MANAGEMENT OF TIBIAL FRACTURES IN DOGS USING PLASTER OF PARIS CAST AND MODIFIED THOMAS SPLINT

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

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DECLARATION

I hereby declare that this thesis entitled **"MANAGEMENT OF TIBIAL FRACTURES IN DOGS USING PLASTER OF PARIS CAST AND MODIFIED THOMAS SPLINT"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis, entitled **"MANAGEMENT OF TIBIAL FRACTURES IN DOGS USING PLASTER OF PARIS CAST AND MODIFIED THOMAS SPLINT"** is a record of research work done independently by **Mr. S. Anoop,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned, members of the Advisory committee of **Mr. S. Anoop,** a candidate for the degree of Master of Veterinary Science in Surgery, agree that the thesis entitled **"MANAGEMENT OF TIBIAL FRACTURES IN DOGS USING PLASTER OF PARIS CAST AND MODIFIED THOMAS SPLINT"** may be submitted by Mr. S. Anoop, in partial fulfilment of the requirement for the degree.

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S. ANOOP

Dedicated to

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Introduction

INTRODUCTION

Fracture treatment in animals is still of paramount importance to the surgeons. The goal of any method of fracture repair should be early return of stress adaptability of the fractured bone and prevention of fracture disease. This can be accomplished through adhering to basic principles of good patient and fracture assessment, choosing the correct method of fracture repair and appropriate patient care (Oakley, 1999). The incidence of fracture of tibia in dogs is more common because the lower third of the shaft of tibia is more exposed to injury and is covered only by skin and fascia with thin muscular layer. It is nearly 18-22 per cent in dogs (Singh *et al.*, 1983; Boone *et al.*, 1986a, Balagopalan *et al.*, 1995 and Aithal *et al.*, 1999).

In the treatment regimen of fracture in a bone like tibia, external immobilization procedures have an important role in stabilizing the region for favourable healing process. Closed reduction of the fracture and application of external coaptation methods viz. Modified Thomas splint and plaster of Paris cast were employed more frequently in juveniles and open reduction and internal fixation techniques in adult dogs (Boone *et al.*, 1986a). Favourable factors associated with external reduction and coaptation were preservation of soft tissues, haematoma and the blood supply to the fracture sites ending with a shortened healing time (Boone *et al.*, 1986b).

Modified Thomas Splint is used primarily to restrict movement of the fragments of fractured part, but at the same time providing facility for ambulation. It may also be applied to combine limited traction on the affected limbs with fixation of the fractured bone in overriding and impacted fractures. The splint can be easily fabricated using aluminium rods or conduit pipe and can be made to comfortably fit both the foreleg and hindleg. It is light, does not impose any strain and can be modified or changed as per need. The use of external immobilization using plaster of Paris cast and modified Thomas splint has its own demerits as reported by Hunt *et al.* (1980). It includes difficulty to achieve adequate reduction and stabilization of the fracture fragments, pressure induced gangrene of the skin, muscle atrophy, joint stiffness and osteoporosis. Roush and McLaughlin (1998), however reported a few complications like an unacceptable joint contracture, osteoporosis and muscle atrophy in dogs following extended use of Thomas splints.

Eventhough many demerits on use of external immobilization devices for stabilization of fracture of long bones in dogs were reported, perusal of available literature revealed that external fixation techniques like modified Thomas splint and plaster of Paris cast are still common in general veterinary practice.

Hence the present study was undertaken with the objectives of:

1. Assessing the healing process based on clinical symptoms, biochemical parameters and radiography of the affected part after immobilization of tibial fractures with Plaster of Paris cast and modified Thomas splint.

2. Assessing the effect of electrodiagnostic procedures on healing of fracture of tibia.

Review of Literature

REVIEW OF LITERATURE

Lundvall (1960) evaluated various methods of treatment adopted in 151 cases of fractures of long bones in large animals. Plaster cast supported with metal splints was found to be the most satisfactory method for calves. Through and through pinning with stainless steel pins and external bars supported with plaster cast was also reported to be effective.

Fowler (1968) suggested that, while constructing modified Thomas splint for dogs the length should be equal to that of fully extended sound limb and the ring diameter should be equal to the tuber coxae-tuber ischi distance. To allow thigh thickness the ring sides should be bend inward about 45°. He also stated that a complete plaster cast should not be applied after trauma when limb oedema is present.

Gill and Tyagi (1972) studied the effects of Plaster of Paris cast and hanging pin cast with and without Thomas splint for the treatment of fracture of long bones in calves. They found that coaptation with Plaster of Paris bandage supplemented with aluminium bars were the safest technique and Thomas splint was found to be more useful in heavy animals.

Winstanley (1974) stated that the extend of periosteal and endosteal callus formation during healing process depends upon the degree of stability that is present at the fracture site.

Rao (1975) used bamboo splints and gypsona plaster along with "short and modified Thomas splint" to immobilize the fracture of metacarpal and metatarsal bones in adult bovines. The immobilization did not interfere with ambulation and the healing was satisfactory.

Walker *et al.* (1975) reported that soft tissue swelling, irregular periosteal reaction, cortical lysis and increased medullary density as the radiographic signs of bone infection. The bone will show periosteal reaction, separation from bony cortex, sequestrum formation and crossing of the apex of physis by the reaction with resulting growth disturbance and joint involvement.

Singh *et al.* (1976a) in a study to find out time effect of intramedullary pinning in tibial fracture of the dogs concluded that open reduction of fracture could safely be done upto 10 days post fracture without any change in the ultimate outcome. He recommended third day post fracture as the best time for pinning.

Singh *et al.* (1976b) observed a significant increase in serum concentration of alkaline phosphatase at seven and fourteenth days of fracture treatment followed by a fall to normal value. It was opined that the increase was related to the time during which fibrous tissue formation was at its peak.

Cechner *et al.* (1977) reported that 70 per cent of the fractures were in medium to large breeds of dogs. Failure in healing was observed mostly in comminuted or transverse fracture of femur.

Pandiya *et al.* (1977) observed no specific radiographic change at the fracture site upto third day. Swelling of soft tissue over the fracture area was maximum during first week and persisted upto fourth week. The bridging of osseous callus along with a radiolucent line at the fracture site was evident at fourth week.

Ackerman and Silverman (1978) reported that radiographic evidence of fracture healing became apparant long after clinical union.

Singh *et al.* (1979) observed no significant difference in the pre and post fracture values of total serum protein in dogs. Serum albumin level was significantly lower than normal on third and seventh post fracture day. However an upward trend was observed thereafter. It is possible that the fall in albumin level may be due to its loss through capillaries at the fracture site or its increased demand at the fracture site during soft callus formation.

Boom and Mentstege (1980) opined that the extend of callus healing or contact healing was considered to be related to the degree of fragmentation and to the degree of immobilization during healing.

Hunt *et al.* (1980) in a review of 100 cases of complications of diaphyseal fractures in dogs reported that the major cause of failure of fracture treatment was instability resulted from poor technique together with infection. Plaster of Paris cast failed to provide adequate immobilization particularly when used for correction of oblique fractures.

Sharma *et al.* (1980) noted that the healing process started after third or fourth day post fracture and the best time of immobilization in large animals was around third post fracture day.

Singh *et al.* (1983) reported a higher incidence of fracture in male pups aged below one year and the occurrence of fracture was high at the middle and proximal third of the tibia.

Singh *et al.* (1984) observed malalignment and infection were the most common postoperative complication after external and internal immobilization of fractures. External immobilization by simple coaptation mostly associated with complications like malunion, delayed union and non-union.

Milne (1985) stated that alkaline phosphatase constitute a group of enzymes which catalyse the hydrolysis of a variety of phosphate esters at an alkaline pH. In bone the enzyme is thought to be involved in calcification during healing process.

Boone *et al.* (1986a) evaluated fractures of distal part of tibia in dogs with regard to fracture pattern, methods of stabilization and time for bone union. The location of the fractures were classified as metaphyseal (9.3%), physeal (30.9%), epiphyseal (2.3%) and those involving malleoli (58.2%). Open reduction and internal fixation technique were applied to all size of dogs and cats and an average bone healing time of six weeks was noticed.

Boone *et al.* (1986b) reported closed reduction and external coaptation as methods of fracture repair more frequently in juveniles and open reduction and internal fixation in adults. Healing time generally increased in adult animals and was related to stability of fracture fixation. Osteomyelitis and non-union were the complications observed.

Brinker *et al.* (1990) explained the procedure for fabricating modified Thomas splint with aluminium alloy rods of diameter 1/8".

Denny (1991) opined that fracture healing would proceed in the presence of certain amount of tension. Considerable amount of bending would be tolerated but torsion or rotation impeded healing because it causes tearing of the fibroelastic network of the callus and thus may lead to non-union.

Patil *et al.* (1991) reported that the incidence of fracture was higher in females than males except in donkeys, camel and dogs. Among dogs a higher incidence of femoral fractures (35%) followed by fracture of tibia (34%), humerus (13.3%), radius ulna (11.4%) and vertebrae (8.2%) was noticed.

Tomlinson (1991) reported the complications of fracture as delayed union and non-union from lack of adequate fracture stability, pressure and rub sores, leg swelling, dermatitis, joint laxity or stiffness, cast or splint breakage and refracture. Most of the complications were due to improper application of the coaptation devices or poor management of the patient.

DeCamp (1993) opined that the Thomas splint could be used to provide traction at the fracture site and immobilization of the joints of the limb in dogs. Thomas splint could be used as a primary fixation for selected minimally displaced midshaft fractures of radius, ulna and tibia.

Sanecki *et al.* (1993) reported a reduction in bone alkaline phosphatase activity in puppies markedly within the first three months, reaching a level of activity consistent with that of the adult dog by approximately fifteen months.

Anderson *et al.* (1994) opined that Thomas splint and cast combination were effective and economical technique for stabilization of tibial fractures in cattle.

Balagopalan *et al.* (1995) reported a high incidence of fracture in Alsatian dogs followed by Doberman Pinscher, non descript and Pomeranian. Incidence was more in dogs of age group 0-3 months (30.8%) followed by day old to three months (27.9%). In case of tibia the most common type of fracture was oblique (78.2%) followed by transverse (15.4%).

Morgan and Leighton (1995) opined that stable reduction of a fracture could result in production of little or no callus. Early use of the limb and absence of pain on palpation of the fracture site should be relied on to provide evidence of fracture healing.

Zaal and Hazewinkel (1996) in a study on 202 cases of tibial fractures in dogs and cats observed that 73 per cent of tibial fractures were at diaphysis, oblique fractures being the most frequent (24%). Proximal tibial fracture in dogs would be usually extra articular and 87 per cent of them involved avulsion of the tibial tubercle.

Jin *et al.* (1997) assayed the normal base alkaline phosphatase level in the serum of dogs of age ranging from six weeks to seven years and observed a wide range from 23.27 ± 14.73 IU/L in six weeks old dog to 9.24 ± 3.36 IU/L at one to seven years of age. There was no correlation with sex.

Zaal and Hazewinkel (1997) opined that the treatment of tibial fractures by external splinting had a good prognosis in immature animals and external or internal fixation in mature dogs.

Lescum *et al.* (1998) in a case report of management of gastrocnemius rupture in a horse opined that a properly constructed modified Thomas splint decreased joint flexion by allowing weight to be transmitted from the inguinal region to the ground through the splint thus bypassing the inguinal area.

Roush and McLaughlin (1998) opined that eventhough Schroedr-Thomas splint was still in common use in veterinary practice, it was the most complication prone device as its extended use often resulted in unacceptable joint contracture, osteoporosis and muscle atrophy.

Sahkhar *et al.* (1998) observed a significant increase in the serum alkaline phosphatase activity at the end of first postoperative week and a decrease thereafter to the base value at the end of fourth postoperative week following fracture treatment in poultry.

Aithal *et al.* (1999) in a survey of fractures in dogs reported that the number of males affected (63%) was significantly more than females (37%) and majority of fractures were recorded in young animals aged less than one year. The cause of trauma were mainly automobile accidents (48.86%) and fall from height (39.11%). Among different types of fractures oblique/spiral fractures (54.86%) were significantly higher than comminuted (16.57%), transverse (14.86%), incomplete (6.57%) and multiple fractures (5.14%). The higher percentage of fractures were in femur followed by tibia (17.16%). In tibia the occurrence was more in middle and proximal third of the bone.

Oakley (1999) stated that the goal of any method of fracture repair should be the early return of total limb function and prevention of fracture disease. This could be accomplished by adhering to the basic principles on fracture assessment, choosing the correct method of fracture repair and appropriate patient care.

Materials and Methods

MATERIALS AND METHODS

The study was conducted in twelve selected clinical cases of fracture in dogs of either sex presented to the Department of Surgery. These animals were randomly divided into two groups (Group I and Group II) consisting of six animals each and serially numbered as A1-A6 and B1-B6 respectively. Following treatment modalities were adopted in the animals.

Group I – Fracture was reduced by closed method and the limb was immobilized by application of modified Thomas splint.

Group II – Fracture was reduced by closed method and the limb was immobilized by application of plaster of Paris cast.

All the animals were observed for a period of six weeks.

Pre-operative observations

All the animals were examined clinically and the lame limb was observed for gross abnormalities in posture and weight bearing. History and the symptoms exhibited were recorded. Radiographs were taken to assess the type of fracture, extend of soft tissue damage and other complications, if any.

Procedure

Preparation of the Thomas splint

Aluminium rods of 3-4 mm diameter in size was used for fabricating Thomas splint as described by Decamp (1993). The animals were placed on lateral recumbency with the affected leg approximating a standing position. The diameter of the upper most part of thigh was approximated by encircling the thigh with both hands. The aluminium rod was bend to form a circle of the same diameter as the thigh. The bending was continued until one and one-half circles have been formed. The lower half of the circle was bend at a 45° angle towards the median line of the animal to relieve pressure from medial aspect of thigh. The entire ring was padded well with cotton and secured with gauze and tape. The cranial and caudal bars were continued down to accommodate the entire limb, without touching it. The distal ends were bend to the suitable size and fastened with adhesive tape (Fig.1).

Anaesthesia

All the animals were premedicated with Atropine sulphate* at the rate of 0.04 mg/kg body weight administered intramuscular, followed by Xylazine hydrochloride** at the rate of 1 mg/kg body weight administered intramuscular ten minutes later.

Atrowok – Atropine sulphate injection (0.6 mg), Wockhardt Ltd., Nans Daman

* Xylocad –Xylazine hydrochloride injection (20 mg/ml) Cadila Pharma, India.

Fracture reduction technique

Closed reduction technique was followed in all the animals. The animals were secured on lateral recumbency with the affected limb at the top. The position of the fragments were determined by palpation of the site as well as observing the radiographic details. The fragments were grasped through the soft tissue and brought to the original position to the possible extent by applying traction and countertraction. The bone fragments were then manipulated into position (Brinker, 1974).

Immobilization procedure

Group I

In animals of Group I, the limb was immobilized using fabricated modified Thomas splint by the method described by DeCamp (1993). The ring was firmly pushed into the inguinal area with the limb maintained in a standing position. The cranial and caudal bars were contoured accordingly. The foot was anchored to the platform of the splint using adhesive tape. Horizontal strips of adhesive tape were used to anchor proximal and distal metatarsus to the caudal splint rod. The upper leg was anchored to the cranial bar using adhesive tape (Fig.2).

Group II

In animals of group II, the limb was immobilized by application of Plaster of Paris cast by 'roll on' method as described by Fowler (1968). The plaster cast was applied spirally over the limb running from top to bottom, with sufficient pressure.

The plaster of Paris cast was anchored to the other limb by a bandage passing through the groin region of the opposite limb (Fig.3).

The immobilization devices were removed at the end of first, second and third week for recording of clinical data and reapplied. It was removed at the end of sixth week in both the groups.

Postoperative management

All the animals were observed for a period of six weeks postoperatively and were provided rest for a period of three weeks. The animals having compound fracture/soft tissue damage were given Ampicillin sodium* at the rate of 10 mg/kg body weight BID orally for five consecutive days.

Main items of observation

The status of health of the animals were evaluated based on the following parameters before immobilization and at the end of first, second, third and sixth week post treatment period.

(1) Clinical symptoms

a. General condition

The general appearance of the animals, feed intake, posture and position were recorded.

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* ROSCILLIN DISTAB – Ampicillin 250 mg Ranbaxy Laboratories Ltd., Industrial Area-3, Dewas, India.

b. Clinical evaluation of the affected limb

Clinical evaluation of the affected limb was made on the day of presentation and after removal of immobilization device on first, second, third and sixth week based on:

a. Limb dysfunction
b. Pain at the site
c. Fracture instability
d. Oedema
e. Trauma to adjacent soft tissue
f. Abnormal posture/crepitus
g. Abnormalities other than fracture if any

(ii) Physiological parameters

Rectal temperature (°C), pulse rate (per min), respiration rate (per min), colour of mucous membrane and other observations were recorded preoperatively and at weekly intervals upto sixth week..

(iii) Haemogram was studied preoperatively and at weekly intervals upto sixth week.

Blood smear was prepared and venous blood samples were collected in EDTA* for estimation of Haemoglobin content (Hb), Packed cell volume (PCV), Total erythrocyte count (TC) and Differential leukocyte count (DC) (Schalm, 1975).

(iv) Biochemical parameters

a. Total serum protein** was estimated using total protein kit by biuret method (Inchiosa, 1964) using Photometor 5010.

b. Alkaline Phosphatase*** was estimated using Alkaline phosphatase kit. The rate of increase in 4-nitrophenolate which was directly proportional to Alkaline phosphatase activity was determined using Photometer 5010 (Bergmeyer, 1972).

c. Aspartate transaminase was estimated using SGOT kit**** by the procedure recommended by "The Scandinavian Committee on Enzymes" (1974).

(v) Radiological studies

Affected region of the limb of the dogs were radiographed on the day of presentation to confirm the type of fracture and its configuration. Radiographs were

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* EDTA – EDTA Disodium salt (Nice Laboratory Reagent), New India Chemical Eneterprises, Kochi

** Total protein and Albumin Kit – Merck Diagnostics E. Merck (India) Limited, Worli, Mumbai.

*** Alkaline phosphatase kit – Merck Diagnostics. E. Merck (India) Limited, Worli, Mumbai

****SGOT Kit – Reckon Diagnostics Pvt. Ltd. 3/7 Industrial Estate, Gorwa, Baroda, India.

also taken after removing the immobilization devices on first, second, third and sixth week post treatment period to evaluate the healing process.

(vi) Electrodiagnostic procedure

Evaluation of the muscular activity at the affected region of the limb was made using muscle stimulator* on the day of presentation to evaluate the extend of soft tissue damage other than bone as per the method described by Bowen (1978). With the frequency of stimulation adjusted to 1/sec or slower and the voltage output set at zero, the voltage was g radually increased until a maximal contractile response was observed. Then the voltage was reduced until minimal contractile response was observed. Voltage at this point was considered the threshold voltage. The muscular activity at the healing site was evaluated following the same procedure after removing the immobilization device on first, second, third and sixth week postoperatively, under sedation using xylazine hydrochloride under premedication with atropine sulphate. Strength-duration (S-D) curves were prepared by plotting on one axis the strength of the stimulus required to induce the minimal contractile response to motor point stimulation at various pulse duration. The degree of innervation of the muscles were derived through S-D curve (Fig.4).

Statistical analysis

The data obtained in all the groups were analysed using analysis of covariance test and mean were compared with base values (Snedecor and Cochran, 1967).

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*Muscle Stimulator – Electrostim DT – Electrocare Systems and Services Pvt. Ltd., Chennai

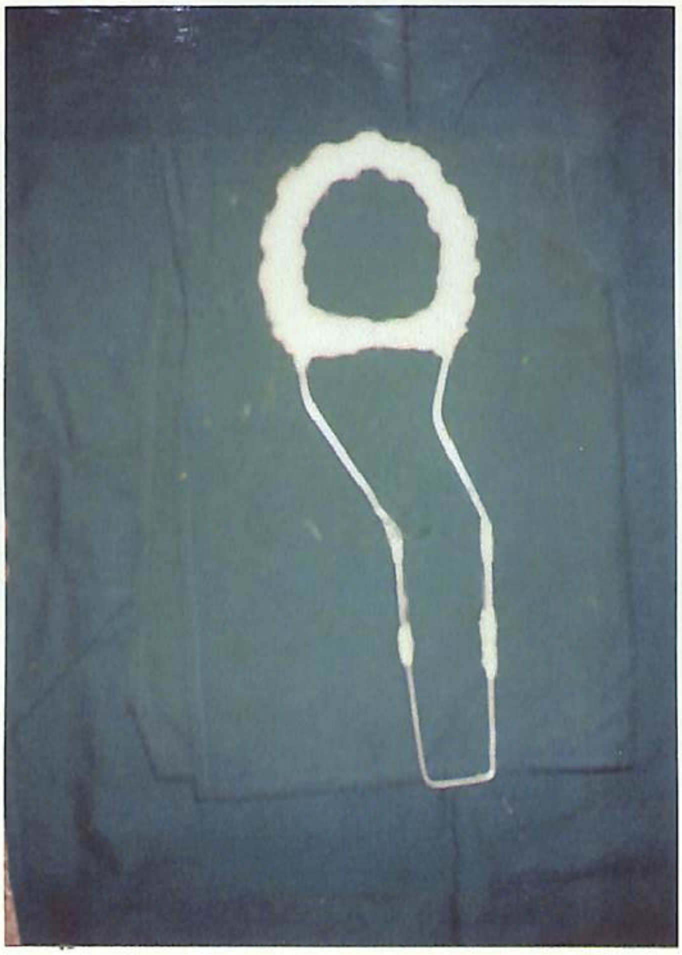

Fig. 1. Fabricated modified Thomas splint before application

Fig. 2. Animal A3 after application of modified Thomas splint

Fig. 3. Animal B1 with plaster of Paris cast in position on zero day

Fig. 4. Animal B1 on lateral recumbency with the electrodes of muscle stimulator in position

Results

RESULTS

GROUP I

The observations are presented in Tables 1 to 10.

Pre-operative considerations

History

a. Breed, age and sex

The breeds of dogs in this group included Alsatian (1), Pomeranian (2), Rottweiler (1) and non-descript (2). They were aged between 3 to 25 months and weighing 5 to15 kg. Fifty per cent of them were males.

b. Etiology

Automobile accident (33.3%) and fall from height (33.3%) were the major exciting causes of fracture followed by fighting (16.6%) and hit with stick (16.6%).

c. Day of presentation

Two animals were presented on the day of fracture itself, one each on third and fourth day and two on seventh day post fracture, respectively.

Clinical observation

a. General condition

All the animals were active and alert when presented to the hospital except for lameness.

Clinical evaluation of the limb

Day of presentation

All the animals were unable to bear weight on the affected limb and were lifting the limb. The site of fracture was painful in all the animals. Oedema and fracture instability were present in animals A1, A2, A3 and A6. Mobility at the fracture site was evident in these animals. None of the animals showed rotational deformity.

First week

Animal A3 mutilated the splint injuring the lower extremity of the limb. Animal A1 and A2 started bearing weight on the affected limb. All the animals were dragging the splint during progression. Animals A1, A3, A5 and A6 showed pain on palpation of the fracture site. Oedema at the fracture site persisted in animals .A1 and A3. Animals A1, A2 and A3 showed fracture instability. Mobility at the fracture site and soft tissue trauma were evident in animal A1.

Second week

All the animals mutilated the splints. Animals A1, A2 and A6 started bearing weight on the affected limb. Other animals could stand up on the limb with assistance. Animal A1, A3, A5 andA6 showed pain on palpation of the fracture site. Oedema subsided in all the animals. Fracture instability was persisting in animals A2 and A3. Mobility at fracture site was evident in animal A3. All the animals developed a hard palpable mass at the fracture site. None of the animals showed signs of soft tissue trauma.

Third week

Animals A2, A5 and A6 showed slight difficulty in bearing weight on the affected limb. Pain and oedema were not evinced at the fracture site. Hard palpable callus at the fracture site was evident in all the animals. None of the animals showed fracture instability or mobility of fracture site. Signs of soft tissue trauma persisted in animal A3.

Sixth week

All the animals could bear weight on the affected limbs. Animal A5 showed slight pain on palpation at the fracture site. It developed severe skin rashes at the groin region due to constant rubbing by the splint. Well palpable callus and fracture stability were evident in all the animals.

Physiological parameters

Temperature

Rectal temperature (°C) was 38.63 ± 0.32 on the day of presentation. Marginal variation within the normal range was noticed throughout the period of observation.

Pulse rate

Pulse rate (per min) was 114.33 ± 9.8 on the day of presentation. There was a marginal decrease on the first week post fracture and remained at a lower level throughout the period of observation.

Respiration rate

Respiration rate (per min) was 39.00 ± 0.50 on the day of presentation and showed only marginal variation within normal range throughout the period of observation.

Mucous membrane

The conjunctival mucous membrane was slightly pale in all the animals on the day of presentation. By second week, mucous membrane became normal in all the animals.

Haemogram

The haemoglobin concentration (g/dl) was 11.28 ± 0.28 on the day of presentation. It showed gradual increase upto second week followed by a marginal variation thereafter.

The packed cell volume (per cent) was 34.33 ± 1.08 on the day of presentation. There was a marginal increase on first week followed by a decrease during the period of observation.

The total erythrocyte count ($10^6/mm^3$) was 5.86 ± 0.10 on the day of presentation. It increased marginally on the first week and remained near normal throughout the period of observation.

The neutrophil count (per cent) was 64.60 ± 1.90 on the day of presentation. It showed a marginal decrease within normal range on the first week post fracture and increased to reach near normal by sixth week.

The lymphocyte count (per cent) was 34.66 ± 1.49 on the day of presentation. Marginal increase in the count was observed during first week and decreased to normal range by second week and remained in the same level during the period of observation.

The eosinophil and monocyte count (per cent) showed a marginal and insignificant variation in the post fracture period.

Serum biochemical parameters

Serum total protein (g%) was 6.01 ± 0.54 on the day of presentation. It showed a gradual decrease till second week followed by an increase afterwards.

Serum alkaline phosphatase (IU/L) was 351.00 ± 64.50 on the day of presentation. It showed an increase till second week followed by a decrease thereafter.

Serum aspartate amino transminase activity (IU/L) was 14.66 ± 1.02 on the day of presentation. The value remained at higher level throughout the period of observation.

Radiological observations

Day of presentation

An oblique fracture line at the middle diaphysis was seen in A1, A3 and A6. A transverse fracture line at the proximal third of the diaphysis was observed in A5. A comminuted fracture at the middle diaphysis with separation of two butterfly fragments were seen in A2. Animal A4 showed presence of a greenstick fracture at middle diaphysis. There was involvement of both cortex and medulla in all the animals except A4. Outward displacement of the distal fragment and angulation was observed in A1, A2, A3, A5 and A6. Soft tissue damage was evident in A1, A2, A3 and A6.

First week

Periosteal callus was evident in A1, A2, A4, A5 and A6. All the animals showed opacity of fragment ends. Progressive obliteration of fracture line was evident in A4. Displacement and angulation of fragments were noticed in A3 (Fig.5). But in A2 with communited fracture, fragments were found in position without any displacement (Fig.6).

Fig. 5. Skiagram showing displacement and angulation of fragments following mutilation of the Thomas splint on first week.

Fig. 6. Skiagram showing evident periosteal callus and well positioning of the fragments in a comminuted fracture of tibia on first week.

Second week

All the animals showed moderate amount of periosteal callus and increase in density of fragment ends. Angulation of the fragments still persisted in A1, A3 and A5. A6 showed reduction in angulation. There was progressive obliteration of fracture line in A4.

Third week

Sharp margins of fragment ends had undergone smoothening. None of the animals showed interfragmentary motion. Large sized periosteal callus was noticed in A1 (Fig.7) A2, A3, A5 and A6. Shortening of the limb due to severe distraction and angulation of fragments were seen in A3 (Fig.8).

Sixth week

Callus was large in A1. Callus was well developed in A2, A3, A4 and A6. Complete obliteration of fracture line and well developed periosteal callus was noticed in A4 and A5. Outer surface of the periosteal callus appeared smooth and more dense and there was complete bridging of fracture gap in A6 (Fig.9).

Electrodiagnostic procedure

Day of presentation

The strength required to produce a minimal contractile response on the affected limb was slightly lower than the threshold for normal limb upto a duration

Fig. 7. Skiagram showing massive periosteal callus at the fracture site on third week

Fig. 8. Skiagram showing deviation and angulation of fragments with periosteal callus at the fracture site on third week.

Fig. 9. Skiagram showing smooth periosteal callus and complete bridging of fracture gap on sixth week.

of 0.3 milliseconds. The values were maintained marginally at a higher level later on (Fig.10).

First week

The strength required to produce a minimal contractile response on the affected limb remained at a lower level in all the durations than the threshold for normal limb (Fig.10).

Second week

The strength required to produce a minimal contractile response on the affected limb remained at a higher level in all the durations from 100 milliseconds onwards (Fig.10).

Third week

The strength required to produce minimal contractile response on the affected limb remained at a lower level in all the durations than the threshold for normal limb (Fig.10).

Sixth week

The strength required to produce a minimal contractile response on the affected limb was maintained marginally at a higher level than the threshold for normal limb till the duration of 3 milliseconds after which it showed a marginal decrease till duration 3 and an increase thereafter (Fig.10).

Fig. 10. Graph showing strength of stimulus at different duration recorded for normal and affected limb of dogs during the period of observation
S-D Curve (Group I)

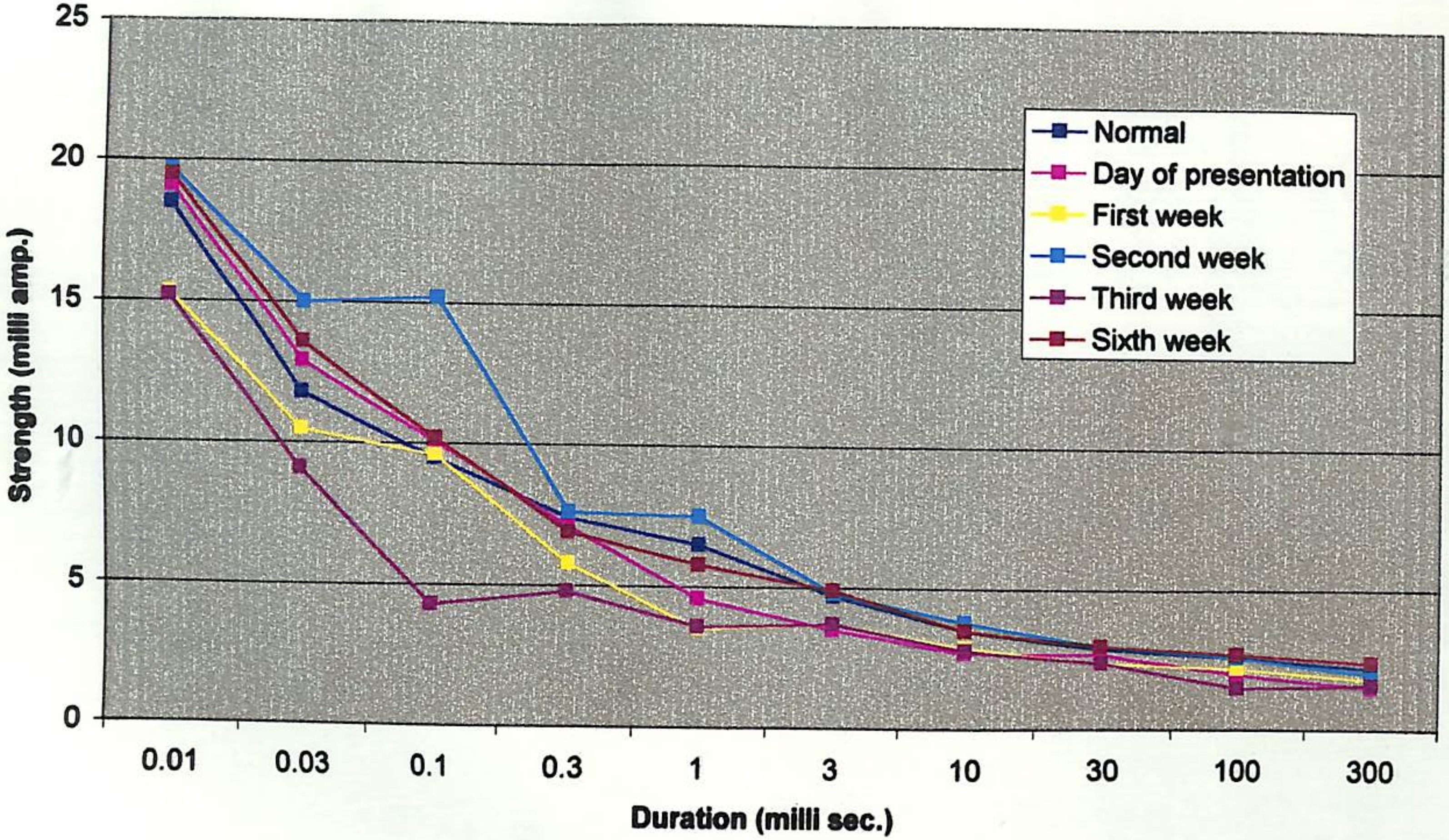

Table 1. Clinical details of the animals (group I) on the day of presentation

Animal No.	Breed	Age (months)	Body weight (kg)	Sex	Exciting cause of fracture	Duration of illness (days)	Location	Type of fracture
A1	Alsatian	9	15	Female	Fall from a height	4	Middle diaphysis	Oblique
A2	Pomeranian	25	5	Female	Hit with a stick	7	Middle diaphysis	Comminuted
A3	Pomeranian	6	7	Male	Fight with other dogs	1	Middle diaphysis	Oblique
A4	Non descript	6	7	Female	Automobile accident	1	Middle diaphysis	Green stick
A5	Rottweiler	4	11	Male	Fall from a height	7	Proximal third of diaphysis	Transverse
A6	Non descript	3	5	Male	Automobile accident	3	Middle diaphysis	Oblique

Table 2. Observation on the affected limb on the day of presentation (group I animals)

Symptoms	A1	A2	A3	A4	A5	A6
Limb dysfunction	+	+	+	+	+	+
Pain on palpation	+	+	+	+	+	+
Oedema	+	+	+	-	-	+
Fracture instability	+	+	+	-	-	+
Soft tissue trauma	-	-	-	-	-	-
Crepitation	+	+	+	-	-	+
Abnormalities other than fracture	-	-	-	-	-	-

Table 3. Observations 1 week following immobilization in group I animals

Symptoms	A1	A2	A3	A4	A5	A6
Limb dysfunction	-	-	+	+	+	+
Pain on palpation	+	-	+	-	+	+
Oedema	+	-	+	-	-	-
Fracture instability	+	+	+	-	-	-
Soft tissue trauma	+	-	-	-	-	-
Mobility	+	-	-	-	-	-
Abnormalities other than fracture	-	-	-	-	-	-

Table 4. Observations 2 weeks following immobilization in group I animals

Symptoms	A1	A2	A3	A4	A5	A6
Limb dysfunction	-	-	+	+	+	-
Pain on palpation	+	-	+	-	+	+
Oedema	-	-	-	-	-	-
Fracture instability	+	+	+	-	-	-
Soft tissue trauma	-	-	-	-	-	-
Mobility	-	-	+	-	-	-
Abnormalities other than fracture	-	-	-	-	Fracture of femur	Hard swelling

Table 5. Observations 3 weeks following immobilization in group I animals

Symptoms	A1	A2	A3	A4	A5	A6
Limb dysfunction	-	+	-	-	+	+
Pain on palpation	-	-	-	-	-	-
Oedema	-	-	-	-	-	-
Fracture instability	-	-	-	-	-	-
Soft tissue trauma	-	-	++	-	-	-
Mobility	-	-	-	-	-	-
Abnormalities other than fracture	Swelling	-	-	Swelling	-	-

Table 6. Observations 6 weeks following immobilization in group I animals

Symptoms	A1	A2	A3	A4	A5	A6
Limb dysfunction	-	-	-	-	-	+
Pain on palpation	-	-	-	-	+	-
Oedema	-	-	-	-	-	-
Fracture instability	-	-	-	-	-	-
Soft tissue trauma	-	-	-	-	-	-
Mobility	-	-	-	-	-	-
Abnormalities other than fracture	-	-	-	-	Skin rashes at groin region	-

Table 7. Rectal temperature, pulse rate and respiration rate (Mean ± SE) in group I animals before and after *immobilization*

n=6

Parameters with units	Post fracture period (week)				
	0	1	2	3	6
Rectal temperature (°C)	38.63 ± 0.32	38.70 ± 0.18	38.78 ± 0.21	38.55 ± 0.17	38.60 ± 0.33
Pulse rate (per min)	114.33 ± 9.80	108.16 ± 4.80	106.83 ± 1.20	107.83 ± 5.60	106.16 ± 3.70
Respiration rate (per min)	39.00 ± 0.50	38.50 ± 0.60	40.20 ± 0.20	38.00 ± 0.20	40.20 ± 0.82

Table 8. Haemogram (Mean ± SE) in group I animals before and after immobilization

n=6

Parameters with units	Post fracture period (week)				
	0	1	2	3	6
Haemoglobin (g/dl)	11.28 ± 0.28	12.90 ± 0.65	12.33 ± 0.42	11.76 ± 0.54	12.66 ± 0.47
Packed cell volume (%)	34.33± 1.08	36.33 ± 1.58	35.33 ± 0.84	35.00 ± 1.34	34.66 ± 1.22
Total erythrocyte count ($10^6/mm^3$)	5.86 ± 0.10	5.91 ± 0.24	5.86 ± 0.13	5.75 ± 0.12	5.81 ± 0.09
Neutrophils (%)	64.60 ± 1.90	60.12 ± 3.60	62.60 ± 3.10	62.33 ± 2.10	63.00 ± 1.67
Lymphocyte (%)	34.66 ± 1.49	39.80 ± 2.80	33.60 ± 2.15	36.60 ± 2.30	35.66 ± 1.60
Esinophils (%)	0.20 ± 0.20	0.00 ± 0.00	0.30 ± 0.30	0.40 ± 0.40	0.40 ± 0.40
Monocyte (%)	1.16 ± 0.40	1.16 ± 0.54	0.00 ± 0.00	0.60 ± 0.49	0.33 ± 0.21

Table 9. Serum constituents (Mean ± SE) in group I animals before and after immobilization

n=6

Parameters with units	Post fracture period (week)				
	0	1	2	3	6
Total protein (g%)	6.01 ± 0.54	5.88 ± 0.39	5.73 ± 0.15	6.10 ± 0.22	6.46 ± 0.59
Alkaline phosphatase IU/L	351.00 ± 64.50	375.00 ± 43.60	420.00 ± 46.10	318.80 ± 38.90	309.83 ± 22.50
Aspartate amino transaminase (IU/L)	14.66 ± 1.02	20.16 ± 1.83	20.00 ± 1.71	20.33 ± 3.98	22.66 ± 2.17

Table 10. Strength of stimulus at different duration recorded for normal and affected limb (Mean) in group I animals

Duration (milli sec)	Strength (milliamp)						
	Normal limb	Affected limb					
		0 week	1st week	2nd week	3rd week	6th week
300	2.2	1.5	1.8	2,0	1.6	2.4
100	2.6	2.0	2.2	2.6	1.5	2.7
30	2.9	2.7	2.4	3.0	2.4	3.0
10	3.5	2.7	2.9	3.8	2.8	3.5
3	4.7	3.5	3.7	4.8	3.7	4.9
1	6.5	4.6	3.5	7.5	3.6	5.8
0.3	7.4	7.1	5.8	7.6	4.8	6.9
0.1	9.5	10.1	9.6	15.2	4.3	10.2
0.03	11.8	12.9	10.5	15.0	9.1	13.6
0.01	18.5	19.1	15.3	19.7	15.2	19.5

GROUP II

The observations are presented in Tables 11-20.

Pre-operative considerations

History

a. Breed, age and sex

The breeds of dogs in this group included Pomeranian (2), Dachshund (2), Alsatian (1) and Great Dane (1). They were aged between 6 to 48 months and weighing 7 to 26 kg, 33.4 per cent of them were males.

b. Etiology

Automobile accident (33.3%) and hit with a stick (33.3%) were the major exciting causes for fracture, followed by fall from height (16.6%) and attack by dogs (16.6%).

c. Day of presentation

Three animals were presented on the day of fracture itself, one on second day and two animals each on fourth and tenth day post fracture.

Clinical observation

General condition

All the animals were active and alert when presented to the hospital except for lameness.

Clinical evaluation of the affected limb

Day of presentation

All the animals were unable to bear weight on the affected limbs. The site of fracture was oedematous and painful in all the animals. Fracture instability was noticed in all the dogs except B5. An open wound was present at the fracture site in B1 and B3 and on the foot in animal B4. Crepitation was observed on palpation of the fractured site in all the animals. Outward rotation of the distal extremity of the limb was noticed in B6.

First week

Animal B1 completely mutilated the cast by itself. B2 and B5 started bearing weight on progression. Pain on palpation of the fractured site was noticed in all the animals except B4. Severe oedema was observed distal to the plaster cast in B5. Fracture site was oedematous in B1 and B3. Fracture instability was noticed in all the animals except B5. All the animals except B1 could move freely with the plaster cast intact. Animals B1 and B3 showed signs of soft tissue trauma.

Second week

Animal No. B1 completely mutilated the Plaster cast. B1 and B3 started bearing weight on the affected limb. Pain on palpation of the fracture site was shown by B1, B2 and B3. Oedema was present at the fracture site and distal extremity of the limb in Animal A5. Fracture instability and soft tissue trauma was present in B1 and B3. A hard palpable mass was present at the vicinity of the fracture site in B1 and B3.

Third week

All the animals started bearing weight on the affected limbs. Pain or oedema was not evident at the fracture site. A well palpable callus at the fracture site was observed in all the animals. Signs of soft tissue trauma still persisted in animal B3. Mobility was not observed at the fracture site in any of the animals.

Sixth week

All the animals could bear weight on the affected limbs. All the animals developed alopacia and dermatitis at the area covered by Plaster of Paris cast. Slight outward rotation of the limb was noticed in Animal B2. All the animals showed the presence of a hard callus at the fracture site.

Physiological parameters

Temperature

Rectal temperature (°C) was 39.66 ± 0.22 on the day of presentation and showed only marginal variation during the period of observation.

Pulse rate (per min) was 103.00 ± 3.10 on the day of presentation. It showed a marginal increase on the first week post fracture and remained at a higher level throughout the period of observation.

Respiration rate (per min) was 42.00 ± 2.00 on the day of presentation. It showed only marginal variation during the period of observation.

The conjunctival mucous membrane was slightly pale on the day of presentation. By second week mucous membrane became normal in all the animals.

Haemogram

The haemoglobin concentration (g/dl) was 13.56 ± 0.36 on the day of presentation. Variation during the post fracture observation period was marginal and within the normal range.

The packed cell volume (per cent) was 37.16 ± 1.04 on the day of presentation. There was a marginal increase upto second week followed by a decrease during the period of observation.

Total erythrocyte count ($10^6/mm^3$) was 6.20 ± 0.14 on the day of presentation. It increased marginally on the first week, and remained near normal throughout the period of observation.

The neutrophil count was (per cent) 69.30 ± 2.30 on the day of presentation. It showed a marginal and insignificant decrease during the period of observation.

The lymphocyte count (per cent) was 28.80 ± 2.10 on the day of presentation. Marginal variation in the count was observed during the period of observation.

The eosinophil and monocyte count (per cent) showed a marginal and insignificant variation in the post fracture period.

Serum biochemical parameters

Serum total protein (g%) was 6.50 ± 0.58 on the day of presentation. Variation during post fracture period was within normal range.

Serum alkaline phosphatase (IU/L) was 318.33 ± 60.20 on the day of presentation. It showed an increase till second week followed by a decrease thereafter.

Serum aspartate amino transaminase (IU/L) was 26.16 ± 5.13 on the day of presentation. The value remained at a lower level throughout the period of observation.

Radiological observations

Day of presentation

A transverse fracture line at the mid diaphysis was seen in B1 and B3. In B3 the fragments were found to be separated. Oblique fracture line at the mid diaphysis was noticed in B2, B4, and B6. In B6, there was separation of a butterfly fragment. In B5 it was a green stick fracture at the mid diaphysis. In all the animals there was involvement of both cortex and medulla of the bone. Displacement of the fractured fragments with slight angulation was seen in B1, B2, B4 and B6. Soft tissue damage was obvious in B1, B2, B3, B4 and B6.

First week

Periosteal callus was evident in B2 and B3 (Fig.11). There was increase in density of the fragment ends in all the animals. Progressive obliteration of fracture line was evident in all the animals except B5 which showed an increase in the gap between the fragments (Fig.12). Angulation of the fragments persisted in animal B1, B2 and B4.

Second week

All the animals showed presence of periosteal callus. There was increase in density of fragment ends in all the animals. Progressive obliteration of fracture line was evident in all the animals (Fig.13).

Third week

Sharp margins of fragment ends had become smooth in all the animals. None of the animals showed inter fragmentary motion. Well developed callus was evident in B1, B2, B4 and B6 (Fig.14). Periosteal callus was less developed in animal B5. Periosteal callus with irregular outline was seen in B1.

Sixth week

Periosteal callus with irregular outline along with complete obliteration of fracture line was seen in B1. Periosteal callus become smooth and dense and complete bridging of the fracture gap and obliteration of fracture line was evident in B2 (Fig.15) B3 and B4. There was very little periosteal callus but there was

Fig. 11. Skiagram showing periosteal callus formation at the fracture site on first week

Fig. 12. Skiagram showing gap between the fragments on first week.

Fig. 13. Skiagram showing progress of healing on second week.

Fig. 14. Skiagram showing massive periosteal callus on third week.

Fig. 15. Skiagram showing complete bridging of fracture gap on sixth week.

bridging of the fracture gap in B5. Animal B6 showed well developed periosteal callus and there was shortening of the limb.

Electrodiagnostic procedure

Day of presentation

The strength required to produce a minimal contractile response on the affected limb was maintained marginally at a higher level than the threshold for normal limb till duration 30 milliseconds followed by a decrease in value till duration of 1 millisecond. The threshold value was at a higher level for the remaining period (Fig.16).

First week

The strength required to produce a minimal contractile response on the affected limb was maintained marginally at a higher level than the threshold for normal limb till the duration of 1 millisecond and the values showed a marginal decrease thereafter (Fig.16).

Second week

The strength required to produce a minimal contractile response on the affected limb was maintained marginally at a higher level than the threshold for normal limb till the duration of 0.1 milli seconds and the values showed a marginal decrease thereafter (Fig.16).

Third week

The strength required to produce minimal contractile response on the affected limb showed marginal variation in all the pulse durations with the threshold for normal limb (Fig.16).

Sixth week

The strength required to produce a minimal contractile response on the affected limb was marginally at a lower level till pulse duration 3 milliseconds. Later on the values were maintained marginally at a higher level than the threshold for normal limb in all the pulse durations (Fig.16).

Fig. 16. Graph showing strength of stimulus at different duration recorded for normal and affected limb of dogs during the period of observation S-D Curve (Group II)

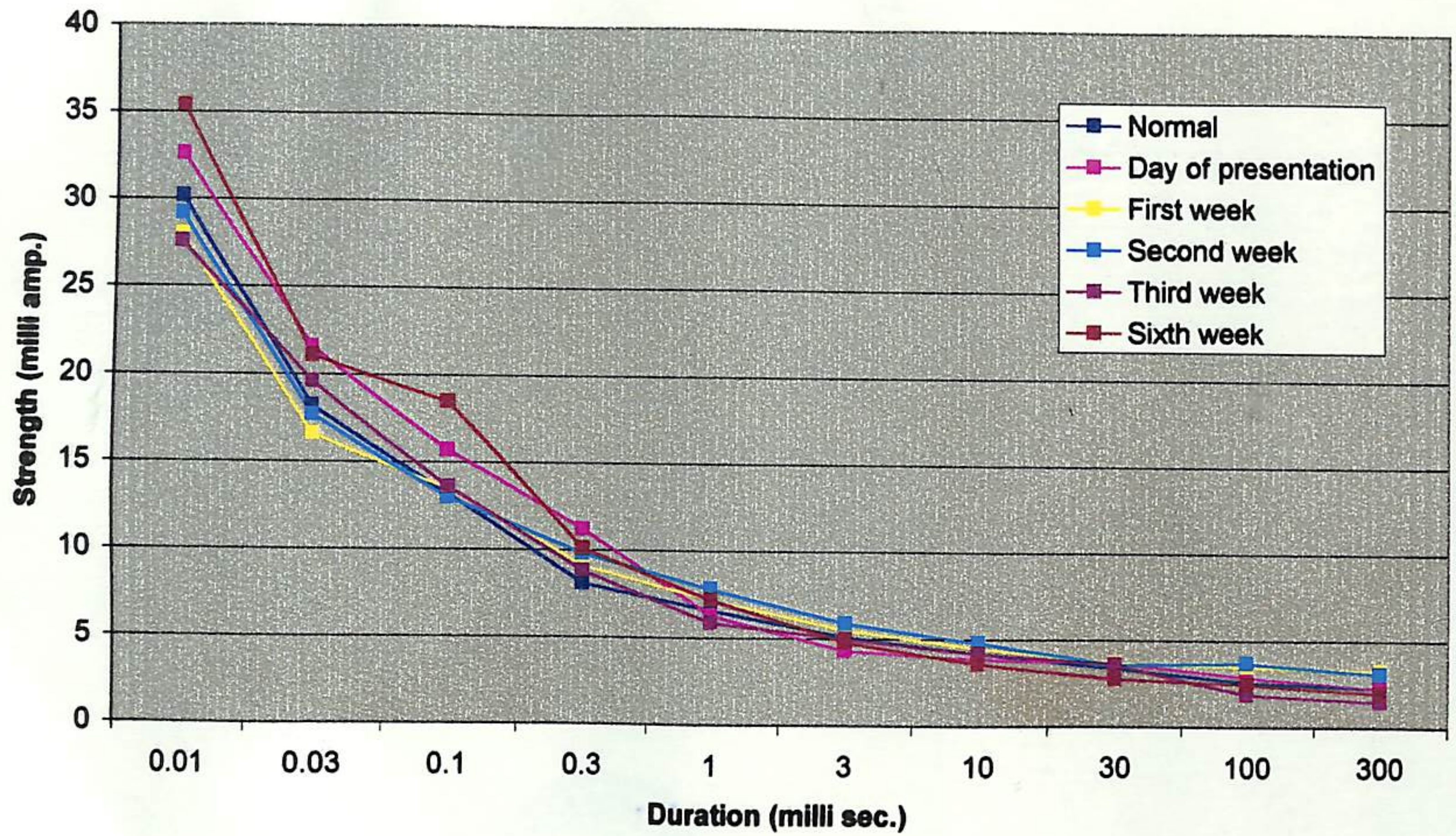

Table 11. Clinical details of the animals (group II) on the day of presentation

Animal No.	Breed	Age (months)	Body weight (kg)	Sex	Exciting cause of fracture	Duration of illness (days)	Location	Type of fracture
B1	Great Dane	27	26	Female	Hit with a stick	1	Mid diaphysis	Transverse
B2	Alsatian	4½	15	Male	Automobile accident	1	Mid diaphysis	Oblique
B3	Pomeranian	48	7	Female	Attack by a group of dogs	4	Mid diaphysis	Transverse
B4	Dachshund	6	10	Male	Hit by a child	2	Mid diaphysis	Oblique
B5	Dachshund	24	9	Female	Automobile accident	1	Mid diaphysis	Green stick
B6	Pomeranian	24	11	Female	Fall from a height	10	Mid diaphysis	Oblique

Table 12. Observation on the affected limb on the day of presentation (group II animals)

Symptoms	B1	B2	B3	B4	B5	B6
Limb dysfunction	+	+	+	+	+	+
Pain on palpation	+	+	++	++	+	+
Oedema	+	+	+	+	+	+
Fracture instability	+	+	+	+	-	+
Soft tissue trauma	+	-	++	-	-	-
Crepitation	+	+	+	+	+	+
Abnormalities other than fracture	Wound at fracture site	-	Wound at fracture site	Salivation anorexia	Wound at the digits	-

Table 13. Observations 1 week following immobilization in group II animals

Symptoms	B1	B2	B3	B4	B5	B6
Limb dysfunction	+	-	+	+	-	+
Pain on palpation	+	+	+	-	+	+
Oedema	+	-	+	-	+	-
Fracture instability	+	-	+	-	-	-
Soft tissue trauma	+	+	+	+	-	+
Mobility	+	-	-	-	-	-
Abnormalities other than fracture	-	Alopacia	Wound	-	Oedema	-

Table 14. Observations 2 weeks following immobilization in group II animals

Symptoms	B1	B2	B3	B4	B5	B6
Limb dysfunction	-	+ (favouring)	-	+	+	+
Pain on palpation	+	+	+	-	-	-
Oedema	-	-	-	-	+	-
Fracture instability	+	-	+	-	-	-
Soft tissue trauma	+	-	+	-	-	-
Mobility	+	-	+	-	-	-
Abnormalities other than fracture	-	Swelling	Wound	-	-	-

Table 15. Observations 3 weeks following immobilization in group II animals

Symptoms	B1	B2	B3	B4	B5	B5
Limb dysfunction	-	-	-	-	-	-
Pain on palpation	-	-	-	-	-	-
Oedema	-	-	-	-	-	-
Fracture instability	-	-	-	-	-	-
Soft tissue trauma	-	-	+	-	-	-
Mobility	-	-	-	-	-	-
Abnormalities other than fracture	-	Anorexia	-	-	Swelling of hock region dermatitis alopacia	-

Table 16. Observations 6 weeks following immobilization in group II animals

Symptoms	B1	B2	B3	B4	B5	B6
Limb dysfunction	-	-	-	-	-	-
Pain on palpation	-	-	-	-	-	-
Oedema	-	-	-	-	-	-
Fracture instability	-	-	-	-	-	-
Soft tissue trauma	-	-	-	-	-	-
Mobility	-	-	-	-	-	-
Abnormalities other than fracture	Hard callus	Outward rotation of the limb	-	Alopacia swelling	Alopacia at POP cast applied areas	-

Table 17. Rectal temperature, pulse rate and respiration rate (Mean ± SE) in group II animals before and after immobilization

n=6

Parameters with units	Post fracture period (week)				
	0	1st	2nd	3rd	6th
Rectal temperature (°C)	39.66 ± 0.22	39.30 ± 0.14	39.30 ± 0.20	39.20 ± 0.12	39.10 ± 0.04
Pulse rate (per min)	103.00 ± 3.10	108.00 ± 3.50	107.00 ± 4.80	110.00 ± 5.00	108.60 ± 4.70
Respiration rate (per min)	42.00 ± 0.20	40.00 ± 0.35	41.00 ± 0.25	39.00 ± 0.14	38.00 ± 0.22

Table 18. Haemogram (Mean ± SE) in group II animals before and after immobilization

n=6

Parameters with units	Post fracture period (week)				
	0	1st	2nd	3rd	6th
Haemoglobin (g/dl)	13.56 ± 0.36	13.60 ± 0.42	13.46 ± 0.31	13.63 ± 0.58	12.90 ± 0.63
Packed cell volume (%)	37.16 ± 1.04	37.83 ± 0.90	37.00 ± 0.63	36.60 ± 0.66	36.60 ± 0.42
Total erythrocyte count ($10^6/mm^3$)	6.20 ± 0.14	6.31 ± 0.16	6.08 ± 0.04	6.05 ± 0.18	6.10 ± 0.15
Neutrophils (%)	69.30 ± 2.30	67.10 ± 1.40	67.10 ± 3.20	66.80 ± 1.60	66.16 ± 1.50
Lymphocyte (%)	28.80 ± 2.10	32.30 ± 1.50	31.30 ± 3.20	32.30 ± 1.40	33.60 ± 1.40
Esinophils (%)	1.00 ± 0.68	0.16 ± 0.16	0.66 ± 0.33	0.33 ± 0.21	0.16 ± 0.16
Monocyte (%)	1.00 ± 0.44	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.34	0.00 ± 0.00
Basophils (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Table 19. Serum constituents (Mean ± SE) in group II animals before and after immobilization

n=6

Parameters with units	Post fracture period (week)				
	0	1st	2nd	3rd	6th
Total protein (g%)	6.5 ± 0.58	5.33 ± 0.54	5.86 ± 0.42	5.78 ± 0.17	6.80 ± 0.40
Alkaline phosphatase IU/L	318.33 ± 60.20	324.50 ± 38.30	344.60 ± 31.80	258.83 ± 22.40	248.83 ± 9.84
Aspartate amino transaminase (IU/L)	26.16 ± 5.13	23.66 ± 3.94	23.00 ± 3.91	21.66 ± 2.59	24.00 ± 3.90

Table 20. Strength of stimulus at different duration recorded for normal and affected limb (Mean) in group II animals

Duration (milli sec)	Strength (milliamp)					
	Normal limb	Affected limb				
		0 week	1st week	2nd week	3rd week	6th week
300	2.3	2.3	3.3	3.1	1.5	2.0
100	2.6	2..9	3.5	3.7	1.9	2.5
30	3.4	3.7	3.7	3.6	3.6	2.8
10	4.2	3.9	4.5	4.8	4.2	3.6
3	5.1	4.3	5.5	5.9	5.0	4.8
1	6.6	6.3	7.2	7.8	5.9	7.2
0.3	8.1	11.2	9.1	9.8	8.8	10.1
0.1	13.2	15.7	13.5	13.0	13.6	18.5
0.03	18.2	21.6	16.6	17.7	19.6	21.1
0.01	30.2	32.55	28.0	29.15	27.6	32.35

Discussion

DISCUSSION

Fracture of long bones is a common orthopaedic condition encountered in dogs. Tibia is more prone to fracture because lower third shaft of tibia is more exposed to injury and is covered only by skin and fascia with thin muscular layer. Though the percentage of incidence of tibial fractures have been variously reported as 17.16 per cent (Aithal *et al.*, 1999), 22.3 per cent (Singh *et al.*, 1983) and 19 per cent (Boone *et al.*, 1986b and Balagopalan *et al.*, 1995), the condition deserves special attention. Closed reduction and external coaptation are preferred in treatment of tibial fracture in juveniles but open reduction and internal fixation is adopted more frequently in adults (Boone *et al.*, 1986b). Recent practice advocates open-but-do-not-touch technique in which minimal surgical approaches are performed to preserve blood supply and to limit contamination. In addition, fixation appliances are placed to provide fracture stability and overall limb alignment but not to reduce individual fragments (Roush and McLaughlin, 1998).

With the advent of "Ambulatory methods" in modern surgery, the treatment of fractures to a considerable extent has become easy. The principle of this method is that the injured part is kept absolutely immobile, but the animal is permitted to use the limb. Modified Thomas splint is particularly used to achieve this objective (Rao, 1975). Modified Thomas splint, although its use is basically limited to restrict movement, the splint can be applied to combine traction with fixation (Brinker, 1974). Modified Thomas Splint do not reduce fracture but maintains reduction once obtained. Plaster of Paris casts are most effective in treating minimally displaced stable fracture of tibia in young animals. Favourable factors associated with external reduction and coaptation were preservation of soft tissue, haematoma and the blood supply to the fracture site (Boone *et al.*, 1986b). Fracture in animals treated with closed reduction and external fixation heal in an average time of under four weeks regardless of whether the animals were juveniles or adult.

Roush and McLaughlin (1998) opined that Thomas splint was the most complication prone device as its extended use for fixation often resulted in unacceptable joint contracture, osteoporosis and muscle atrophy. With plaster of Paris cast the main cause of failure was incorrect application resulting in inadequate immobilization or malalignment of fragments. Plaster cast often failed to provide adequate immobilization particularly when used for treatment of oblique fractures (Hunt *et al.*, 1980).

The present study was conducted to evaluate and compare the effect of external fixation with modified Thomas Splint and Plaster of Paris cast for treatment of fracture of tibia in dogs. Twelve selected clinical cases of fracture in dogs of either sex presented to the Department of Surgery formed the subjects for the treatment. These animals were randomly divided into two groups (Group I and II) consisting of six animals each. The animals were examined clinically and radiographically and observations were recorded. Following treatment modalities were adopted for the treatment of the animals.

Group I - Fracture was reduced by closed method and the limb was immobilized by application of modified Thomas Splint

Group II - Fracture was reduced by closed method and the limb was immobilized by application of Plaster of Paris cast.

Premedication with atropine sulphate @ 0.04 mg/kg body weight IM followed by xylazine hydrochloride @ 1 mg/kg body weight IM was found to be suitable for the fracture reduction in the present study.

Closed reduction technique as described by Brinker (1974) was followed in all the animals to reduce the fragments into proper apposition and alignment. In animals of Group I, the limb was immobilized by modified Thomas Splints, fabricated using Aluminium rods of 3-4 mm in diameter. It was kept in position and the limb was fixed to it as per the method described by DeCamp (1993). In the animals of Group II, the limb was immobilized by application of Plaster of Paris cast by "roll on" method as described by Fowler (1968).

All the animals were observed for a period of six weeks after immobilization and were provided rest for a period of three weeks. The animals with compound fracture/soft tissue damage were treated with antibiotics.

Clinical and physiological parameters, haemogram and serum biochemical parameters were studied before immobilization and on first, second, third and sixth weeks in all the animals. Radiological and electrodiagnostic evaluation was done in all the animals.

A higher incidence of fractures (33.3%) were recorded in Pomeranian dogs. Balagopalan *et al.* (1995) have reported a higher incidence of fractures in Alsatian (27.8%) dogs; whereas maximum incidence of fractures was recorded in non-descript dogs by Thilagar and Balasubrahmanian (1988) and Aithal *et al.* (1999).

A higher incidence of fracture was recorded in age group of three to six months (50%) followed by age group of two years and more (46%). This is in agreement with the reports of Boone *et al.* (1986a), Thilagar and Balasubrahmanian (1988), Balagopalan *et al.* (1995) and Aithal *et al.* (1999). This may be due to the fact that young ones are more active but are unable to cope with hazards unlike the older animals (Boone *et al.*, 1986a).

Out of the twelve animals presented to the clinics 58.3 per cent were females and 41.6 per cent were males. This is in difference to several reports indicating a high incidence of fractures in males than females (Singh *et al.*, 1983; Boone *et al.*, 1986a; Patil *et al.*, 1991; Balagopalan *et al.*, 1995; Aithal *et al.*, 1999). In the present study the variation could be due to the limited number of animals included.

Automobile accident (33.3%) and fall/jump from height and hit with stick (25%) were the major exciting cause of fracture followed by attack by group of dogs (16.6%). Similar observations were reported by Aithal *et al.* (1999) and Phillips (1979).

Forty one per cent of cases were presented on the day of incidence itself, 34 per cent in two to four days and 25 per cent within seven to ten days.

All the animals showed limb dysfunction manifested as inability to bear weight on the affected limb and lifting the limb. There was severe pain on palpation of the fracture site in all the animals. In four animals there was oedema around the fracture site, fracture instability and crepitation at the fracture site on palpation. Roush and McLaughlin (1998) explained the clinical symptoms in fracture site as limb dysfunction, pain, fracture instability, overlying soft tissue trauma, abnormal posture of limb/position and crepitus.

Twenty per cent of the dogs mutilated the Thomas splint one week after immobilization. Two animals started bearing weight on the affected limb. Two animals showed absence of pain on palpation of fracture site and persistence of oedema. Fracture instability was found to be persistent in three animals. One animal developed soft tissue trauma. Mobility on palpation of the fracture site was noticed in one animal.

By second week all the animals mutilated the Thomas splint. Three animals showed inability to bear weight on the affected limb. Four animals showed persistence of pain on palpation of the fracture site. All the animals showed complete regression of oedema. Fracture instability persisted in two animals. None of the animals showed presence of soft tissue trauma. One animal showed mobility at the fracture site.

At the end of second week, the symptoms of fracture except oedema were found to be persisting in animals which might have resulted due to violation of the Thomas splint and exaggerated movement of the fracture site.

All the animals tolerated the modified Thomas splint during the third week. Limb dysfunction still persisted in three animals. None of the animals showed pain, oedema, fracture instability or mobility at the fracture site. One animal showed signs of soft tissue trauma. Morgan and Leighton (1995) reported that the use of the limb and absence of pain on palpation of the fracture site should be relied on as evidence of fracture healing.

All the animals could bear weight on the affected limb at sixth week. All the animals except one showed complete absence of pain on palpation of the fracture site. None of the animals showed presence of oedema and fracture instability, soft tissue trauma and mobility at the fracture site. Hard palpable callus was evident at the fracture site. One animal developed skin rashes at the groin region due to constant rubbing by the splint. This was in agreement with the observation of Gill and Tyagi (1972) that excoriation at the fold of flank and inguinal region was noticed on removal of modified Thomas splint in calves after three weeks.

Eventhough, tolerance to the Thomas splint was comparatively less, it had not apparently affected the healing process much, since all the animals could bear weight on the affected limb by sixth week. Absence of any sign of complication indicated the suitability of this technique for immobilizing tibial fracture in dogs.

Rectal temperature, pulse rate and respiration rate showed only marginal variation throughout the period of observation in all the animals. Mucous membrane which was slightly pale on the day of presentation become normal by second week in all the animals.

The observation on physiological parameters during the post fracture period revealed that the incidence of fracture and the immobilization procedure employed did not produce any untoward systemic effects.

Haemoglobin concentration, packed cell volume, total erythrocyte count and lymphocyte count showed marginal increase in the first week followed by a decrease thereafter. Neutrophil count showed a fall on the first week, followed by a gradual increase thereafter. Eosinophil and monocyte count showed only marginal and insignificant variation throughout the period of observation.

The marginal variation observed in haemogram may be due to the cellular reaction to trauma during the healing process (Gourley and Vasseur, 1985).

Serum total protein showed a decrease till second week followed by an increase thereafter. The initial decrease observed in total protein content could be attributed to the relative protein deficit associated with trauma (Carlson, 1997). Singh *et al.* (1979) observed no significant difference in pre and post fracture values of total serum protein in dogs.

Serum alkaline phosphatase showed an increase till second week followed by a decrease thereafter. A significant rise in serum concentration of alkaline phosphatase was observed at 7th and 14th days post fracture in dogs (Singh *et al.*, 1976b) and in poultry (Sahkhar *et al.*, 1998).

Serum aspartate amino transaminase values remained at a higher level in the post fracture period.

Eighty three per cent of fractures were located in middle diaphysis. It is in accordance with the findings of Singh *et al.* (1983). Boone *et al.* (1986b) and Aithal *et al.* (1999). However, Thilagar and Balasubrahmanian (1988) reported a high incidence of fracture in lower third of diaphysis. Since the proximal third of the tibia is positioned away from the central axis of the limbs, it is generally under greater stress, especially bending. The stress may get aggravated during fall or automobile accident when animal struggle to position itself (Aithal *et al.*, 1999).

Among different type of fracture in tibia, there was oblique (50%), transverse (16.6%), green stick (16.6%) and comminuted fracture (16.6%). This was in agreement with the findings of Singh *et al.* (1983), Boone *et al.* (1986b) and Aithal *et al.* (1999). Boone *et al.* (1986b) reported that transverse fractures occurred only in the middle portion of diaphysis and accounted for 13.85 per cent of total fractures.

By first week, periosteal callus started developing near the fracture site along with reduction in soft tissue swelling in four animals. Pandiya *et al.* (1977) observed no specific radiographic change at the fracture site upto three days of fracture reduction. All the animals showed opacity of fragment ends. Pandiya *et al.* (1977) cannot found periosteal reaction by seventh day and the fractured ends showed rarefication and appeared hazy. Five animals showed progressive obliteration of fracture line. Roush and McLaughlin (1988) reported early signs of healing as periosteal reaction near the fracture site, callus formation and remodelling of fractured ends of bone.

All the animals showed presence of periosteal callus with increased density of fractured ends by second week. Braden and Brinker (1976) reported that movement of the fragments at the fracture site resulted in the formation of a fibrous callus by seven to 14 days. Gill and Tyagi (1972) noted practically no periosteal reaction on 15^{th} day but only a blurred appearance of the fractured ends indicative of local rarefication following fracture treatment of long bones in calves.

By third week, five animals showed presence of massive periosteal callus. This was in agreement with the observation of Morgan and Leighton (1995) that stable reduction of fracture could result in production of very little or no callus as seen radiographically, whereas mid shaft fracture with no end to end apposition of the fragments treated with an external splint or cast healed by massive bridging callus. Winstanley (1974) stated that the extend of periosteal and endosteal callus formation during healing, process depended upon the degree of stability that was present at the fracture site.

By the end of six weeks of immobilization, three animals showed presence of smooth and dense periosteal callus with complete obliteration of fracture line. Complete bridging of fracture gap with very little periosteal callus was seen in one animal. Ackerman and Silverman (1978) observed the persistence of fracture line radiographically even if the fracture was clinically stabilized.

The strength required to produce a minimal contractible response on the affected limb was at a higher level than the normal limb. This observation was in agreement with that of Bowen (1978) that an increase in threshold might occur in normally innervated muscle when oedema was present. On the day of presentation all the animals showed presence of oedema at the fracture site.

The strength required to produce a minimal contractile response by the end of the first week, on the affected limb was relatively at a lower level than the threshold for normal limb. The strength required to produce a minimal contractile response on the affected limb remained relatively at a higher level with marginal variation by second week in all the duration. The strength required to produce a minimal contractile response on the affected limb was at a lower level in all pulse duration than the threshold for normal limb. Eventhough the strength required to produce a minimal contractile response showed marginal variation throughout the different pulse duration than the normal limb, it was kept at a higher level than the normal limb on sixth week. This was in agreement with the observation of Bowen (1978) that the marginal increase in threshold on sixth week was in agreement with the fact that the threshold will increase when the size and volume of a muscle have been reduced in disuse atrophy. Often trauma can disrupt normal anatomical relationship resulting in displacement of motor points, which may result in apparent discrepancy in the threshold of symmetrical muscle.

All the animals showed limb dysfunction manifested as inability to bear weight on the affected limb and lifting the limb. There was severe pain on palpation of the fracture site in all the animals. All the animals showed oedema and crepitation at the fracture site. Five animals showed fracture instability and two animals showed signs of soft tissue trauma. It is in agreement with that reported by Roush and McLaughlin (1998) in the case of long bone fracture.

Twenty per cent of the dogs mutilated the plaster cast one week after immobilization. Two animals started bearing weight on the affected limb. One animal showed absence of pain on palpation of the fracture site. Three animals showed persistence of oedema with one animal developing severe oedema distal to the cast. In two animals fracture instability and soft tissue trauma was found to be persistent. One animal showed mobility at the fracture site on palpation.

By second week one animal mutilated the plaster of Paris cast. Two animals showed inability to bear weight on the affected limb. Three animals showed persistence of pain on palpation of fracture site. Two animals showed persistence of oedema, fracture instability, soft tissue trauma and mobility at the fracture site.

All the animals could bear weight on the affected limb by third week. None of the animals showed pain, oedema, fracture instability and mobility at the fracture site. One animal showed signs of soft tissue trauma. Gill and Tyagi (1972) reported that calves treated with plaster of Paris cast could bear sufficient weight on the limb by 28^{th} day only.

All the animals could bear weight on the affected limb at sixth week. None of the animals showed signs of pain, presence of oedema, fracture instability, soft tissue trauma or mobility at the fracture site. Hard palpable callus was evident at the fracture site. Dermatitis and alopacia at the area covered by Plaster of Paris cast was noticed in all the animals. Tomlinson (1991) observed complication of external coaptation technique as delayed and non-union healing from lack of adequate fracture stability, pressure and rubsore, leg swelling, dermatitis, joint laxity or stiffness, cast or splint breakage or refracture.

Rectal temperature, pulse rate and respiration rate showed only marginal variation throughout the period of observation in all the animals. Mucous membrane which was slightly pale on the day of presentation become normal by second week in all the animals. The observations indicate that the incidence of fracture and the immobilization procedures prevented occurrence of any untoward systemic effects.

Haemoglobin concentration, packed cell volume, total erythrocyte count and lymphocyte count showed marginal variation throughout the period of observation. Neutrophil count showed a decreasing trend but eosinophil and monocyte count showed only marginal and insignificant variation during the period of observation. The variations observed in haemogram is suggestive of cellular reaction to trauma (Gourley and Vasseur, 1985).

Serum total protein showed a decrease till second week followed by an increase thereafter. The initial decrease observed in total protein content could be attributed to the relative protein deficit associated with trauma (Carlson, 1997). Singh *et al.* (1979) observed no significant difference in pre and post fracture values of total serum protein in dogs.

Serum alkaline phosphatase showed an increase till second week followed by a decrease thereafter. A significant rise in serum concentration of alkaline phosphatase was observed at 7th and 14th days post fracture in dogs (Singh *et al.*, 1976b) and in poultry (Sahkhar *et al.*, 1998).

Serum aspartate amino transaminase values remained relatively at a lower level in the post fracture period.

All the fractures were located in middle diaphysis. It is in accordance with the findings of Singh *et al.* (1983), Boone *et al.* (1986b) and Aithal *et al.* (1999). Among different types of fractures in tibia, there was obligue (50%), transverse (33.3%) and green stick (16.6%) fractures. This is in agreement with the findings of Singh *et al.* (1983), Boone *et al.* (1986b) and Aithal *et al.* (1999).

By first week periosteal callus started developing near the fracture site along with reduction in soft tissue swelling in two animals. All the animals showed opacity of the fragment ends. Five animals showed progressive obliteration of fracture line. Roush and McLaughlin (1998) reported early signs of healing as periosteal reaction near the fracture site, callus formation and remodelling of fractured ends of bone.

All the animals showed presence of periosteal callus with increased density of fragment ends by second week, which is in variation to the observation by Gill and Tyagi (1972) who reported that periosteal reaction was present by 15th day and a blurred appearance of the fractured ends indicated local rarefication following fracture treatment of long bones in calves.

By third week four animals showed presence of massive periosteal callus. This was in agreement with the observation of Bommaiah *et al.* (1976) that periosteal circulation is the major source of blood supply in fractures immobilized with plaster of Paris cast and such fractures heal mainly by periosteal callus. Winstanley (1974) stated that the extend of periosteal and endosteal callus formation during healing process depended upon the degree of stability that was present at the fracture site.

At the end of six weeks of immobilization three animals showed presence of smooth and dense periosteal callus with complete obliteration of fracture line. Complete bridging of fracture gap with very little periosteal callus was seen in one animal. Singh and Nigam (1975) opined that by the end of sixth week the fracture gap was only partially obliterated in calves as evidenced in radiography. Only one animal in the present study interfered with retention of plaster cast, though it is opined that the main cause of complication after application of plaster of Paris cast was interference by the dog (Hunt *et al.*, 1980).

The strength required to produce a minimal contractile response on the affected limb was at a higher level than the normal limb in all duration on the day of presentation. The observation was in agreement with that of Bowen (1978) that an increase in threshold might occur in normally innervated muscle when oedema was present.

By the end of first week the strength required to produce a minimal contractile response on the affected limb was relatively at a lower level than the threshold for normal limb. But it remained relatively at a higher level with marginal variation by second week in all duration. The strength required to produce a minimal contractile response showed marginal variation in all pulse duration than normal limb on third week.

Eventhough the strength required to produce a minimal contractile response showed marginal variation throughout the different pulse duration than normal limb, it was maintained at a higher level than the normal limb on sixth week. This was in agreement with the observation of Bowen (1978) that the marginal increase in threshold on sixth week was in agreement with the fact that the threshold will increase when the size and volume of a muscle have been reduced in disuse atrophy. Often trauma can disrupt normal anatomical relationship resulting in displacement of motor points which may result in apparent discrepancy in the threshold of symmetrical muscles. Hunt *et al.* (1980) observed that the problem associated with external fixation was fracture disease, characterised by atrophy of muscles, joint stiffness and osteoporosis when a limb was immobilized in a cast.

Summary

SUMMARY

The study was conducted in twelve selected clinical cases of fracture of tibia in dogs of either sex presented to the Department of Surgery. These animals were randomly divided into two groups (group I and group II) consisting of six animals each. All the animals were examined clinically and radiographically and observations were recorded. They were premedicated with Atropine sulphate (0.04 mg/kg body weight) intramuscular followed by xylazine hydrochloride (1 mg/kg body weight) intramuscular. The fracture was reduced by closed method in all the animals. The limb was immobilized by application of modified Thomas Splint in Group I and by application of plaster of Paris cast in Group II.

History and observations on clinical and physiological parameters, haemogram, serum constituents, radiography of the limb and electrodiagnostic procedures were recorded in all the animals on the day of presentation and at the end of first week, second week, third week and sixth week after immobilization. All the animals were kept under observation for a period of six weeks.

Though 30 per cent of the animals in each group started bearing weight on the affected limb by the end of first week, fracture instability and other associated symptoms persisted relatively more in animals of group I.

At the end of second week, the symptoms of fractures except oedema were found to be persisting in more number of animals belonging to group I due to mutilation of the Thomas splint.

By third week all the animals in group II could bear weight on the affected limb but limb dysfunction still persisted in fifty per cent of the animals in group I.

By the end of sixth week all the animals in both the groups showed apparently normal use of the limb.

Temperature, pulse rate and respiration rate showed variation within normal range during the period of observation in all the animals.

Haemoglobin concentration, packed cell volume, total erythrocyte count and lymphocyte count showed marginal increase on first week post fracture followed by a decrease thereafter in all the animals of both the groups. But neutrophil count showed a fall on the first week post fracture followed by a gradual increase in group I, but in group II it revealed a decrease in values throughout the period of observation. Eosinophil and monocyte count showed only marginal variations during the period of observation in both the groups.

Serum total protein showed a decrease till second week followed by an increase in group I but the variation was marginal in group II. Serum alkaline phosphatase showed an increase till second week followed by a decrease thereafter in both the groups. Serum aspartate amino transaminase values remained at a higher level in the post fracture period in group I but in group II it was relatively at a lower level.

Periosteal callus started developing near the fracture site along with reduction in soft tissue swelling and opacity of fragment ends in four animals in group I and two animals in group II by the end of first week. Five animals in group I and four animals in group II showed presence of massive periosteal callus by the end of third week and three animals in group II and two animals in group I showed presence of smooth and opaque periosteal callus with complete disappearance of fracture line by the end of sixth week.

Eventhough there was marginal increase in the strength required to produce minimal contractile response in the initial period after fracture reduction, by sixth week, the values were near normal at all the duration in both the groups.

From the results of the present study it could be concluded that

1. Plaster of Paris cast favoured the return of limb function and disappearance of the symptoms of fracture earlier than modified Thomas splint, in fracture of tibia.

2. Plaster of Paris cast and modified Thomas splint used in immobilisation of tibial fractures did not affect the haemogram and serum biochemical parameters and the healing in the two groups was comparable radiographically and clinically.

1. The strength required to produce a minimal contractile response in the muscle of the affected limb was near normal by the end of six weeks of immobilization in both the groups.

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MANAGEMENT OF TIBIAL FRACTURES IN DOGS USING PLASTER OF PARIS CAST AND MODIFIED THOMAS SPLINT

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ABSTRACT OF THE THESIS

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ABSTRACT

The study was undertaken with the objectives of

1. Assessing the healing process based on clinical symptoms, biochemical parameters and radiography of the affected part after immobilization of tibial fractures with plaster of Paris cast and modified Thomas splint.

2. Assessing the effect of electrodiagnostic procedures on healing of fracture of tibia in dogs.

The study was conducted in twelve selected clinical cases of fracture of tibia in dogs of either sex presented to the Department of Surgery. These animals were randomly divided into two groups (group I and group II) consisting of six animals each. All the animals were examined clinically and radiographically and observations were recorded. They were premedicated with Atropine sulphate (0.04 mg/kg body weight) intramuscular followed by xylazine hydrochloride (1 mg/kg body weight) intramuscular. The fracture was reduced by closed method in all the animals. The limb was immobilized by application of modified Thomas Splint in Group I and by application of plaster of Paris cast in Group II.

History and observations on clinical and physiological parameters, haemogram, serum constituents, radiography of the limb and electrodiagnostic procedures were recorded in all the animals on the day of presentation and at the end of first week, second week, third week and sixth week after immobilization. All the animals were kept under observation for a period of six weeks.

Though 30 per cent of the animals in each group started bearing weight on the affected limb by the end of first week, fracture instability and other associated symptoms persisted relatively more in animals of group I. At the end of second week, the symptoms of fractures except oedema were found to be persisting in more number of animals belonging to group I due to mutilation of the Thomas splint. By third week all the animals in group II could bear weight on the affected limb but limb dysfunction still persisted in fifty per cent of the animals in group I. By the end of sixth week all the animals in both the groups showed apparently normal use of the limb.

Temperature, pulse rate and respiration rate showed variation within normal range during the period of observation in all the animals.

Haemoglobin concentration, packed cell volume, total erythrocyte count and lymphocyte count showed marginal increase on first week post fracture followed by a decrease thereafter in all the animals of both the groups. But neutrophil count showed a fall on the first week post fracture followed by a gradual increase in group I, but in group II it revealed a decrease in values throughout the period of observation. Eosinophil and monocyte count showed only marginal variations during the period of observation in both the groups.

Serum total protein showed a decrease till second week followed by an increase in group I but the variation was marginal in group II. Serum alkaline phosphatase showed an increase till second week followed by a decrease thereafter in both the groups. Serum aspartate amino transaminase values remained at a higher level in the post fracture period in group I but in group II it was relatively at a lower level.

Periosteal callus started developing near the fracture site along with reduction in soft tissue swelling and opacity of fragment ends in four animals in group I and two animals in group II by the end of first week. Five animals in group I and four animals in group II showed presence of massive periosteal callus by the end of third week and three animals in group II and two animals in group I showed presence of smooth and opaque periosteal callus with complete disappearance of fracture line by the end of sixth week.

Eventhough there was marginal increase in the strength required to produce minimal contractile response in the initial period after fracture reduction, by sixth week, the values were near normal at all the duration in both the groups.