III-6** | Irritation of pin to soft tissue around the insertion site |

This could be attributed to the incapability of the intramedullary pin to resist rotational forces. Infection was seen in two cases at the incision site. Similar finding were reported by Piermattei *et al,* (2006) (Table-17).

## 4.6 Parameters investigated

### 4.6.1 Etiology of fracture

In group I, Causes of injury in 4 cases were automobile accident followed by 2 cases of fall from height.

In group II, causes of injury in 5 cases were automobile accident followed by 1 cases of fall from height.

In group II, Causes of injury in 5 cases were automobile accident and 1 case of dog bite.

In present study automobile accident was the major cause of fracture in long bones. These results were comparable to those reported by Aithal *et al.* (1999) and Kornmayer *et al.* (2014).

### 4.6.2 Clinical parameters

The clinical parameters like rectal temperature, heart rate and respiration rate of all animals were recorded at 0, 30$^{th}$ and 60$^{th}$ day in group I, II and III.

#### 4.6.2.1 Rectal temperature

In group I the rectal temperature in $^{0}$F was found to be 103.00 ± 0.30 on '0' day whereas it was 101.06 ± 0.16 and 100.95 ± 0.18 on 30$^{th}$ and 60$^{th}$ days respectively.

In group II the rectal temperature in $^{0}$F was found to be 103.75 ± 1.37 on '0' day whereas it was 100.85 ± 0.23 and 100.96 ± 0.29 on 30$^{th}$ and 60$^{th}$ days respectively.

In group III the rectal temperature in $^{0}F$ was found to be 102.12 ± 0.24 on '0' day whereas it was 101.18 ± 0.12 and 101.22 ± 0.15 on 30th and 60th days respectively (Table – 18).

The mean values of rectal temperature on day '0' in all groups were significantly higher than mean value of rectal temperature on day 30 and 60. No significances were observed in values between all groups. The increase in rectal temperature in all groups might be due to initial inflammatory response to fracture.

Srinivasamurthy (2002) reported that, there was a rise in rectal temperature up to third post-operative day in dogs treated for long bone fracture.

In group I and respiration rate per minute was found to be 29.75 ± 2.33 at '0' day whereas it was 23.75 ± 1.32 and 22.83 ± 0.91 on 30th and 60th day respectively.

In group II the respiration rate per minute was found to be 30.00 ± 2.36 at '0' day whereas it was 25.62 ± 1.94 and 24.62 ±` 1.84 on 30th and 60th day respectively.

In group III the respiration rate per minute was found to be 29.66 ± 1.98 at '0' day whereas it was 23.16 ± 1.16 and 22.5 ±` 0.98 on 30th and 60th days respectively.

The mean values of respiration rate on day '0' in all groups were significantly higher than mean value of respiration rate on day 30 and 60. No significances were observed in values between all groups. The increase in respiratory rate in all groups might be due to severe injury and initial inflammatory response to fracture. Pardeshi (2007) reported that significant elevation of respiratory rate between first and third post-operative days and subsequently returned to normal.

4.6.2.3 Heart rate

In group I the heart rate per minute was found to be 109.66 ±` 3.66 at '0' day whereas it was 102.91 ±` 3.36 and 103.66 ±2.81 on 30th and 60thd ays respectively.

In group II the heart rate per minute was found to be 109.00 ± 4.90 at '0' day whereas it was 105.5 ± 3.94 and 100.37 ± 3.92 on 30th and 60th days respectively.

In group III the heart rate per minute was found to be 102.25 ± 4.09 at '0' day whereas it was 100.00 ± 3.10 and 98.66 ± 3.19 on 30th and 60thdays respectively.

The mean values of heart rate on day '0' in all groups were significantly higher than mean value of heart rate on day 30 and 60. No significances were observed in values

between all groups. The increase in heart rate in all groups might be due to severe injury and initial inflammatory response to fracture. The results were agreement with Pardeshi (2007).

### 4.6.3 Local parameters (at fracture site)

Up on physical examination all the selected 18 dogs belonging to groups I, II and III showed the clinical symptoms of non weight bearing, swelling, pain, crepitus and limping gait during admission at the hospital. Similar finding were reported by

**Table 15: Physiological parameters of dogs suffering from long bone fracture (Mean ± S.E.).**

| Temperature ($^0$F) | | | |
|---|---|---|---|
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 103.00 ± 0.30 | 101.06 ± 0.16 | 100.95 ± 0.18 |
| **II** | 103.75 ± 1.37 | 100.85 ± 0.23 | 100.96 ± 0.29 |
| **III** | 102.12 ± 0.24 | 101.18 ± 0.12 | 101.22 ± 0.15 |
| **Respiration rate (per minute)** | | | |
| **Group** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 29.75 ± 2.33 | 23.75 ± 1.32 | 22.83 ± 0.91 |
| **II** | 30.00 ± 2.36 | 25.62 ± 1.49 | 24.62 ± 1.84 |
| **III** | 29.66 ± 1.98 | 23.16 ± 1.16 | 22.5 ± 0.98 |
| Heart rate (per minute) | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| I | 109.66 ± 3.66 | 102.91 ± 3.36 | 103.66 ± 2.81 |
| II | 109.00 ± 4.90 | 105.5 ± 3.94 | 100.37 ± 3.92 |
| III | 102.25 ± 4.09 | 100.00 ± 3.10 | 98.66 ± 3.19 |

Singh *et al.* (2012) like history of non-weight bearing and palpation of the affected limb indicated pain, swelling and crepitus.

### 4.6.4 Haematological analysis

#### 4.6.4.1 Haemoglobin (Hb)

In group I at '0' day the average mean value of haemoglobin concentration in gram % was found to be 13.36 ± 1.54 and values of 30$^{th}$ and 60$^{th}$ days were 12.85 ± 0.84 and 12.86 ± 0.92 gram % respectively.

In group II at '0' day the average mean value of haemoglobin concentration in gram % was foung to be 12.38 ± 1.05 and values of 30$^{th}$ and 60$^{th}$ days were 14.02 ± 1.76 and 13.57 ± 1.28 gram % respectively.

In group III at '0' day the average mean value of haemoglobin concentration in gram % was found to be 12.43 ± 0.94 and value of 30$^{th}$ and 60$^{th}$ days were 13.15 ± 0.88 and 12.38 ± 1.05 gram % respectively. The values obtained are showed in Table – 19.

There was no significant different noticed in mean values of haemoglobin within and between group I, II and III. In the present study haemoglobin concentration remained within the normal range throughout the period of study in all three groups with no significant different at different intervals except one indicative that dogs included in the study had minimum internal hemorrhage. Pardeshi (2007) reported that, there was no significant variation in haemoglobin count during post-operative day of fracture repair.

#### 4.6.4.2 Packed Cell Volume (PCV)

In group I the packed cell volume (%) at '0' day was 39.08 ± 4.03 whereas it was 37.33 ± 2.36 and 36.90 ± 2.54 per cent on 30$^{th}$ and 60$^{th}$ days respectively.

In group II the packed cell volume (%) at '0' day was 35.99 ± 2.58 whereas it was 40.65 ± 4.88 and 41.85 ± 3.88 per cent on 30$^{th}$ and 60$^{th}$ days respectively.

In group III the packed cell volume (%) at '0' day was 36.88 ± 2.94 whereas it was 37.96 ± 2.35 and 38.32 ± 3.24 per cent on 30$^{th}$ and 60$^{th}$ days respectively. (Table-19).

There was no significant different noticed in mean values of packed cell volume percent within and between group I, II and III. In the present study packed cell volume percent remained within the normal range throughout the period of study in all three groups with no significant different at different intervals except one indicative that dogs included in the study had minimum internal hemorrhage due to external trauma to cause significant reduction in the packed cell volume percent Pardeshi (2007) reported that, there

was no significant variation in packed cell volume during post-operative day of fracture repair.

#### 4.6.4.3 Total Erythrocyte Count (TEC)

In group I the total erythrocyte count (millions / cu mm) was found to be 6.57 ± 0.75 millions / cu mm on '0' day, whereas it was 7.19 ± 0.69 and 6.19 ± 0.43 millions / cu mm on $30^{th}$ and $60^{th}$ days respectively.

In group II the total erythrocyte count (millions / cu mm) was found to be 6.15 ± 0.44 millions / cu mm on '0' day, whereas it was 7.26 ± 1.00 and 6.69 ± 0.54 millions / cu mm on $30^{th}$ and $60^{th}$ days respectively.

In group III the total erythrocyte count (millions / cu mm) was found to be 6.01 ± 0.49 millions / cu mm on '0' day, whereas it was 7.65 ± 1.02 and 8.46 ± 3.28 millions / cu mm on $30^{th}$ and $60^{th}$ days respectively. (Table-19).

There was no significant different noticed in mean values of total erythrocyte count percent within and between group I, II and III. In the present study total erythrocyte count remained within the normal range throughout the period of study in all three groups with no significant different at different intervals except three indicative that dogs included in the study had minimum internal hemorrhage due to external trauma to cause significant reduction in the total erythrocyte count. Pardeshi (2007) reported that, there was no significant variation in total erythrocyte count during post-operative day of fracture repair.

#### 4.6.4.4 Total Leucocyte Count (TLC)

In group I the average mean of total leukocyte count at '0' day was found to be 26.43 ± 5.35 ($10^3$ cu mm), whereas it was 13.00 ± 1.26 and 11.19 ± 1.11 ($10^3$ / cu mm) on $30^{th}$ and $60^{th}$ days respectively.

In group II the average mean of total leukocyte count at '0' day was found to be 19.91 ± 3.79 ($10^3$ cu mm), whereas it was 15.18 ± 2.3 and 12.29 ± 1.19 ($10^3$ / cu mm) on $30^{th}$ and $60^{th}$ days respectively.

In group II the average mean of total leukocyte count at '0' day was found to be 19.20 ± 1.90 ($10^3$ cu mm), whereas it was 15.70 ± 1.31 and 13.03 ± 1.49 ($10^3$ / cu mm) on $30^{th}$ and $60^{th}$ days respectively (Table – 19).

**Table 16: Haematological parameters of dogs suffering from long bone fracture (Mean ± S.E.).**

| Haemoglobin (gm%) | | | |
|---|---|---|---|
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 13.36 ± 1.54 | 12.85 ± 0.84 | 12.86 ± 0.92 |
| **II** | 12.38 ± 1.05 | 14.02 ± 1.76 | 13.57 ± 1.28 |
| **III** | 12.43 ± 0.94 | 13.15 ± 0.88 | 12.38 ± 1.05 |
| **PCV (%)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 39.08 ± 4.03 | 37.33 ± 2.36 | 36.90 ± 2.54 |
| **II** | 35.99 ± 2.58 | 40.65 ± 4.88 | 41.85 ± 3.88 |
| **III** | 36.88 ± 2.94 | 37.96 ± 2.35 | 38.32 ± 3.24 |
| **TEC ($10^6$/ cu mm)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| I | 6.57 ± 0.75 | 7.18 ± 0.69 | 6.19 ± 0.43 |
| II | 6.15 ± 0.44 | 7.26 ± 1.00 | 6.69 ± 0.54 |
| III | 6.01 ± 0.49 | 7.65 ± 1.02 | 8.46 ± 3.28 |
| **TLC ($10^3$ / cu mm)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 26.43 ± 5.35 | 13.00 ± 1.26 | 11.19 ± 1.11 |
| **II** | 19.91 ± 3.79 | 15.18 ± 2.3 | 12.29 ± 1.19 |
| **III** | 19.20 ± 1.90 | 15.70 ± 1.31 | 13.03 ± 1.49 |

The mean values of total leukocyte count on day '0' in all groups were significantly higher than mean value of total leukocyte count on day 30 and 60. No significances were observed in values between all groups. The increase in TLC count in all groups might be due to initial inflammatory response to fracture. This could be due to inflammatory process (Benjamin, 1998) and trauma at the site of surgery (Srinivasamurthy, 2000). Pardeshi (2007) reported that, there was significant increased in total leukocyte count upto third post-operative day of fracture repair which could be due to inflammatory process originated at the fracture site.

**4.6.4.5 Differential Leucocyte Count (DLC)**

**A) Neutrophils**

In group I the mean values of neutrophils count on '0' day was recorded as 78.58 ± 4.46% whereas it was 71.33 ± 1.70 and 67.08 ± 1.59% on $30^{th}$ and $60^{th}$ days respectively.

In group II the mean values of neutrophils count on '0' day was recorded as 81.25 ± 8.43% whereas it was 65.62 ± 2.91 and 71.75 ± 2.16% on $30^{th}$ and $60^{th}$ days respectively.

In group III the mean values of neutrophils count on '0' day was recorded as 74.58 ± 2.55% whereas it was 63.75 ± 2.42 and 66.5 ± 1.69% on $30^{th}$ and $60^{th}$ days respectively (Table-20).

The mean values of neutrophils count on day '0' in all groups were significantly higher than mean value of neutrophils count on day 30 and 60. No significances were observed in values between all groups. The increase in neutrophils in all groups might be due to response of the body to inflammation (Benjamin, 1998) and trauma at the surgical site (Srinivasamurthy, 2000). Pardeshi (2007) reported that, there was significant increased in neutrophils count upto third post-operative day of fracture repair which could be due to inflammatory process originated at the fracture site.

**B) Lymphocytes (%)**

In group I the mean value of lymphocyte counts on '0' day was recorded as 14.25 ± 4.14% whereas it was 20.75 ± 1.42 and 25.66 ± 2.18% on $30^{th}$ and $60^{th}$ days respectively.

In group II the mean value of lymphocyte counts on '0' day was recorded as 12.25 ± 8.8% whereas it was 27.62 ± 3.06 and 22.71 ± 3.38% on $30^{th}$ and $60^{th}$ days respectively.

In group III the mean value of lymphocyte counts on '0' day was recorded as 17.83 ± 2.76% where it was 27.08 ± 2.40 and 29.25 ± 2.23% on 30$^{th}$ and 60$^{th}$ days respectively (Tabl-20).

The mean values of lymphocyte count on day '0' in all groups were significantly lower than mean value of lymphocyte count on day 30 and 60. No significances were observed in values between all groups. The decrease in lymphocyte in all groups might be due to relatively increase value of neutrophils. Similar findings were given by Benjamin (1998) and Srinivasamurthy (2000).

**C) Eosinophils (%)**

In group I the mean value of eosinophils count on '0' day was recorded as 1.58 ± 0.46% whereas it was 2.33 ± 0.39 and 2.75 ± 1.02%ll on 30$^{th}$ and 60$^{th}$ days respectively.

In group II the mean value of eosinophils counts on '0' day was recorded as 1.37 ± 0.32% whereas it was 2.75 ± 1.25 and 1.57 ± 0.29% on 30$^{th}$ and 60$^{th}$ days respectively.

In group III the mean values of eosinophils count on '0' day was recorded as 2.75 ± 0.68% whereas it was 3.50 ± 0.63 and 1.08 ± 0.14% on 30$^{th}$ and 60$^{th}$ days respectively (Table-20).

There was no significant different noticed in mean values of eosinophils within and between group I, II and III. This indicated that dogs included in the study had no any allergic reaction. Similar findings were earlier reported by Pardeshi (2007).

**D) Monocytes (%)**

In group I the mean value of monocytes count on '0' day was recorded as 5.08 ± 0.81% whereas it was 4.91 ± 0.75 and 4.18 ± 0.61% on 30$^{th}$ and 60$^{th}$ days respectively.

In group II the mean value of monocytes counts on '0' day was recorded as 4.87 ± 1.17% whereas it was 3.50 ± 0.82 and 3.87 ± 0.81% on 30$^{th}$ and 60$^{th}$ days respectively.

In group III the mean value of monocytes counts on '0' day was recorded as 4.00 ± 0.56% whereas it was 5.25 ± 0.70 and 3.66 ± 0.55% on 30$^{th}$ and 60$^{th}$ days respectively (Table-20).

**Table 17: Differential leucocytes of dogs suffering from long bone fracture (Mean ± S.E.).**

| Neutrophils (%) | | | |
|---|---|---|---|
| Groups | Days | | |
| | 0 | 30 | 60 |
| I | 78.58 ± 4.46 | 71.33 ± 1.70 | 67.08 ± 1.59 |
| II | 81.25 ± 8.43 | 65.62 ± 2.91 | 71.75 ± 2.16 |
| III | 74.58 ± 2.55 | 63.75 ± 2.42 | 66.5 ± 1.69 |
| **Lymphocytes (%)** | | | |
| Groups | Days | | |
| | 0 | 30 | 60 |
| I | 14.25 ± 4.14 | 20.75 ± 1.42 | 25.66 ± 2.18 |
| II | 12.25 ± 8.8 | 27.62 ± 3.06 | 22.71 ± 3.38 |
| III | 17.83 ± 2.76 | 27.08 ± 2.40 | 29.25 ± 2.23 |
| **Eosinophils (%)** | | | |
| Groups | Days | | |
| | 0 | 30 | 60 |
| I | 1.58 ± 0.46 | 2.33 ± 0.39 | 2.75 ± 1.02 |
| II | 1.37 ± 0.32 | 2.75 ± 1.25 | 1.57 ± 0.29 |
| III | 2.75 ± 0.68 | 3.50 ± 0.63 | 1.08 ± 0.14 |
| **Monocytes (%)** | | | |
| Groups | Days | | |
| | 0 | 30 | 60 |
| I | 5.08 ± 0.81 | 4.91 ± 0.75 | 4.18 ± 0.61 |
| II | 4.87 ± 1.17 | 3.50 ± 0.82 | 3.87 ± 0.81 |

| | | | |
|---|---|---|---|
| **III** | 4.00 ± 0.56 | 5.25 ± 0.70 | 3.66 ± 0.55 |
| **Basophils (%)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 0.50 ± 0.19 | 0.50 ± 0.19 | 0.50 ± 0.19 |
| **II** | 0.25 ± 0.16 | 0.25 ± 0.16 | 0.37 ± 0.18 |
| **III** | 0.63 ± 0.20 | 0.58 ± 0.19 | 0.25 ± 0.13 |

There was no significant different noticed in mean values of monocytes within and between groups I, II and III. This indicated that dogs included in the study had no any viral infection and neoplastic growth. Similar finding was reported by Pardeshi (2007).

**D) Basophils (%)**

In group I the mean value of basophils count on '0' day was recorded as 0.50 ± 0.19% whereas it was 0.50 ± 0.19 and 0.50 ± 0.19% on 30$^{th}$ and 60$^{th}$ days respectively.

In group II the mean value of basophils counts on '0' day was recorded as 0.25 ± 0.16% whereas it was 0.25 ± 0.16 and 0.37 ± 0.18% on 30$^{th}$ and 60$^{th}$ days respectively.

In group III the mean value of basophils counts on '0' day was recorded as 0.63 ± 0.20% whereas it was 0.58 ± 0.19 and 0.25 ± 0.13% on 30$^{th}$ and 60$^{th}$ days respectively (Table-20).

There was no significant different noticed in mean values of basophils within and between groups I, II and III. This indicated that dogs included in the study had no any acute hypersensitivity or allergic reactions. Similar findings were reported by Pardeshi (2007).

### 4.6.5 Biochemical parameters

Biochemical parameters (serum calcium, phosphorus and alkaline phosphatase) were estimated from serum of all dogs of group I, II and III using standard kits.

#### 4.6.5.1 Serum calcium

In group I the average mean value of serum calcium recorded was 10.69 ± 0.99 mg/dl on '0' day whereas it was 10.87 ± 0.70 and 11.53 ± 0.71 mg/dl on $30^{th}$ and $60^{th}$ days respectively.

In group II the average mean value of serum calcium recorded was 11.58 ± 0.62 mg/dl on '0' day whereas it was 11.38 ± 0.80 and 12.06 ± 0.80 mg/dl on $30^{th}$ and $60^{th}$ days respectively.

In group III the average mean value of serum calcium recorded was 10.51 ± 0.90 mg/dl on '0' day whereas it was 10.48 ± 0.76 and 10.72 ± 0.68 mg/dl on $30^{th}$ and $60^{th}$ days respectively (Table-21).

In the present study mean of serum calcium remained within the normal range throughout the period of study in all three groups with no significant different use at different intervals. This indicated that the fracture and the type of immobilization technique did not interfere with the serum calcium level in the blood. No significant variation in the body calcium values during fracture healing had been also observed by Singh *et. Al.* (1976) and Chandy (2000). However, Kumar *et al.* (1992) reported a significant decline in plasma calcium during the healing period of 21 days in fractured dogs.

#### 4.6.5.2 Serum phosphorus

In group I the average mean value of serum phosphorus was recorded as 5.28 ± 0.37 mg/dl on '0' day whereas it was 5.51 ± 0.34 and 5.38 ± 0.35 mg/dl on $30^{th}$ and $60^{th}$ days respectively.

In group II the average mean value of serum phosphorus was recorded as 5.42 ± 0.26 mg/dl on '0' day whereas it was 5.66 ± 0.30 and 5.21 ± 0.29 mg/dl on $30^{th}$ and $60^{th}$ days respectively.

In group III the average mean value of serum phosphorus was recorded as 5.32 ± 0.43 mg/dl on '0' day whereas it was 5.15 ± 0.40 and 5.20 ± 0.33 mg/dl on $30^{th}$ and $60^{th}$ days respectively (Table – 21).

In the present study mean of serum phosphorus remained within the normal range throughout the period of study in all three groups with no significant different at different intervals indicative that the fracture and the type of immobilization technique did not

interfere with the body phosphorus level in the blood. No significant variation in the serum phosphorus values during fracture healing had been also observed by Singh *et al.* (1976) and Chandy (2000). However, Kumar *et al.* (1992) reported a significant decline in plasma phosphorus during the healing period of 21 days in fractured dogs.

### 4.6.5.3 Serum alkaline phosphatase

In group I serum alkaline phosphaase concentration on '0' day was 107.41 ± 9.43 IU/L whereas it was 146.75 ± 10.55 and 123.16 ± 9.45 IU/L on 30$^{th}$ and 60$^{th}$ days respectively.

In group I serum alkaline phosphatase concentration on '0' day was 107.25 ± 13.39 IU/L whereas it was 141.37 ± 9.87 and 128.37 ± 6.07 IU/L on 30$^{th}$ and 60$^{th}$

**Table 18: Biochemical parameters of dogs suffering from long bone fracture (Mean ± S.E.).**

| Serum calcium (mg/dl) | | | |
|---|---|---|---|
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 10.09 ± 0.59 | 10.87 ± 0.70 | 11.53 ± 0.71 |
| **II** | 11.58 ± 0.62 | 11.38 ± 0.80 | 12.06 ± 0.80 |
| **III** | 11.51 ± 0.90 | 10.43 ± 0.76 | 10.72 ± 0.68 |
| **Serum phosphorous (mg/dl)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| **I** | 5.25 ± 0.37 | 5.51 ± 0.34 | 5.38 ± 0.35 |
| **II** | 5.42 ± 0.26 | 5.66 ± 0.30 | 5.21 ± 0.29 |
| **III** | 5.32 ± 0.43 | 5.15 ± 0.40 | 5.20 ± 0.33 |
| **Alcaline phosphorous (IU/L)** | | | |
| **Groups** | **Days** | | |
| | **0** | **30** | **60** |
| I | 107.41 ± 9.43 | 146.75 ± 10.55 | 123.16 ± 9.45 |
| II | 107.25 ± 13.39 | 141.37 ± 9.87 | 128.37 ± 6.07 |
| III | 104.58 ± 9.00 | 143.08 ± 7.79 | 124.08 ± 6.72 |

In group I serum alkaline phosphatase concentration on '0' day was 104.58 ± 9.00 IU/L whereas it was 143.08 ± 7.79 and 124.08 ± 6.72 IU/L on 30$^{th}$ and 60$^{th}$ days respectively (Table-21).

The mean values of alkaline phosphatase concentration on day 30 in all groups were significantly higher than mean values of alkaline phosphatase concentration on day '0'. However, a significant decrease in values was observed in the all the groups on day 60$^{th}$. No significant were observed in values between all groups. The values came to normal after 30$^{th}$ post-operative day because the stabilization provided by the fixation technique may have been helpful in achieving early healing of fractures. This finding was in accordance with Chandy (2000), Julie (2005), Pardeshi (2007) and Singh *et al.* (2008).

## 4.7 Evaluation of fracture healing

Evaluation of fracture healing in all group was carried out clinically (amount of weight bearing) and radiographically on 0, 30$^{th}$ and 60$^{th}$ day after immobilization.

### 4.7.1 Clinical evaluation of fracture healing

Clinical evaluation of fracture healing was performed by determining the extent of weight bearing on fractured limb. Assessment of weight bearing was made after immobilization of fracture at 30$^{th}$ and 60$^{th}$ day and glade as (-) for non weight bearing, (+) for partial weight bearing, (++) for moderate weight bearing and (+++) for complete weight bearing.

In group I on day 0 no weight bearing was seen immediately after immobilization, while on day 30 partial weight bearing was seen in all dogs with fracture. Complete weight bearing was started at 60$^{th}$ post operative day. Animal of group I showed limping gait between 0-30 days then after 30 day gradually, gait of the animals returned to near normal with a marked improvement in weight bearing capacity of fractured limb on 60$^{th}$ day in 4 dogs. The dogs in group I started complete weight bearing on average 58.25 days. Singh *et al.* (2008) observed mild weight bearing at 15-20 days, moderate weight bearing at 18-21 days, good weight bearing at 28-30 days and very good weight bearing at 40-45 days.

In group II on day 0 no weight bearing was seen observed but on 30$^{th}$ day moderate weight bearing was started in 3 dogs where as partial weight bearing was observed in 3 dogs. There was complete weight bearing at 60$^{th}$ post operative day in 4 dogs while 2 dogs showed only moderate weight bearing. The dogs in group II started complete weight

bearing on average 52.5 days. Singh *et al.* (2008) and Avasthi *et al.* (2012) who reported early weight bearing in radius ulna fractures.

In group III on day 0 no weight bearing was seen observed but on 30$^{th}$ day partial weight bearing was started in 2 dogs where as moderate weight bearing was observed in 2 dogs and complete weight bearing in 2 dogs. There was complete weight bearing at 60$^{th}$ post operative day in all dogs. The dogs in group III started complete weight bearing on average 42.9 days. Similar results were obtained by Ayyappan *et al.* (2009) (Table-22).

### 4.7.2 Radiographic evaluation

All dogs under study were subjected to radiography of fracture site before immobilization and during the process of fracture healing at 30$^{th}$ and 60$^{th}$ days post-operatively. Radiographic findings were given below.

**0 day**

Radiographic examination of fracture site before immobilization in 18 dogs revealed that 8 cases were oblique fractures, 4cases of transverse fractures, 4 cases of incomplete fractures and 2 cases of multiple fractures. The general examination of the radiographs taken immediately after fracture fixation revealed adequate alignment of the fractured fragments in all dogs of group I, II and III.

**30$^{th}$ day**

On day 30$^{th}$ post immobilization, radiographic examination revealed periosteal reaction along with formation of dense callus in all cases of group I in group II on 30$^{th}$ day post immobilization the radiograph showing more area of periosteal reaction and callus formation at fracture site was noticed in 5 cases while dense callus with bridging of cortex and calcification were evident in 7 cases. In group III, periosteal reaction was seen around the fracture site till the 30$^{th}$ days in all cases. This could be attributed to the fact that fractures treated with internal fixation heal with periosteal bridging. These finding were in accordance with those of Gul and Yanik (2006).

**60$^{th}$ day**

**Table 22: Assessment of weight bearing during fracture healing in dogs suffering from radius ulna fracture.**

| Days of observation | Group-I (n=6) | | | | | |
|---|---|---|---|---|---|---|
| | I-1 | I-2 | I-3 | I-4 | I-5 | I-6 |
| 0 | - | - | - | - | - | - |
| 30 | + | + | + | + | + | + |
| 60 | ++<br>+ | ++<br>+ | ++ | ++<br>+ | ++<br>+ | ++<br>+ |
| Day at which started full weight bearing | 51 | 48 | 67 | 43 | 46 | 55 |

| Days of observation | Group-II (n=6) | | | | | |
|---|---|---|---|---|---|---|
| | I-1 | I-2 | I-3 | I-4 | I-5 | I-6 |
| 0 | - | - | - | - | - | - |
| 30 | ++ | + | ++ | + | + | + |
| 60 | +++ | ++ | +++ | ++ | +++ | +++ |
| Days at which started full weight bearing | 35 | 66 | 44 | 72 | 54 | 52 |

| Days of observation | Group-III (n=6) | | | | | |
|---|---|---|---|---|---|---|
| | I-1 | I-2 | I-3 | I-4 | I-5 | I-6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | - | - | - | - | - | - |
| 30 | + | ++<br>+ | ++ | ++<br>+ | + | ++ |
| 60 | ++ | ++<br>+ | ++<br>+ | ++<br>+ | ++<br>+ | ++<br>+ |
| Day at which started full weight bearing | 65 | 28 | 44 | 25 | 56 | 53 |

Note : Non weight bearing (-) Partial weight bearing (+)

Moderate weight bearing (++) Complete weight bearing (+++)

**Table 20: Measurement of callus index during fracture healing in dogs suffering from radius ulna fracture (Mean ± S.E.).**

| Days | Callus Index | | |
|---|---|---|---|
| | **Group I (n=6)** | **Group II (n=6)** | **Group III (n=6)** |
| 30 | 1.57 ± 0.05 | 1.56 ± 0.05 | 1.54 ± 0.04 |
| 60 | 1.53 ± 0.05 | 1.54 ± 0.04 | 1.51 ± 0.04 |

Radiographic examination on day 60 post immobilization revealed complete bridging of cortex at fracture site with uniform classification and reduction in the size of callus giving the sign of remodeling of the bone in group I. In group II 60$^{th}$ day post immobilization radiographic observations revealed reorganization of callus formation as started with absorption of extra callus in all dogs. In group III 60$^{th}$ day post immobilization

radiographic observation revealed reorganization of callus formation as started with absorption of extra callus in all dogs.

#### 4.7.2.1 Measurement of callus index

In group I, the mean callus index was 1.57 ± 0.05 and 1.53 ± 0.05 on day 30$^{th}$ and 60$^{th}$ after immobilization respectively while in group II it was 1.56 ± 0.05 and 1.54 ± 0.04 on day 30$^{th}$ and 60$^{th}$ after immobilization respectively while in group III it was 1.54 ± 0.04 and 1.51 ± 0.04 on day 30$^{th}$ and 60$^{th}$ after immobilization respectively (table-23).

In all groups non significant in callus index was noted up to 60$^{th}$ day post immobilization. No significant difference was observed in time taken to reach maximum value of callus index between all groups indicating that all methods were equally affective for fracture healing on radiographic evaluation.

This peak in callus index might indicate time for maximum callus formation and starting of remodeling phase by day 60. Eastaugh- Waring *et al.* (2009) have stated that a peak in the callus index could be used as an indicator that healing has creased and that remodeling has commenced.

### 4.8 Post-operative care

In all the dogs of all groups, administration of meloxicarn as an analgesic to reduce post-operative pain provided sufficient pain relief to most of the dogs in the present study. This result supported the finding obtained by Julie *et al.* (2007), Bhagat (2009) and Bhatia (2010). In all the cases, use of ceftriaxone as post-operative antibiotic found to be affective.

In all the dogs belonging to group III, the surgical wounds as well as the pin-skin interfaces were cleaned with Povidone iodine solution upto complete wound healing. This provided good antisepsis for the surgical wound as followed by Rani (2008), Bhagat (2009), Bhatia (2010) and Vedpathak *et al.* (2011). The skin sutures were removed from 10$^{th}$ to 12$^{th}$ post-operative day based on wound healing.

### 4.9 Economic parameters

The costofintramedullary pin was Rs. 300. The cost of interlocking nails wasRs. 200 and the cost of plate was Rs. 1500. Group II can be possible at field level but in group I and III (plating) required sophisticated operation theater with orthopedic unit which was not available in field level. The time taken for internal fixation with plate was higher than

intramedullary pinning. Intramedullary pinning was performed in 75 minutes by retrograde technique and 35 minutes by normograde technique.

## 4.7 Complication

Complications are reality of fracture repair. However, surgeons can minimize the incidence of these complications by understanding their pathophysiology and etiology, Additionally, the impact on patients can be reduced by prompt diagnosis and treatment. Adherence to sound surgical technique, proper fracture fixation choices, and a thorough knowledge of local anatomy remain the hallmark of prevention.

In group I, majority of cases showed normal bony union with no complication except one cases in which, the animal took off the apparatus after two weeks. Another cases showed no endosteal or periosteal bridging between the fractured fragments. This nonunion could have been due to the open and infected fracture and also due to unsuccessful intramedullary pinning done earlier. A few cases showed mild wire tract infection. This was improved by daily cleaning of the site with Povidone Iodine solution and providing additional antibiotic dressing topically at the wire-skin interface. Similar finding were reported by Marcellin-Little (2004), Dwivedi *et al.* (2009) and Bhatia (2010).

In group II, occasional limping was observed inspite of complete weight bearing in a few cases. This was due to irritation of pin to soft tissue around the insertion site while flexing and extending the limb. Mild rotation of the distal fragment was observed in one case. This could be attributed to the incapability of the intramedullary pin to resist rotational forces. Infection was seen in one case at the incision site. Similar finding were reported by Piermattei *et al.* (2006). Mild muscle atrophy of the affected limb was seen in few cases. This atrophy was mainly due to not using the affected limb functionally.

## 4.8 Comparative studies

Intramedullary pinning gave better and early healing than plating and also cheaper than plates. These finding were also substantiated by Bhatia (2010).

Closed, transosseous fixation preserved the vascularity of the fracture segments and soft tissues and thus contributed to a more rapid consolidation of the fracture. Furthermore, by avoiding opening of the fracture site, the risk of infection and subsequent osteomyelitis was minimized. When dogs with long bone fracture were treated with Ilizarov apparatus weight bearing was allowed from the first postoperative day in progressive weight bearing was encouraged till the animal stated bearing full weight on

the extremity. Weight bearing added to positive affects of compression forces on the fracture site and also increased the venous and lymphatic return preventing swelling and tissue osteopenia.

Intramedullary pinning when done by closed reduction maintained bone vascularity but better stability was not provided. Hence early weight bearing was not seen.

# CHAPTER-5

# SUMMARY AND CONCLUSION

# V. SUMMARY AND CONCLUSIONS

Fractures in dogs are relatively common surgical affections occurring due to trauma from road accidents and fall from height. The present study was carried out to compare efficacy of plating and intramedullary pinning in radius ulna fractures in dogs. The present study was carried out in department of Veterinary Surgery and Radiology in collaboration with Teaching Veterinary Clinical Complex, Department of Veterinary Pathology and Veterinary Anatomy. To begin, last three years retrospective data on etiology, breed, sex, affected bone, age, fracture line, type of fracture, season and corrective measures applies on dogs presented to the Teaching Veterinary Clinical Complex were collected and analyzed to study the epidemiology of orthopaedic maladies.

The study was divided in two parts comprising of part-A retrospective study which was carried out in dogs having radius ulna fractures presented at teaching veterinary clinical complex (2014-2016), whereas part-B further divided in three groups in which group I (n=6) comprised of dogs suffering from radius ulna fractures were immobilized by radius plating, in group II (n=6) comprised of dogs suffering from radius ulna fracture immobilized by ulna pinning and group III (n=6) comprised of dogs suffering from radius ulna fracture immobilized by both.

**Part : A**

In retrospective study analysis of fracture cases in different species presented to Teaching Veterinary Clinical Complex during 2014-2016 was carried out and incidence of fractures in dogs on basis of age, sex, season, etiology, type of fracture and treatment given were recorded.

A total of 14,069 new cases were registered during the last three years at the TVCC, out of which 4,658 (33.10%) cases were of dogs. Among the canine cases registered, 1,445 (32.33%) were referred to Department of Veterinary Surgery and Radiology and 340 (7.29%) cases showed orthopaedic maladies. Out of 340 cases, 177 (52.05%) cases were of fractures followed by 38 (11.17%) cases of hip dysplasia, 14 (4.11%) cases of rickets, 06 (1.76%) cases of osteoarthritis and 105 (30.88%) cases of other lameness. The major etiological cause was trauma/automobile accidents in 114 (64.40%) cases followed by fall from height which accounted for 34 (19.40%) cases.

The study revealed that majority of the orthopaedic maladies were seen in dog aged below 1 year of age accounting for 115 (64.97%) cases followed by a high number of cases, i.e., 37 (20.90%) in dogs aged between 1-3 years. Then a gradual decline was seen in cases of orthopaedic maladies as the age of the dog increased.

Breed wise data of the fractures highlighted higher occurrence in Non-descript dogs 108 (61.01%) followed by German Shepherd 27 (15.25%), Spitz 17 (9.60%), Labrador Retriever 9 (5.08%) and Doberman 8 (4.51%). Higher incidence of fracture was observed in males 114 (66.40%) as compared to female dogs 63 (35.60%).

Among different bones, highest number of fracture were seen in femur 52 (29.37%) followed by tibia-fibula 46 (25.98%), radio-ulna 31 (17.51%) and humerus 16 (9.03%).

Nature-wise data on fractures revealed majority of fractures as closed 105 (59.32%) while the open fractures accounted 72 (40.69%). Further, majority of fractures were transverse 59 (33.33%) followed by comminuted 55 (31.07%) and oblique / spiral 54 (30.50%) whereas incomplete fractures accounted for only 9 (5.08%) of the total fracture cases.

Incidence based on management of fracture revealed plaster of Paris 74 (41.80%) and intramedullary pinning 39 (22.03%) being the choice of treatment in maximum cases. The highest numbers of fracture cases were recorded in monsoon (July-October) 68 (38.41%) than winter (November-January) 57 (32.20%) and summer season (March-June) 52 (29.37%).

**Part : B**

For clinical study, total 18 dogs suffering from radius ulna fracture were included in this study. Out of total 18 dogs, automobile accident was the etiological factor in 20 dogs followed by fall in 9 dogs stepping in to hall in 2 dogs and dog bite in 1 dog. All the dogs could not bear weight on the fractured limb.

On clinical examination of fractured limb, 16 dogs were affected with right limb, 15 dogs with fracture of left limb and 1 dog with fracture of both limbs. Fractures of femur bone (11 dogs) were more common followed by tibial fractures (10 dogs), radius-ulna fractures (8 dogs), humerus fracture (1 dog), metatarsal fracture (1 dog) and metacarpal fracture (1 dog). Radiographic examination of fracture site before immobilization in 32 dogs revealed that 11 cases of oblique fractures, 8 cases of incomplete fractures, 7 cases of

transverse fracture and 6 cases of multiple fractures with mid-shaft fractures (15) more common as compared to proximal third (8), distal third (7) and metaphyseal fractures (2).

Pain, crepitating sound and abnormal mobility in lateral direction was observed on palpation of fractured fragment in all the dogs with long bone fracture. Physiological parameters i.e. respiration rate was ranged in normal physiological limits throughout period of study while significant difference was noticed in value of rectal temperature and heart rate between all groups on '0' day.

All the dogs were partially or completely off feed due to injury hence further fasting was not required. Premedication with Atropine Sulphate prevented excessive salivation in all the dogs belonging to groups I, II and III. All the dogs were premedicated with Atropine sulphate at the dose rate of 0.04 mg/kg body weight subcutaneously, anaesthesia were induced with Ketamine hydrochloride and Diazepam combination at the dose rate of 10mg/kg and 1mg/kg body respectively intravenously and were maintained on ketamine. Perioperative use of analgesic, and antibiotic helped in managing pain, stabilizing the patient and in preventing further possibilities of infection during and after the immobilization procedures.

In group II & III, The affected limb of the dogs was prepared for aseptic surgery by clipping, shaving and scrubbing the entire region of fractured bone with Betadine scrub. For intramedullary pinning the patient's limb was secured at the paw with bandage in lateral recumbency. Steinmann pins in the range of 3 mm to 7 mm diameter were used to immobilize the fracture fragments. The intramedullary pin was inserted by normograde method of pinning in 4 cases and 8 cases of fractures immobilized by retrograde method of pinning.

In group I, the incidence of displacement of bandage and injury by were seen. In group III, occasional limping was observed in a 3 cases due to irritation of pin to soft tissue around the insertion site while flexing and extending the limb.

Haematological and biochemical examination was performed in groups I, II and III on 0, 30$^{th}$ and 60$^{th}$ day post immobilization. No significant differences were observed in haematological parameters like baemoglobin, packed cell volume, total erythrocyte count and differential leucocyte count (except neutrophils) within and between all three groups. Significant increase was observed in total leucocyte count and neutrophils count in all groups at '0' day.

In all groups the mean value of serum calcium and serum phosphorous remained within the normal range throughout the period of study with no significant different at different intervals.

Serum alkaline phosphatase values in all groups on day 0 were remained within the normal range. However, a non significant increase in values was observed in the all the groups on day $30^{th}$ after which the values lowered on day $60^{th}$.

The clinical and radiographic evaluation of fracture healing was performed on 0, $30^{th}$ and $60^{th}$ day post immobilization. Group-III dogs showed early full weight bearing than group II. This was possibly due to intramedullary pinning prevented bending force and modified Thomas splint prevent rotational force during fracture healing. Group-II dogs showed early full weight bearing than group I. This was possibly due to stiff and unbreakable property for fiber glass cast in addition to the fact that it was examined for presence of fracture gap, extent and type of callus and position of fracture fragments.

In group I radiograph observation on day 30 post immobilization radiographic examination revealed periosteal reaction along with formation of dense callus in all cases of this group, probably due to rigid immobilization. Radiographic examination on day 60 post immobilization revealed complete bridging of cortex at fracture site with uniform calcification and reduction in the size of callus giving the sign of remodeling of the bone.

In group II radiograph on 30th da$^{y}$ post immobilization the radiograph showing more areas of periosteal reaction and callus formation at fracture site was noticed in 5 cases while dense callus with bridging of cortex and calcification were evident in 3 cases. On $60^{th}$ day post immobilization radiographic observations revealed reorganization of callus formation as started with absorption of extra callus in all dogs.

In group III, periosteal reaction was seen around the fracture site till the $30^{th}$ days in majority cases. This could be attributed to the fact that fractures treated with internal fixation heal with periosteal bridging. On $60^{th}$ day post immobilization radiographic observations revealed reorganization of callus formation as started with absorption of extra callus in all dogs.

In group I the mean value of callus index was 1.567± 0.05 and 1.51 ± 0.05 on the day $30^{th}$ and $60^{th}$ after immobilization respectively. In group II it was 1.56 ± 0.05 and 1.54 ± 0.04 on day $30^{th}$ and $60^{th}$ after immobilization respectively. In group III it was 1.54 ± 0.04 and 1.51 ± 0.04 on day $30^{th}$ and $60^{th}$ after immobilization respectively. No significant

difference was observed in time taken to reach maximum value of callus index between all groups indicating that all methods were equally effective for fracture healing on radiographic evaluation. The radiological union was almost similar in dogs of all the groups.

The cost of plate was higher than the intramedullary pin. The time taken for internal fixation with intramedullary pinning was lower than time taken for plating. Application of pin can be possible at field level butplating requires sophisticated operation theater with orthopedic unit which was not available in field level.

**Conclusions**

- Retrospective study of fracture cases during year 2014-2016 revealed and increased incidences in canines as compared to others.
- In dogs, radius ulna fractures were also common (around 20%) with automobile accident.
- In dogs, incidences of fractures were more in males and in age group of below 1 year.
- Physiological and haematological parameters were found within normal range except significant difference was noticed in heart rate, rectal temperature, total leucocyte count and neutrophils.
- Serum calcium and phosphorous level were within normal physiological range at different interval after immobilization.
- Alkaline phosphatase level was increased on post immobilization day 30 and become normal on $60^{th}$ day.
- Cost of intramedullary pin as compared plate is lower and it can be affordable by pet owner.
- Intramedullary pinning required less time in application with less complication.
- On clinical evaluation, radiographic evaluation and estimation of callus index, intramedullary pinning was found better plating techniques which required sophisticated instruments, operation theater and technical expertization.

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