CHAPTER-1

INTRODUCTION

Small animals, mainly dogs and cats are the best companion animals in the world. Now-a-days, people of Bangladesh prefer to raise dogs and cats in their own houses considering as family member rather than pet. With the comparative increase in pet animal's propriety, bone fractures comprise a major problem among dogs and cats (Senna, 2001; Harari, 2002). Most of the long bone fractures eventuate in the hind limbs, where femur bone is one of the most commonly injured (Harasen, 2003; Piermattei *et al.*, 2006; Scott and McLaughlin, 2007).

Femur fractures accounting for 20% to 26% of all fractures (Brinker and Bailey, 1997). The femoral fractures represented 37.5% and 25% in dogs and cats respectively (Ali, 2013). Other study represented that maximum fractures in femur (42.86%) followed by humerus (25.40%), radius and ulna (20.63%) and tibia and fibula (11.11%) (Das *et al.*, 2010).

The age range for dogs and cats about 78% were 6 months old or younger and 15.6% were 7 to 12 months old in dogs and 27.5% were 6 months old or younger and 52.9% were 7 to 12 months old in cats (Stigen, 1999).

Orthopedic diseases in dogs and cats mainly caused by traumatic injuries (Piermattei *et al.*, 2006; Scott and McLaughlin, 2007) specially fallen from height, vehicles, or rarely gunshot wounds (Whitehair and Vasseur, 1992). Most femoral fractures are observed as closed fracture because of the heavy overlying muscles (Beale, 2004).

Bone fractures in dogs and cats are amenable to a variety of surgical or nonsurgical intervention options based on the type of fracture, available materials and directives of the client (Denny and Butterworth, 1993; Langley-Hobbs *et al.*, 1996; Farese *et al.*, 2002; Harari, 2002). Conservative treatment doesn't allow along with external coaptation fixation, due to their anatomical characteristics of the femur and surrounding soft tissues (Beale, 2004; Piermattei *et al.*, 2006).

The ultimate goal of the fracture management is to place the rigid fixation and perfect alignment of the bone to allow both timely and maximized return to function of the affected area (Beale, 2004). The important factors in repair of femur fracture such as appropriate surgical approach, gentle handling and preservation of regional soft tissues and also their attachments to bone fragments, either anatomic reduction, enough stabilization, appropriate choice and application of implant system and accurate postoperative care (Beale, 2004; Stiffler, 2004).

Several techniques have been described for proper stabilization of femoral fractures, including use of intramedullary pins with or without cerclage wires, external coaptation, external skeletal fixators, bone plates with screws, or combinations of these techniques (DeYoung and Probst, 1985). Intramedullary pinning (IMP) is one of the most commonly used techniques and best choice for the management of long bone fractures (Kaur *et al.*, 2015). Actually all types of fracture, even severe diaphyseal comminuted fractures can be successfully treated by IMP in conjunction with cerclage wires (Denny and Butterworth, 2000).

The complications of IMP of femur fracture management included pin migration, infection sciatic nerve block, non-union, late union, quadriceps muscle contracture, and premature physeal closure (Beale, 2004; Roush, 2005).

Femoral fracture in dogs and cats is commonly found in Bangladesh. The incidence of femur fracture is high among all of long bone fractures in dogs and cats but there is not adequate facility (internal fixation technique) for femur fracture management in Bangladesh. On the other hand, it is not possible to correct femur fracture by external coaptation. In Bangladesh, adequate information was not available in scientific articles regarding orthopaedic issues. Therefore; the aim of the present study was to survey the incidence of long bone fractures along with femur fracture management in dogs and cats in SAQTVH, CVASU, Chattogram.

Objectives

- To assess the incidence of long bone fractures in dogs and cats.
- To evaluate the efficacy of femur fracture management.
- To study the complication of femur fracture management, if any.

CHAPTER-2

REVIEW OF LITERATURE

2.1. Anatomy of femur in dogs and cats

The femur is a typical long bone with cylindrical shaft including expanded extremities (Whitehair and Vasseur, 1992). It is the largest bone in skeleton, strongest of all long bones and provides origin and attachment with many muscles and tendons (Ghosh, 1998). The canine femur shaft is slightly convex cranially, whereas in feline femur shaft is almost straight with less discernible isthmus (Whitehair and Vasseur, 1992).

The femur mid shaft is covered laterally and cranially by the the biceps femoris and quadriceps muscles, respectively. The distal portion of the femur consists of the trochlea and condyles. Fixation pins inserted too far distally in the femur can enter the intercondylar fossa and disrupt ligament attachment sites (Whitehair and Vasseur, 1992).

The sciatic nerve originates from last two lumbar and first two sacral nerves (Evans and Christensen, 1979). It goes underneath to the superficial gluteal muscle and caudal to greater trochanter before ongoing distally underneath the biceps femoris muscle. The location of nerve is important, when retracting muscles and placing IM pins (Fanton *et al.*, 1983; Palmer *et al.*, 1988).

The major blood supply towards the diaphyseal region of the femur underneath to the bone at nutrient foramen which located at caudal aspect of the proximal third of diaphysis. The adductor muscle attachment with the caudal aspect of the diaphysis is also important source of periosteal vessels, which becomes significant in the healing of diaphyseal fractures (Kaderly *et al.*, 1982).

2.2. Incidence of long bone fracture of dogs and cats

Practicable literatures on incidence of fractures have been reviewed according to age, sex, breed, location, type and etiology in dogs and cats.

2.2.1. Incidence of long bone fracture according to sex, age and breed

Keosengthong *et al.* (2019) reported that mongrel breed were the most affected at 40.6% and 66.3% in dogs and cats respectively. Male (58.4%) were more prone to fracture than female (41.6%), whereas the proportion was almost similar in males and females at 49.6% and 50.4% in cat, respectively. 55% and 65% of bone fractures in dogs and cats occurred less than one-year-old respectively.

Langley-Hobb *et al.* (1996) represented 35 cats where 17% were spayed females and 11% were intact, 46% were neutered males and 17% intact; in 9% cats, the sex was unrecorded. The median age was four years and four months with a range of six months to sixteen years and three months. Of these the breed variety was 97% Domestic Short hair and 3% Siamese.

Stigen (1999) reported the age range was known for 159 dogs and cats. Of all the dogs, 78% were 6 months old or younger and 15.6% were 7 to 12 months old. Of the cats, 27.5 % were 6 months old or younger and 52.9% were 7 to 12 months old. Gender was known for 62 of the dogs and 51 of the cats. There, 58.1 % bitches and 52.9 % queens.

Alcantara and Stead (1975) stated 44 % dogs and 12 % cats were male and 29 % dogs and 12 % cats were female. Of these there were 82% fractures happened between 2 and 10 months of age.

Peirone *et al.* (2002) analyzed 15 femur cases where 60 % was male and 40 % was female. The patient’s age ranged from 2-11 months (median: 5 months). Among these femur fracture cases of breed analysis in case dog 20 % German shepherd, 13 % Boxer, 13 % Mixed breed and 6 % setter and in case of cat 27 % Domestic Short Hair and 6 % Persian.

Yardimci *et al.* (2018) analyzed total 20 dog patient with 21 fractures. Of these 70 % was male and 30 % was female. The age ranged from 5 months to 9 years (mean: 22 months).

2.2.2. Incidence of long bone fracture according to the type and location

Yardimci *et al.* (2018) stated that types of fractures in dogs were oblique (43%), comminuted (33%), and transverse (24%).

Langley-Hobb *et al.* (1996) reported about 83% Comminuted, 9% Transverse, 6% Oblique and 2% segmental femoral fractures in cat.

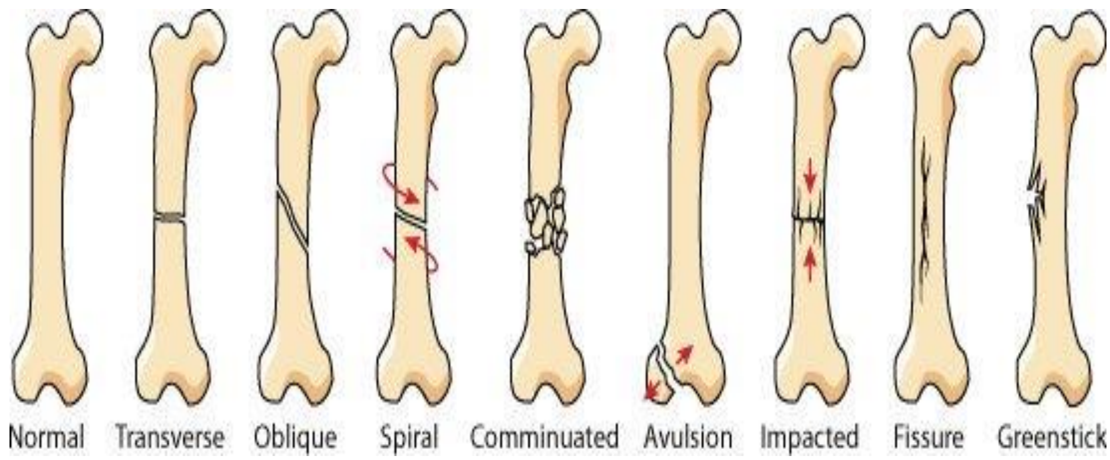

Figure 1: Types of facture (Unger *et al.*, 1990)

2.3. Etiology of fracture in dogs and cats

Libardoni *et al.* (2018) represented 61 animals, 50 (50/61, 82.0%) dogs and 11 (11/61, 18.0%) cats, where high incidence in car accidents were the main cause (45 dogs; 3 cats), followed by fallen from height (2 dogs; 4 cats), dog bite (1 dog; 3 cats), treadmill (1 cat), human aggression (1 dog), and ballistic projectile (1 dog).

Keosengthong *et al.* (2019) reported that automobile accidents were the major cause of bone fractures in both dogs (79.5 %) and cats (56.3%).

Johnson *et al.* (1994), Piermattei *et al.* (2006), Whitehair and Vasseur (1992) and Simpson and Lewis (2003) reported that long bone fractures in dog usually occur due to motor vehicle accident.

Rani *et al.* (2004) reviewed that fractures in dogs occurred due to automobile accidents (68.24%) and falling from height (31.76%).

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

Ness and Armstrong (1995) reported that the major cause of fracture was due to road traffic accidents although kicks, bites and crushing injuries can also be responsible.

2.4. Diagnosis of fracture

The diagnosis is based on history as well as clinical and radiographic signs (Jackson and Pacchiana, 2004).

The main clinical signs included moderate to severe lameness, extreme difficulty in posture and gait, swelling, crepitus and moderate to severe pain on palpation of fracture site, bilateral asymmetry of the limbs and lacerations and mal-alignment of the lower jaw (Hill, 1977).

The radiographic features of nonunion include defects between the fracture end, closed medullary cavities, smooth surfaces of fracture fragments, sclerosis, hypertrophy, or atrophy of bone fragments (Denny and Butterworth, 2006).

2.5. Fracture biology and biomechanics

The massiveness, direction, rate of usage of the force, material property, size, and geometry of a bone ultimately discover the mechanical consequences that a force has on bone (Hulse and Hyman, 1993; Sumner and Fackelman, 2002; Nordin *et al.*, 1980; Schwarz, 1991). A load-deformation curve allows detecting the mechanical behavior (e.g., stiffness, strength, energy absorption capacity) of the entire structure such as whole bone or implant-bone composite (Nordin *et al.,* 1980; Schwarz, 1991). The age of patient influences the mechanical behavior of bones (Sumner and Fackelman, 2002).

The location of fracture within a bone (epiphysis, metaphysis, or diaphysis) and the pattern of the fracture (e.g., spiral, transverse, oblique, comminuted) are detected by the (1) type of bone (cortical vs cancellous), (2) apparent density or porosity of the bone, (3) rate which the bone is loaded (rapid vs slow), (4) orientation of the bone's microstructure related to the direction of loading, (5) age of the patient and also the bone, and (6) health status of the patient (Sumner and Fackelman, 2002; Nordin *et al.*, 1980; Schwarz, 1991).

Five basic forces can act directly on bone: compression, tension, shear, bending, and torsion (Hulse and Hyman, 1993; Schwarz, 1991; Smith *et al.*, 1985).

The overall goal of all fracture fixations is to obtain a biomechanically stable environment conducive to bone healing. These forces cause bending, compressive, shear, tensile, or torsional stresses to act on fractured bone and fixation system (Radasch, 1999).

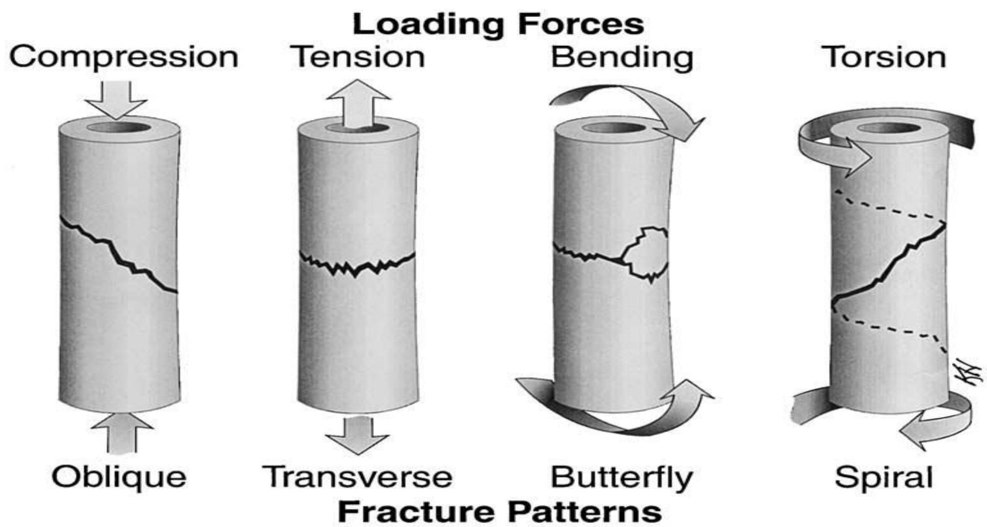

Figure 2: Types of loading forces applied to bone columns and resultant fractures (Harari, 2002).

2.6. Intramedullary pinning technique

IMP acts as internal splint of medullary canal that shares loading with bones maintain alignment of fracture and resists bending forces in all of the directions applied to bone (Beale, 2004). Steinman and Kirschner pins are 2 types of pins available. The use of more pins or pins combined with wires or pins locked with screws such as interlocking nail, increases their resistance to fracture forces (Dueland *et al.*, 1996).

For decreasing bending potential, intramedullary pins should engage both proximal and distal cortical surfaces without penetrating joint surface. Pins can be inserted either normograde or retrograde fashion and should fill at least 70% of the diameter of the bone's medullary cavity (Slatter, 2003). Stacking multiple smaller pins can minimally increase resistance to rotational forces (Stiffler, 2004).

Intramedullary pins are satisfactory for shaft fractures of the femur in small dogs and cats (Hill, 1977; Phillips, 1979). Intramedullary pinning must unite by peripheral callus formation because the pin blocks endosteal callus and the new bone does not develop from vascular cortical ends (Asma *et al.*, 2014). The intramedullary pinning offers high-quality balance and also provides great biomechanical surroundings for fracture recovery (Inas *et al*., 2012). Fractures and separations at distal epiphysis of the femur were repaired by retrograde pin technique in which pin is introduced first through femoral trochlear and up into the shaft (Singleton, 1966).

2.7. Bone healing

Three areas of osteogenic potential in the healing of any types of diaphyseal Fracture: periosteal reaction, endosteal callus and time fractures hematoma. The adductor muscle attachment to caudal aspect of diaphysis is also important source of periosteal vessels which especially significant in the healing of diaphyseal fractures (Kaderly *et al.*, 1982; Newton and Nunamaker, 1985). Transformation of fracture hematoma into the healing bone follows orderly sequence of inflammation, repair, and remodeling phases (Radasch, 1999). Bone marrow is able to regenerate vascularisation after one week and irrigate bone cortex (Autefage, 1992).

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

The determination of feline fracture healing rates and guidelines for the radiographic assessment are difficult to standardize as because of some variables, such as patient age, type of injury, and method of fixation, also including cancellous grafting (Langley-Hobbs *et al.*, 1996; Fitch *et al.*, 1997; Newman and Milton, 1989).

Asma *et al.*, 2014 revealed callus formation on 20th day post treatment. The 35th day indicated beginning of the reabsorption of excessive callus, reduced the periosteal reaction and process of remodeling of the new bone.

2.8. Complications of IMP technique

Major complications of fracture healing was reported as osteomyelitis (Asma *et al.*, 2014), delayed union, malunion, nonunion (Das *et al.*, 2019), premature physeal closure and fracture associated sarcoma, pin migration (Tercanlioglu and Sarierler, 2009; Das *et al.*, 2019; Asma *et al.*, 2014), Implant loosening (Stiffler, 2004; Palmer *et al.*, 1992), quadriceps contracture damaged to soft tissues, infection (Stiffler, 2004; Palmer *et al.*, 1992), temporary or permanent damage to the sciatic nerve (Jackson and Pacchiana, 2004; Stiffler, 2004; Chandy *et al.*, 2007).

Anterior cruciate ligament rupture was a frequent complication to the distal femoral fracture in dog and cat (Alcantara and Stead, 1975). Sometimes muscle atrophy, joint motion reduction, and periarticular fibrosis may occur (Marti and Miller, 1994; HÖ and YS, 2009; Whitehair and Vasseur, 1992; Yardimci *et al.*, 2011).

The use of intramedullary pins and wires in the comminuted femoral fractures is associated with high rate of complication for the reason of inadequate axial and rotational stability (Schrader, 1991).

CHAPTER- 3
MATERIALS AND METHODS

3.1. Place and duration of the study

The study was conducted at S. A. Quaderi Teaching Veterinary Hospital (SAQTVH), Chittagong Veterinary and Animal Sciences University (CVASU). The duration of the study was one year from January 2018 to December 2018.

3.2. Incidence of long bone fracture

3.2.1. Selection of incidence study cases: The cases were selected from the hospital after registering the patients into the hospital. The data were collected (species, breed, age, sex, location and direction of fracture, risk factors) during clinical examination of patient. Every data included in the excel sheet for further analysis of incidence of long bone fracture.

3.3. Evaluation of femur fracture management

3.3.1. Diagnosis of the femur fracture

3.3.1.1. Anamnesis: Detail anamnesis regarding actual cause of lameness, limb affected and depth of trauma inflicted, progression of lameness, duration of illness, previous treatments if any were recorded as presumptive diagnosis. Signalment including specially breed, age, sex and body weight of the animal were also recorded.

3.3.1.2. Clinical examinations: Distant and close clinical examinations were performed sequentially in each case. Each animal was observed from a distance while standing, walking and also trotting. Grading of weight bearing, gait of the animal and lameness scoring were analyzed in this phase to identify the affected limb and assess the severity of lameness. Close observation includes palpation of the affected limb to detect pain, swelling and crepitating of the fractured bone in each case.

3.3.1.3. Radiological examination: For confirmatory diagnosis, medio-lateral and cranio-caudal views of the affected bone were taken to diagnose each case.

3.4. Selection of the cases for femur fracture management

The study design of femoral fracture was randomly selected without any concurrent neurological, metabolic or infectious diseases for the study of fracture management. 12 clinical cases were corrected by intramedullary pinning technique.

3.5. Intramedullary pinning (IMP) technique

3.5.1. Instruments and implants used for the study

3.5.1.1. Basic orthopedic instruments for IMP

Some basic orthopedic instruments used in this study were given below (Figure 3).

1) Pointed reduction forceps
2) Self-centering bone holding forceps
3) Serrated reduction forceps
4) Hohmann reduction forceps
5) Senn retractor
6) Periosteal elevator

Figure 3: Basic orthopedic instruments

3.5.1.2. Orthopedic implants

Trocar pointed Steinmann pins were used all cases of femoral fracture. Pins occupying 70-80% of diameter of medullary canal were selected for the study. The appropriate sizes of the pins were selected by measuring the diameter from the lateral radiograph of the respective contralateral bone.

Figure 4: Orthopedic Implants (K-wire and Steinmann pin)

3.5.2. Imaging tools

3.5.2.1. Computed radiography (CR)

CR-30X scanner (AGFA) was used to read the exposed radiographic cassette (Figure 5). The scanned images were seen on the monitor. In addition, a portable X-ray machine (Figure 6) was used to generate X-ray and focused on those cassettes. Two different sized cassettes were used; i) 35 cm X 43 cm and ii) 24 cm X 30cm. CR X-Ray was used to assess radiographic score of pre and post-fracture evaluation.

Figure 5: Computed radiography (CR) scanner

Figure 6: Portable X-ray machine

3.5.2.2. C-arm

A high frequency mobile X-ray image intensifier television system (Allengers- HF49R)) with 230 mm diameter image intensifier with voltages between 40-110 kV at variable tube currents between 0.1 to 3 mA was used for fluoroscopy (Figure 7). The main control units with mobile trolley contains an operating console, lifting column, tragarm and holder for C-arm, image intensifier tube with CCD camera and HF single tank with iris collimator. The X-ray tube had a stationary anode with a nominal kV of 110 kV. There are two monitors, one each for LIH and stored memory display with a temporary storage capacity of up to 4 images. The unit was connected to a desktop computer in which the images were further processed and stored using iMagic software. In this study, C-arm was used during intraoperative IMP technique to acquire appropriate insertion of pin in all cases to acquire better anatomical reduction and alignment of fracture fragments.

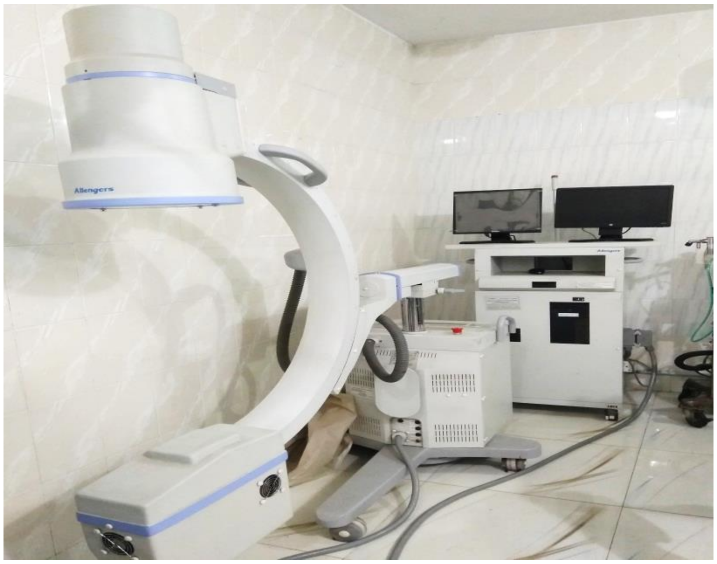

Figure 7: C-arm

3.5.3. Patient preparation

The patients were completely off feed for 12 hours. Clipping and shaving above hip joint to below stifle joint in femur was done of the affected limb. Clipping and shaving should be performed around the incision site. The extremity was wrapped firstly with unsterile gauze and finally wrapped with sterile gauze just before the surgery. Operated part was made sterile by using 10% povidone iodine followed by 70% alcohol.

3.5.4. Anesthesia of the patient

3.5.4.1. Premedication

Premedication was performed by Atropine sulphate (Inj. Tropin Vet®, ACME Pharmaceutical, BD) at the rate of 0.04mg/kg subcutaneously. After 10 minutes given 2% Xylazine Hydrochloride at the dose rate of 1mg/kg (Inj. Xylaxin®, Indian Immunologicals Limited, India) intramuscularly. Patient was restrained on lateral recumbancy after complete sedation in OT table. Intravenous fluid administration was set through IV cannula at the rate of 10ml/kg/hour.

3.5.4.2. Induction and maintenance of anesthesia

In case of dog, 5% Ketamine Hydrochloride (Inj. Ketalar®, Popular Pharmaceutical, BD) was given at the rate of 8 mg/kg body weight intravenously. Diazepam (inj. Sedil®, Square Pharmaceuticals Ltd. BD) was given at the rate of 0.5 mg/kg body weight intravenously. In case of cat, only Ketamine Hydrochloride was used at the rate 10 mg/kg body weight intravenously. The maintenance dose was given half of the total dose if needed.

3.5.5. Surgical procedure

Long linear incision was made (Figure 8). Separation of the fascia lata (Figure 9) and then muscle separation also performed respectively (Figure 10). The bone was exposed eventually for the reduction of femur fracture (Figure 11). The fracture was reduced and the proximal and distal bone fragments are aligned and pin was then inserted within the distal fragmented and anchored the distal extremity thus immobilizing the fracture (Figure 12). After conducting the open reduction the muscle was sutured and the skin was sutured in habitual way (Figure 13). After suturing the skin, the extra pin was cut by the pin cutter (Figure 14). Soft cotton bandage was given post-operatively and then X-ray was taken after surgery (Figure 15). Same procedure was performed in all dogs and cats.

IMP Procedure

Figure 8: Linear skin incision on craniolateral aspect of femur

Figure 9: Separation of fascia lata

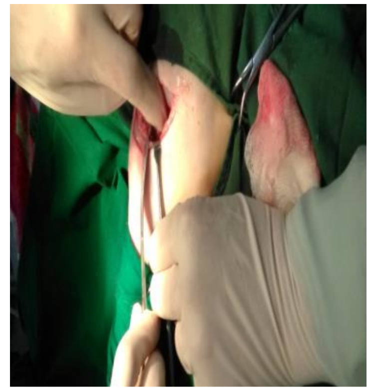

Figure 10: Separation of muscle bundle

Figure 11: The bone was exposed

Figure 12: Alignment of bone fragments and insertion of IMP

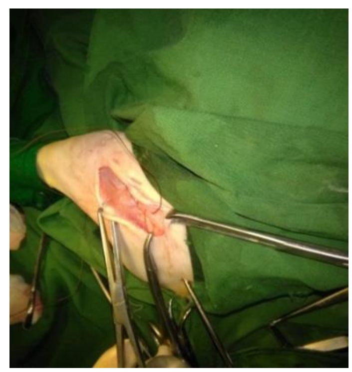

Figure 13: The muscle bundle closure

Figure 14: Extra length of Steinmann pin was cut

Figure 15: Postoperative wound protection with soft cotton bandage

3.5.6. Post-operative care

Ceftriaxone (Trizon vet®, Acme Laboratories Ltd., BD) at the rate of 50mg/kg body weight was given intramuscularly at 24 hours interval in all dog and cat up to 7th post-operative day. Meloxicam (Mel Vet®, Acme laboratories Ltd., BD) @ 0.5 mg/kg subcutaneously upto 3rd post-operative days and Diphenhydramine HCl (Inj.Phenadryl®, Acme Pharmaceuticals Ltd. BD) @ 1.5mg/kg intramuscularly were administered up to 7th post-operative days, respectively. Skin sutures were removed after appropriate healing. Restricted movement was advised up to 2 weeks following surgery. Passive flexion and extension exercise was advised for the operated limb after two weeks.

3.5.7. Removal of implants

In some cases after proper bone healing or complication (pin migration) removal of pin if necessary.

3.6. Parameters studied for fracture management

3.6.1. Lameness grade

A lameness grade was assigned before and after fracture management (day 1, 15, 30 and 45) on the basis of severity of clinical signs to assess the response to treatment. Clinical lameness score (0-5) was given as follows (Cook *et al.*, 1999).

0 – No observable lameness.

1 – Intermittent, mild weight bearing lameness, if any change in gait.

2 – Consistent, mild weight-bearing lameness with little change in gait.

3 –Moderate weight-bearing lameness – obvious lameness with noticeable “head bob” and change in gait.

4 – Severe weight-bearing lameness – “Paw touching” only.

5 – Non-weight-bearing.

3.6.2. Functional limb outcome

Functional limb outcome was evaluated on the 45th day of post fracture management and categorized as excellent, good, fair and poor (Clark, 1986). The assessment was subjective and based on individual evaluation.

Excellent: No lameness compared to the opposite limb, no post-operative complications.

Good: Moderate occasional lameness, does not require treatment, no post-operative complications.

Fair: Moderate persistent lameness requiring treatment.

Poor: Persistent severe lameness may require revision surgery.

3.6.3. Radiographic assessment

Radiographs were taken before and after fracture management (day 1, 15, 30 and 45) to assess the response to treatment. Post fracture management radiographs were evaluated and scored for reduction and fracture alignment. Score for fracture reduction and alignment (0-3) was given as follows (Cook *et al.*, 1999).

0 - Anatomical reduction.

1 - Minimal (<1mm) malreduction.

2 - Moderate (1-3mm) malreduction.

3 - Severe (>3mm) malreduction.

3.7. Post fracture management complications

Post fracture management complications were studied and recorded, if any likely Joint stiffness/ Muscle atrophy/ Pin loosening/ pin migration/ Seroma formation/ bone infection/ Skin infection/ Inward rotation of affected limb/ Outward rotation of affected limb/ Others.

3.8. Data analysis

Data obtained related to incidence from the study was imported to the Microsoft Excel-2010 and the transferred to the statistical software STATA-11 for calculating percentage of different variables.

CHAPTER- 4

RESULTS

4.1. Incidence of long bone fracture

4.1.1. Overall incidence of long bone fracture

From January 2018 to December 2018 a total of 1358 clinical cases of dogs and cats were recorded of which 3.24% (N=44) cases were long bone fracture in dogs and cats (Table 1).

Table 1: Overall incidence of long bone fracture

Criteria	**No. of Animal**	**Percentage (%)**
Total clinical cases of dogs and cats	1358	-
Total No. of long bone fracture cases in dogs and cats	44	3.24

4.1.2. Incidence of long bone fracture according to species

The incidence of long bone fracture in dogs and cats were 38.64% (N=17) and 61.36% (N=27) respectively. (Table 2)

4.1.3. Incidence of long bone fracture according to breed

Table 2: Fracture incidence of long bone fracture according to breed

Species	Breeds	Number	Percentage (%)
Dog	Local (ND)	9	20.45
	Labrador	2	4.55
	Spitz	5	11.36
	German Shepherd	1	2.27
Total		**17**	**38.64**
Cat	Local (ND)	13	29.55
	Persian	9	20.45
	Cross	5	11.36
Total		**27**	**61.36**

Table 2 represented that among 17 fracture cases of dog, 20.45% (N=9) were Local, 4.55% (N=2) were Labrador, 11.36% (N=5) were Spitz and 2.27% (N=1) were German shepherd.

In case of cat, higher incidence were found in indigenous 29.55% (N=13) followed by lower incidence were found in persian 20.45% (N=9) and Cross 11.36% (N=5).

4.1.4. Incidence of long bone fracture according to the age

In dogs, out of 17 fracture cases, 15.91 % (N=7) were below 6 months, 11.36 % (N=5) were 6 months to 12 months, 11.36 % (N=5) was more than 12 months.

On the other side in cats, 20.45 % (N=9) were below 6 months, 27.27 % (N=12) were 6 months to 12 months, 13.64 % (N=6) were more than 12 months.

So it was cleared that higher incidence were found in below 6 months in dog and 6 months to 12 months in cat whereas lower incidence was found in more than 12 months of age in both dog and cat. (Figure 16)

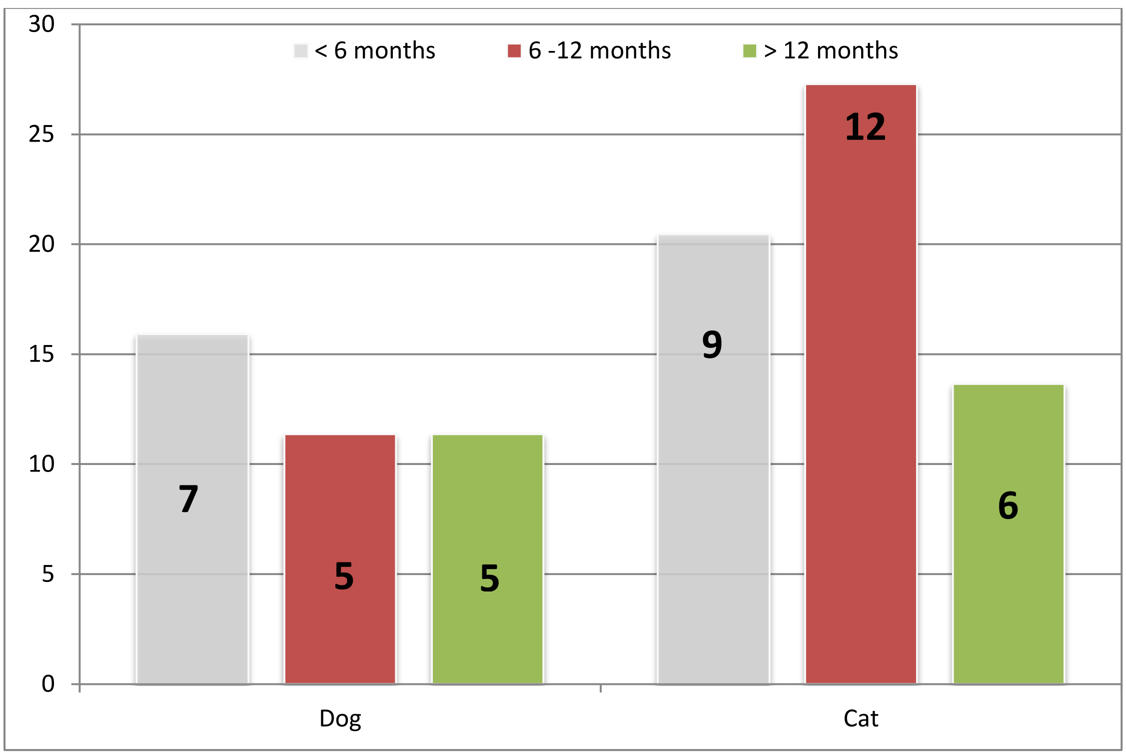

Figure 16: Incidence of long bone fracture according to age

4.1.5. Incidence of long bone fracture according to sex

Among 17 fracture cases of dogs, 25% (N=11) were male, and 13.64% (N=6) was female.

Among 27 fracture cases of cat, Table 3 represented 27.27% (N=12) were male and 34.09% (N=15) were female.

The table represented that higher incidence in male rather than female in case of dog and incidence rate is higher female than male in case of cat. (Table 3)

Table 3: Fracture incidence according to sex

Species	**Sex Percentage (%)**		**Total Number**
	Male	**Female**	
Dog	11(25)	6 (13.64)	17 (38.64)
Cat	12 (27.27)	15 (34.09)	27 (61.36)
Total	**23 (52.27)**	**21 (47.73)**	**44 (100.00)**

4.1.6. Incidence of long bone fracture on the basis of closed and open fracture

Within all of the cases (N=44), 95.46% (N=42) were closed fracture and 4.54% (N=2) were open fracture. The both open fracture cases were observed in cats.

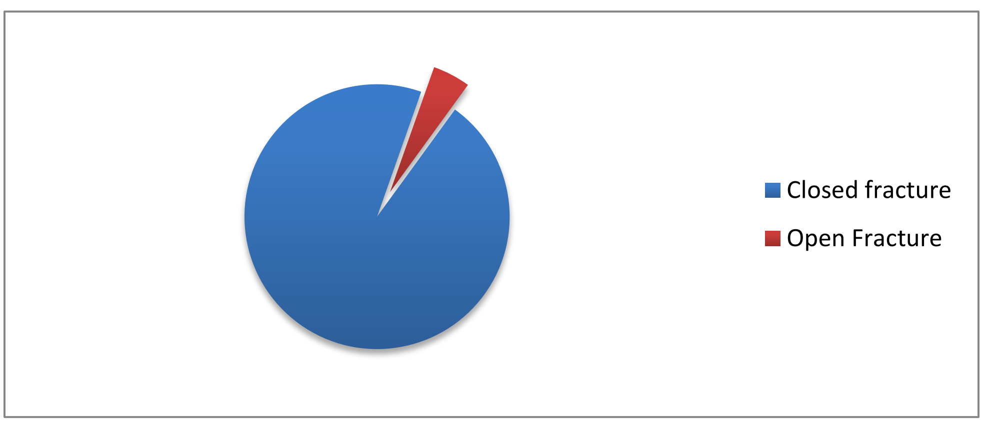

Figure 17: Incidence of fracture on the basis of close and open nature

4.1.7. Incidence of long bone fracture according to the location and direction

Table 4: Incidence of long bone fracture according to the location and direction

Bone involved	Fracture Direction	Affected species		Subtotal (%)	Total (%)
		Dog	Cat		
Humerous	Transverse	**1**	**2**	**6.82**	**20.45**
	Oblique	**2**	**2**	**9.09**	
	Spiral	**0**	**1**	**2.27**	
	Comminuted	**0**	**1**	**2.27**	
Radius/Ulna	Transverse	**0**	**1**	**2.27**	**11.36**
	Oblique	**1**	**2**	**6.82**	
	Spiral	**0**	**0**	**0.00**	
	Comminuted	**1**	**0**	**2.27**	
Metacarpal	Transverse	**1**	**0**	**2.27**	**15.9**
	Oblique	**1**	**2**	**6.82**	
	Spiral	**1**	**1**	**4.54**	
	Comminuted	**1**	**0**	**2.27**	
Femur	Transverse	**1**	**1**	**4.54**	**27.26**
	Oblique	**3**	**5**	**18.18**	
	Spiral	**0**	**2**	**4.54**	
	Comminuted	**0**	**0**	**0.00**	
Tibia/Fibula	Transverse	**0**	**1**	**2.27**	**15.91**
	Oblique	**1**	**2**	**6.82**	
	Spiral	**1**	**2**	**6.82**	
	Comminuted	**0**	**0**	**0.00**	
Metatarsal	Transverse	**0**	**0**	**0.00**	**9.08**
	Oblique	**1**	**1**	**4.54**	
	Spiral	**1**	**1**	**4.54**	
	Comminuted	**0**	**0**	**0.00**	
Total		**17**	**27**	**100.00**	**100.00**

4.1.8. Incidence of long bone fracture according to the risk factors

Statistical data represented in table-5 that 54.55% (N=24) were caused due to fall down during jumping; 20.45% (N=9) were caused due to trauma. Other fracture cases were due to automobile accident; 24.99% (N=11).

Table 5: Incidence of fracture according to risk factors

Risk Factors	Dog	Cat	Total
Automobile accident	9 (20.45)	2 (4.54)	11 (24.99)
Falling from height	3 (6.82)	21 (47.73)	24 (54.55)
Trauma	5 (11.36)	4 (9.09)	9 (20.45)
Total	17 (38.64)	27 (61.36)	44 (100.00)

4.2. Evaluation of femur fracture management technique

4.2.1. Overall description of femur fracture management in dogs

Table 6: Overall description of femur fracture management in dogs

Case no.	Sex	Age (Months)	Breed	Weight (kg)	Limb affected	Fracture location	Size of Steinmann Pin
1	Male	8	Local	13.5	Right	Distal oblique diaphyseal	3.5mm
2	Female	5	Local	7.8	Right	Proximal transverse diaphyseal	3mm
3	Female	3	Local	5.5	Left	Mid diaphyseal oblique	2.5mm
4	Male	4.5	Labrador	9.5	Right	Distal metaphyseal oblique	3mm

4.2.2. Overall description of femur fracture management in cats

Table 7: Overall description of femur fracture management in cats

Case no.	Sex	Age (Month)	Breed	Weight	Limb affected	Fracture location	Size of K-wire
1	Male	3.5	Local	2.3 kg	Right	Distal oblique diaphyseal	2mm
2	Male	7	Local	3.6 kg	Right	Proximal Spiral overriding diaphyseal	2mm
3	Female	3	Persian	1.9 kg	Left	Bilateral mid shaft diaphyseal	2mm
4	Male	18	Local	3.9 kg	Right	Distal short oblique epiphyseal	2.5mm
5	Female	9	Persian	3.2 kg	Left	Distal spiral metaphyseal	2mm
6	Female	7	Local	2.9 kg	Right	Mid shaft oblique diaphyseal	2mm
7	Female	11	Persian	3.6 kg	Left	Distal short oblique overriding diaphyseal	2.5mm
8	Female	14	Local	3.5 kg	Right	Proximal oblique metaphyseal	2mm

4.2.3. Parameter studied for femur fracture management

4.2.3.1. Lameness grade evaluation

A lameness grade was assigned on the basis of severity of clinical signs on pre and post fracture management on 1st, 15th, 30th and 45th postoperative day to assess the response to treatment.

Preoperatively maximum cases had grade 5 except case number 2 (grade 4) and case number 6 (grade 3). All the cases, lameness grade was gradually improved on 45th post-operative day from grade 5 to grade 1, except in dog case number 3 (grade 3 at 45th day) and cat case number 3 (Dead) (Table 8).

Table 8: Lameness grade for both dogs and cats

Species	Case no.	pre-operative	Lameness grade			
			Post-operative			
			Day1	Day 15	Day 30	Day 45
Dog	1	5	5	3	1	1
	2	5	5	3	1	1
	3	5	4	4	3	3
	4	5	5	3	1	1
Cat	1	5	5	3	1	1
	2	4	5	3	1	1
	3	5	-	-	-	-
	4	5	4	4	1	1
	5	5	5	3	1	1
	6	3	4	3	1	1
	7	5	4	3	1	1
	8	5	5	3	1	1

4.2.3.2. Functional limb outcome: Functional limb outcome was evaluated on the 45th day of post fracture management and categorized as excellent, good, fair and poor.

All the cases, functional limb outcome was noticed as excellent (Day 45) in post fracture management except in dog case number 3, cat case number 3 where functional limb outcome was poor and good respectively.

4.2.3.3. Radiographic evaluation: Fracture healing was evaluated through radiographic examination on different interval on pre and post fracture management on 1st, 15th, 30th and 45th postoperative day.

In all cases of dog and cat, secondary bone healing (periosteal callus formation) was noticed (Day 30) (Table 9).

Table 9: Radiographic assessment score

Species	**Case no.**	**Pre-operative**	**Fracture reduction and alignment**			
			Post-operative			
			Day1	**Day15**	**Day 30**	**Day 45**
Dog	1	3	0	1	0	0
	2	3	0	1	0	0
	3	2	0	0	0	0
	4	3	0	1	0	0
Cat	1	3	0	1	0	0
	2	3	0	1	0	0
	3	3	-	-	-	-
	4	3	0	0	0	0
	5	2	0	1	0	0
	6	2	0	1	0	0
	7	3	0	0	0	0
	8	3	0	0	0	0

Intramedullary pinning technique of dog (Pre and Post-operative evaluation)

Figure 18: Non weight bearing fractured dog (Day 1)

Figure 19: Preoperative X-ray (Lateral view) - Proximal Diaphyseal transverse overriding fracture of right femur.

Figure 20: Implant in position (Day 1) (C-arm guided)

Figure 21: Post-operative x-ray view – Implant in position (Day 7)

Figure 22: Periosteal callus bridge formation at 45^{th} PO day.

Figure 23: Functional limb outcome at 45^{th} PO day.

Intramedullary pinning technique of Cat (Pre and Post-operative evaluation)

Figure 24: Mild weight bearing fractured cat. (Grade 5)

Figure 25: Preoperative X-ray (Lateral view) - Distal oblique diaphyseal fracture

Figure 26: Post-operative X-ray view- Implant in position (Day 1)

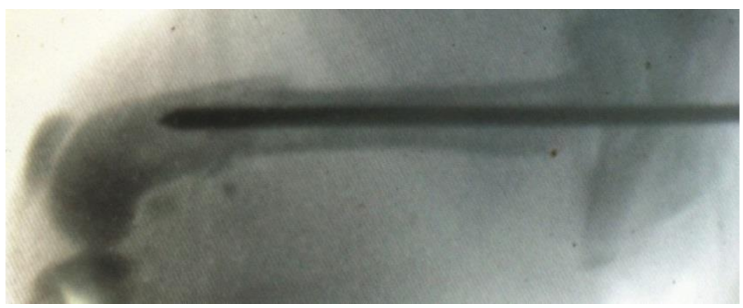

Figure 27: Implant in position (Day 1) (C-arm guided)

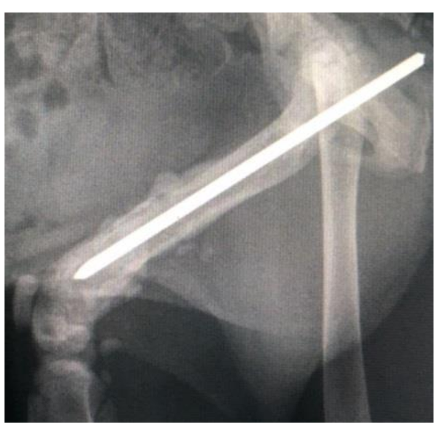

Figure 28: Periosteal callus bridge formation at 45th PO day.

Figure 29: Functional limb outcome at 45th PO Day

4.2.3.4. Complications

Pin migration (cat case no. 7) (Day 25) and infection (cat case no. 2) (Day 10) were noticed. Unexpected death (cat case 3) (Day 1) was found in cat. All of the complicated cases were only found in cat.

Figure 30: Pin migration in Cat (Case no. 7)

Figure 31: Infection in Cat (Case no. 2)

CHAPTER-5

DISCUSSION

Fractures are common injuries in small animals. Accurate management techniques can be recovered and restored the normal healthy life of animals. This was observed in the number of pet animals admitted to the SAQTVH, Chittagong Veterinary and animal Sciences University of Bangladesh.

5.1. Incidence of long bone fracture in dogs and cats

5.1.1. Incidence of fracture according to species

A total of 44 fracture cases were evaluated in dogs and cats in this present study. The long bone fractures were 38.64% and 61.36% in dogs and cats respectively. This indicates that orthopedic problems in cats are more than that of dogs. The reason of increasing orthopedic cases in cats due to owner ignorance about cat. This finding is contrast with the report of Ali 2013.

5.1.2. Incidence of fracture according to the breed

The present study showed that fractures were most commonly found in local non-descript breeds than others in both species. In dogs, local (n=9, 20.45%) were the most common breed, followed by Labrador (n=2, 4.55%). The present result disagreed with Peirone *et al.* (2002) report where 20% German shepherd, 13% Boxer, 13% Mixed breed and 6% setter. Few researchers found highest fracture incidence in German Shepherd (Balagopalan *et al.*, 1995) and Spitz (Kushwaha *et al.*, 2011) breeds.

Among the cat breeds, also local (n=13, 29.55%) were the most common breed followed by Persian (n=9, 20.45%). Langley-Hobb *et al.* (1996) represented the breed variety was 97% Domestic Short hair and 3% Siamese and Peirone *et al.* (2002) reported 27% Domestic Short Hair and 6% Persian which were completely different from the present study. The local cat exposed to fracture due to either estrous condition demand to mate or catch the bird. The owners were accountable for the fracture owing to not maintain cat proof system in their house. The incidence of breed wise distribution of fractures can vary depending upon availability of breeds in the particular study area.

5.1.3. Incidence of fracture according to the sex

There was a predominance of males involved in case of dog and female in case of cat and according to sex wise distribution among 44 long bone fracture cases, 52.27% (n=23) was male, and 47.73% (n =21) was female had experienced the fracture in this study. Peirone *et al.* (2002) mentioned 15 cases where 60 % was male and 40 % was female in dog and Yardimci *et al.* (2018) analyzed total 20 dog patient where 70 % was male and 30 % was female. The present study showed total of 17 only for dog cases about 64.71% was male and 35.29% was female. These findings nearly matched with both Peirone and Yardimci study. Moreover the dog patient was few in amount in the present study. Stigen (1999) reported 58.1% bitches and 52.9% queens whereas the findings of present study reported 13.64% bitches and 34.09% queens. Those findings mismatched with the present study findings. A higher occurrence of fractures in males may be due to their higher activity and a more aggressive nature as compared to females in dog. Similar findings have also been reported by Philips, 1979, Thilager and Balasubramanium, 1988, Aithal *et al.,* 1999 and Singh *et al.,* 1999. The female cats were susceptible for fracture due to their mating tendency in estrous state more than female dogs.

5.1.4. Incidence of fracture according to the age

Figure-16 reported that among 44 long bone fracture cases, 15.91% (n=7) was below 6 months, 11.36% (n=5) was 6 months to 12 months, 11.36% (n=5) was more than 12 months in case of dog. On the other side, 20.45% (n=9) was below 6 months, 27.27% (n=12) was 6 months to 12 months, 13.64% (n=6) was more than 12 months in case of cat. Stigen (1999) reported 78 % were 6 months old or younger and 15.6% were 7 to 12 months old in dogs. Of the cats, 27.5 % were 6 months old or younger and 52.9% were 7 to 12 months old. So it was cleared between the report analysis that higher incidence was found below 6 months in dog and 6 months to 12 months in cat whereas lower incidence was found in more than 12 months of age in both dog and cat. Alcantara and Stead (1975) analyzed 82% fractures happened between 2 and 10 months of age in dog and cat. One explanation is that dogs and cats become acquainted to cope with the dangers of their environment through experience; therefore, the younger are more at risk (Kolata *et al*., 1974; Hill, 1977; Umphlet and Johnson, 1990).

5.1.5. Incidence of fracture according to the types and location of fracture

The present study has represented the overall result of the types of fracture where 52.27% (n=23) were oblique, 18.18% (n=8) were transverse, 22.73% (n=10) were spiral fractures in case of dog and cat. A higher incidence was found in oblique fracture (52.27%, n=23) followed by lower incidence was found in both transverse (18.18%, n=8) and spiral fracture (22.73%, n=10). The positive similarity between the present study and Yardimci study that oblique fracture was more significant than other types of fracture. Minimum cases of Oblique fractures (6%) in cat reported in Langley-Hobb *et al.* (1996) which was contradictory to the present study.

In present study both dogs and cats, femoral bone was the most affected location (12/44 cases) and the frequency of femoral bone fracture was significantly higher than other long bone fracture. Philips (1979) represented that most commonly affected long bones in the dogs were radius and ulna (17.3%), pelvis (15.8%), femur (14.8), and tibia (14.8%) and in the cats were femur (28.2%), pelvis (24.8%) and mandible (11.4%). Braden *et al*., 1995 documented that amongst 1000 femur fractures case, 77% was dog and 23% was cat which completely disagreed with the present study.

5.1.6. Incidence of fracture according to the risk factors

The risk factors associated with fracture observed in the present study that 47.73% (n=21) cases were caused by fallen from height in cat. Falling from height was seen either in the estrous season when searching tendency to mate with other cat or want to catch the bird. All of the long bone fracture cases in the study showed maximum occurrence of fractures in case of dog (20.45%, n=9) were responsible for automobile accident for the reason of either carelessness of drive or swift running to fight with other dogs carelessly. Johnson *et al.* (1994), Piermattei *et al.* (2006), Whitehair and Vasseur (1992) and Simpson and Lewis (2003) reported that in the dog usually occur due to motor vehicle accidents which were completely agreed with the present study. Aithal *et al.* (1999) reported that the major cause for fracture was falling from a height (53.1%) and automobile accidents (34.69%) whereas the present study shown 54.55% (n=24) cases were fallen from height and 24.99% (n=11) cases were automobile accident. The maximum of the cases were responsible mainly due to fallen from height especially for cat and automobile accident mainly for dogs which similarity was found in two study.

5.2. Evaluation of Femur fracture management

5.2.1. Intramedullary pinning technique

In this research femur fractures were managed by applying mainly with internal fixation technique using IMP. The selection of internal fixation technique based on biologic, mechanical, and clinical parameters associated with each patient and fracture, not just fracture pattern itself (Aron *et al.,* 1995; Stiffler, 2004). Among them Intramedullary pinning is most commonly used methods in fracture management throughout the world with high success rate. Asma *et al.,* 2014, they treated one group of fractured dogs and found that all animals showed progressively dense of periosteal reaction at the 2nd week. At 5^{th} week, beginning of periosteal callus bridge formation, full training callus generally after one month follow up. In a research by (Inas *et al*., 2012) argue that the IMP offers high-quality balance for long bones fracture, so it offers an excellent biomechanical surroundings for fracture recovery. The present study observed similar outcome as like as Inas *et al*., 2012. It has also been reported that intramedullary pins were satisfactory for shaft fractures of the femur in small dogs and cats (Hill, 1977; Harari, 2002) The present study was also agree with Hill, 1977 and Harari, 2002. In this study, it was found that intramedullary pinning were the most satisfactory methods of treatment, followed by Modified Robert Jones bandage. The outcome of the surgery also revealed a positive prognosis in most of the fractured patients. Shnian and Markus, 1995 reported that successful management of femoral fracture in 164 dogs by using intramedullary pinning. Plates are very expensive in comparison with intramedullary pins in developing countries like Bangladesh so intramedullary pins are more comfortable and easy fixation technique.

In the current study, some patients belong to medium or large breeds, all operated femur fractures were treated with IMP. None of the cases were managed with amputation in present study. We did not use plate or other expensive implants, because of the economic reasons. Most of the owners demand the less expensive method. We encountered only two minor complications in cat: one pin migration and one minimal infection on the suture site. Both of the complications were treated successfully with proper treatment methods. Unexpected death after surgery was found in cat.

5.2.2. Bone healing of IMP technique

Bone healing depends on fracture site stability and vascularization (Hulse and Johnson, 1997; Radasch, 1999). The promotion of bone healing through the insertion of intramedullary pin even by bringing in contact with bone fragments, pluripotent cells derived from bone marrow (Fossum, 2007). Unlike the installation of the plate, the insertion of intramedullary pinning does not harm the periosteal blood operating time was reduced by half (Daglar *et al*., 2007). In present case study, femoral fracture repaired by IMP, cat was observed carefully and showed gradual weight bearing and functional limb outcome was observed at 45th day postoperatively. A positive relationship was found in the improvement of bone healing between age and time to achieve union. The equal findings were found at Strube *et al.* 2008 where noticed that the bones of young animals tend to heal faster than bones of older animals. Because the immature animals have numerous arteries that perforate newly formed appositional bone running longitudinally over periosteal surface observed by Johnson *et al.* 1998. This may be due to the extra forces on the fractured leg in the postoperative period. The reason was that comminuted fractures are likely high energy fractures with associated vascular and soft tissue disruption, which has a strong negative influence on fracture healing (McCartney and MacDonald, 2006).

5.2.3. Complications of IMP technique

Complications are a reality of fracture repair. It can be minimized or overcome by being aware of their predisposing factors and pathophysiology. Major complications of fracture repair include delayed union, osteomyelitis, malunion, nonunion, premature physeal closure, and fracture associated sarcoma. (Jackson and Pacchiana, 2004). In the present study, pin migration and minimal suture site infection were noticed in case of IMP of cat.

Pin migration and non-union were common complications in intramedullary pinning which was the outcome of several author’s study. Pin migration might be due to uncontrolled movement during postoperative days, inappropriate selection of intramedullary pin diameter. This similar finding was notified in Fossum, 2007 study. Delayed healing or nonunion can occur due to lack of rigid fixation (Stiffler, 2004). But osteomyelitis and non-union case were not observed in the present study. All of the cases were satisfactory outcome followed by weight bearing condition after 45th post-operative day except death of cat in one case (Case No. 3)

From this study, we found a significant conclusion on the use of intramedullary pinning technique in femoral fracture of dogs and cats. Intramedullary pinning technique can be successfully applied in dogs and cats in field condition of Bangladesh. Open reduction internal fixation (ORIF) by using intramedullary pins, is safe, economic if basic principles of fracture repair are used.

CHAPTER-6

CONCLUSIONS

The following conclusions can be made from the findings of the present study.

The present research work revealed that long bone fracture incidence was found more in cats (27/44, 61.36%) than that in dogs (17/44, 38.64%). Local breeds (22/44, 50%) are more susceptible in both dogs and cats. Long bone fracture incidence was found more in below 6 months aged dogs (7/44, 15.91%) and 6 months to 12 months aged cats (12/44, 27.27%) whereas lower incidence was found in more than 12 months of age in both dogs and cats. Higher incidence was found in male (11/44, 25%) rather than female (6/44, 13.64%) in case of dogs and incidence rate is higher female (15/44, 34.09%) than male (12/44, 27.27%) in case of cats. Most common causes of fracture due to fall down (24/44, 54.55%) in case of cats and automobile accident (9/44, 20.45%) was common in case of dogs. About 52.27% (23/44) cases were oblique fracture followed by 22.73% (10/44) spiral fracture, 18.18% (8/44) transverse fracture and 6.82% (3/44) comminuted fracture. Among all the long bone fracture (44) cases higher incidence rate was found in femoral fracture (12/44, 27.26%) in both dogs and cats. The percentage of closed fracture (42/44, 95.46%) was more significant than open fracture (2/44, 4.54%) in both dogs and cats. For femur fracture management, outcome of lameness grade and functional limb activities were satisfactory in both dogs and cats. So, IMP technique can be successfully applied in dogs and cats in field condition of Bangladesh. Open reduction internal fixation (ORIF) by using intramedullary pins, is safe, economic if basic principles of fracture repair are used.

CHAPTER-7

LIMITATIONS AND RECOMMENDATIONS

This study has some limitations. Being a retrospective clinical investigation, the study design has inherent uncontrolled variables. Among those is the multi-centric nature of the study, which introduces a high level of intra-surgeon variability in the surgical approach, PO management, complication management, and timing for dynamization and/or destabilization. The main limitations of this study is that failing to record post-operative conditions and radiograph in few cases due to owner's negligence or communication gap. Moreover the implants used in fracture fixation are not adequately available in Bangladesh. Proper diagnosis along with appropriate fixation technique and also post-operative management will give excellent outcome in femoral fracture management. The availability of the diagnostic tools will make fracture management easier to diagnose and treatment.

CHAPTER-8

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ANNEX

Questionnaire followed for data collection

Thesis title:

<u>Pre-fracture management record/preoperative record</u>

Signalment:

Breed: Age: Sex: Body wt.:

C/N: Tel no. /Mob. No: Date of Admission:

O/N: Color:

History/ Caused of fracture/ Duration of fracture:

Clinical findings: Limping (Rt/Lt) wt. bearing/Non-wt. bearing/Swelling (Location:)/no-swelling/Crepitation/no crepitation/closed wound/open wound/hanging limb/no hanging limb

Pain: Mild/Moderate/Severe

Radiographic finding (Lateral & Cranio-Caudal view):

Fracture management/Intraoperative record

Total days of before operation: Before operation: no callus/Mild/Moderate/Huge

Types of anesthesia:

Premedication: Induction: Maintenance:

Type of implant: Size of implant:

Post-operative findings:

Day	Clinical findings	Radiographic findings	Treatment
1	**Wt. bearing:** **Swelling:** **Exudation:** **Pain:** **Suture:**	**Healing condition:**	
15			
30			
45			

Post bandage/post-operative complications:

Conclusions: Output- Poor/Good/Excellent

Remarks:

Biography

DR. SUSHYAM BISWAS passed the Secondary School Certificate Examination in 2009 followed by Higher Secondary Certificate in 2011. He had successfully completed Doctor of Veterinary Medicine (DVM) Degree in 2017 from Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh. Now, he is a candidate for the degree of MS in Surgery, under the department of Medicine and Surgery, Chattogram Veterinary and Animal Sciences University (CVASU). His Research and publications are based on small animal surgery. He has great interest on small animal surgery.