V. DISCUSSION

The present study was carried out to compare and evaluate the different configurations like Type 1b, Type 2 and Type 3 external skeletal fixators for radius fracture treatment in dogs. The results of the study are discussed as follows.

5.1 Occurrence

Among 29,803 cases which were presented to the Veterinary College Hospital during the study period of 20 months, 330 (1.10%) cases had long bone fracture. The 22.42 per cent of radial fractures accounted for 74 dogs out of 330 long bone fractures in dogs. Thilagar and Balasubramanian (1988) reported on incidence of 31.40 per cent of radius and ulna fracture. Similarly 29.41 per cent was recorded by Rani et al. (2004) in their study of 85 cases of fracture in dogs and Phillips (1979) recorded 17.3 per cent of radius and ulna fracture in dogs. There was not much difference in the incidence of radius and ulna fracture recorded by different authors compared to the present study, although slight variation observed may be due to variation in study periods.

The region within the radius that was found to be highly susceptible for fracture was distal third diaphyseal fracture (44.59%). Ozsoy and Altunatmaz (2003) reported in their study of six cases of radial fracture, three were at mid diaphysis and other three were at distal diaphysis. Similarly, Milovancev and Ralphs (2004) reported a higher incidence of radial fracture at diaphysis. The findings of present study were in accordance with that of Rani et al (2004) who also recorded a higher incidence of distal diaphyseal fracture (40%) of radius and ulna in dogs.
In the present study of the different types of radius fracture recorded, the highest being oblique fracture (51.36%), followed by transverse fracture (33.78%), incomplete fractures (6.76%), comminuted fractures (5.40%) and multiple (2.70%) fracture cases. The main force for an oblique fracture to occur was shear and compressive forces, for transverse fracture it was rotational and torsion forces as reported by Hulse and Hyman (2003). Whereas, in spiral and comminuted fractures the predominating forces were torsion and high energy forces respectively (Johnson and Hulse, 2002). Similar observations had been made earlier by Aithal et al. (1999) who reported the higher incidence of oblique fracture (50%) followed by transverse fracture (33.33%), comminuted fracture (20.61%), incomplete (4.55%) and other fractures (1.5%) of radius and ulna in dogs. However, Rani et al. (2004) recorded highest incidence of transverse fracture (45.88%) compared to oblique fractures (42.35%).

In the present study it was found that higher incidence of radius and ulna fracture was seen in animals with age group of 1 to 5 years (45.95%) followed by more than 6 to 12 months (18.92%), more than 5 years (13.51%), less than 3 months (12.16%) and more than 3 to 6 months (9.46%). Phillips (1979) recorded higher incidence of fractures in less than six months of age (28.60%). Aithal et al. (1999) reported higher incidence in young animals aged less than one year (54%), followed by age group of 1 - 3 years (35.52%), 6 - 12 months (20.40%), 3 - 6 months (18.64%), less than 3 months (14.60%) and above 3 years of age (10.83%). Similarly Rani et al (2004) reported the incidence of fracture which was more common in younger animals of less than one year of age (58.82%), again in that highest incidence was in animals of age group of 7 - 9 months (22.35%) followed by 4 - 6 months (16.47%).
Forty five (60.81%) dogs with radial fractures were males while 29 (39.19%) were females. The higher incidence in males may be because of preference of people to keep male dogs as companion animals than females. This finding was in accordance with that of Singh et al. (1983), where in they observed that males had higher incidence of fractures than females. Similarly Aithal et al. (1999) reported higher incidence in males (63%) compared to females (37%).

As per the breed wise distribution, the highest occurrence of the condition was seen in non-descript dogs (31.74%) followed by Spitz and German Shepherd (14.86%). The highest occurrence of the condition in non-descript dogs may be explained by the fact that most of them were maintained as semi domestic animals and most of the time they spent in streets where they are more likely to encounter external trauma. Aithal et al. (1999) and Rao et al. (1999) also reported the higher incidence of fracture in non-descript dogs compared to other breeds. But, Balagopalan et al. (1995) in their study had reported that, among the different breeds Alsatian recorded first (27.90%) followed by Doberman Pinscher (17.80%), non-descript dog (17.30%) and Pomeranians (15.40%).

Among the pure bred dogs, the higher incidence of radial fracture was seen in Spitz and German Shepherd dogs, which may be because of their popularity in and around the Bangalore. Balagopalan et al. (1995) and Rao et al. (1999) in their survey, among the pure breeds, German Shepherd showed first in radius fracture incidence. The lesser occurrence in other pure breeds could be due to, the fact that animals were mostly kept indoors or confined within the premises of the owner’s house.
5.2 Selection of cases for the study

Eighteen clinical cases of complete fractures of radius bone in dogs were randomly selected out of 74 cases and were divided into three groups viz. Group A, B and C each with six animals irrespective of age, breed and sex which were presented to the Veterinary College Hospital, Bangalore. In the present study, only the dogs having diaphyseal fracture were selected because it was found to be better for comparison of different types of external skeletal fixator. Similar types of fractures were selected for comparison of Acrylic and stainless steel external skeletal fixation for the radius fracture by Julie (2005).

5.3 Anamnesis

In the present study, automobile accidents (61.11%) appeared to be the most common cause of radial fracture in dogs compared to fall from height (16.67%). This was an acceptable finding since most of commonly affected dogs were non-descript native dogs which were more aggressive and maintained as semi domestic pets and hence had more chances of road traffic accidents. Dogs kept indoor met with automobile accidents only when they were let out and ran into streets. Present finding is in agreement with Ness and Armstrong (1995) who also reported that radius fractures were usually due to road accidents and also Rani et al. (2004) reported that highest incidence of radius fracture was due to automobile accidents (68.24%) compared to fall from height (31.76%). However, Aithal et al. (1999) and Rao et al. (1999) reported the most common cause for long bone fracture was fall from height (43.06% and 53.10% respectively) followed by road traffic accidents (22.66% and 34.69% respectively).
The duration of the fracture of different cases ranged from one to five days in the present study.

### 5.4 Selection of material

Schanz screws were used in dogs of all three groups (Group A, B and C) and in additional Denham pins were used in groups B and C as reported by several workers based on the experience (Nunamaker, 1985; Palmer et al., 1992; Egger, 1993; Gorse, 1998; Harari et al., 1998 and Pardeshi, 2007). They opined that a diameter of the screws should not exceed 20-30 per cent of diameter of the bone shaft. The pins thus selected were found to be tough enough to withstand the stress acting at fracture site. Ellis pins (negative profile) shields the relative weak threaded - shaft junction from bending forces by placing it within the medullary cavity as reported by Johnson and DeCamp (1999). The centrally threaded positive profile Denham pins were better than smooth pins as they reduced bone strain by increasing surface area between bone and fixator over which force can be transmitted as opined by Harari et al. (1998).

The clamps used in the present study were selected as per the suggestion of Johnson and DeCamp (1999) which suited the transfixation pins and the connecting bars. The connecting clamps used in the study were mechanically stiff and was in accordance with Gilley et al. (2001). In the present study stainless steel connecting bar were used which is in accordance with Julie (2005) and Pardeshi (2007).

### 5.5 External skeletal fixator configuration adopted

In the present study three types of external skeletal fixator configuration viz., Type1b, Type 2 and Type 3 were adopted. Egger et al. (1985) reported Type 1b ESF for
the treatment of long bone fracture in dogs and found more effective than Type II configuration. Similarly Gemmill et al. (2004) opined that Type 2a and Type 3 frames were not necessary in the majority of cases and also they opined that Type 1a frames were to be avoided in heavier patients. However, usefulness of Type 2 external skeletal fixation for radius fracture was reported by several authors (Nunamaker, 1985; Fox et al., 1995; Johnson et al., 1996 and Risselada et al., 2007). Harari et al. (1998) reported that Type III frame was more suitable for highly comminuted fractures with bone loss involving the radius and tibia. In the present study, Type 1b and 2 external fixators were used in medium sized dogs and type 3 in large breeds as reported by Harari et al. (1998).

For ideal clinical comparison and statistical evaluation of population subjected to different configurations of external skeletal fixator, the subjects of study should be from uniform populations with comparable physiological parameters.

5.6 Evaluation of the technique

5.6.1 Premedication and Anesthesia

The anesthetic protocol for the surgery included Xylazine as preanesthetic which produced good sedation and muscle relaxation. This was in accordance with Julie (2005) who used the same drug for premedication for the repair of long bone fracture in dogs. Pardeshi and Ranganath (2008) also used the same at the dose rate of 0.5 mg / kg body weight for tibial fracture repair in dogs. It was used safely as a preanesthetic during the course of this study.

A 2.5 per cent solution of Thiopentone sodium was administered intravenously for induction and maintenance of general anesthesia. The induction of surgical plane of
anesthesia was smooth. This confirmed the observations made by several workers (Ramesh Kumar et al., 2004, Singh et al., 2006, Fazili et al., 2008 and Pardeshi and Ranganath, 2008).

5.6.2 Reduction and retention of fracture fragments

In the present study, for achieving the required reduction of fracture fragments, closed as well as open methods were followed. Similar method was followed as described by Egger et al. (1985) and Julie (2005). But Gorse (1998) followed closed method for application of external fixator which preserved the vascular supply to the bone and soft tissues, minimized iatrogenic contamination at the fracture site and shortened the healing period. In the present study, open reduction was adopted in five cases, because in these cases overriding fracture on external manipulation could not reduced.

5.6.3 Positioning

All the dogs were positioned in dorsal recumbency on operation table with affected limb suspended to the drip stand, which helped to realign the fracture, stretch and fatigue the muscle. Similar method was adopted by Gorse (1998) and Corr (2005).

5.6.4 Application of external skeletal fixator

The safe corridor and landmarks employed for insertion of transfixation pins were based on the observations made by Marti and Miller (1994). The transfixation pins were inserted by making a nick incision on skin. Predrilling with power drill of low speed (150 rpm) using a drill bit having lesser diameter than that of pin, enhanced the application and firm fixation of pins. This is similar to the observations made earlier by several authors.
In the present study, half pins were drilled almost parallel to each other into the bone. Similar finding was reported by Risselada et al. (2007). Various authors reported different angles for insertion of pins into the bone. Carmichael (1991) and Harari et al. (1998) recommended insertion of pins at converging angles on each side of the fracture for better stability. But, Egger et al. (1985) recommended the pins to be placed at divergent angle of approximately 40° to each other in order to maintain a mechanical grip on the bone.

In the present study, centrally threaded pins were driven to the bone perpendicularly and parallel to each other as suggested by Risselada et al. (2007). In case of Type 2 external skeletal fixator, the smooth pins were introduced at a 30° angle to the bone surface to prevent the frame displacement due to pin loosening whereas, centrally threaded pins were placed perpendicular to the bone and parallel to one another for better stability. Type 3 external skeletal fixator was used in Group C animals as per the procedure described by Butterworth (1993). The procedure followed in all the animals was as per the guidelines suggested by Carmichael (1991) and Corr (2005).

5.7 Post-operative care

In the present study, the apparatus were checked daily and pin-skin interfaces were cleaned till the cessation of discharge and wound healing was seen. Similar findings were reported by many authors (VanEe and Geasling, 1992; Carmichael, 1991; Butterworth 1993; Anderson et al., 2002 and Canapp, 2004). The activity of dogs were
restricted and allowed for leash walking as suggested by McLaughlin and Roush (1999) to avoid stiffness of joint and it also stimulated fracture healing, bone remodeling and minimized fracture disease as opined by VanEe and Geasling (1992).

Systemically meloxicam and ceftriaxone sodium were administered to prevent post-operative inflammation and infection respectively. Mathews (2000) suggested the use of meloxicam post-operatively as an anti-inflammatory drug. The antibiotic protocol followed in the present study was satisfactory and it was in accordance with several authors (Harari et al., 1998; Ness, 2006 and Julie et al., 2007).

5.8 Post-operative evaluation

5.8.1 Clinical evaluation

5.8.1.1 Temperature, Respiratory rate, Heart rate and Pulse rate

In the present study, the mean temperature was elevated from first to third post-operative days which could be the manifestation of pyrexia and influenced by inflammatory conditions (Srinivasamurthy, 2000 and Pardeshi, 2007).

The respiratory rate, heart rate and pulse rate were elevated from first to second post-operative day which may be due to excitement, reparative inflammatory process occurring at the site of surgical wound and stress due to surgery (Aithal et al., 1998, Srinivasamurthy, 2000 and Pardeshi, 2007).

The rectal temperature, respiratory rate, heart rate and pulse rate were increased apparently during early post-operative days but they were statistically non significant. These results were with agreement with the findings of Julie (2005) but the author also
did not find any significant variation in physiological parameters. Chandy (2000) reported an increase in rectal temperature with local warmth of the affected region of limb which might be due to osteomyelitis. But in the present study, no such complications were observed.

5.8.2 Hematological studies

5.8.2.1 Hemoglobin (Hb) (g %)

The mean values of hemoglobin ranged from 10.43±0.44 to 11.63±0.48, 11.66±0.33 to 12.20±0.45 and 12.03±0.20 to 12.60±0.30 in Group A, B and C respectively during the study period. The values were within the normal range in all stages of different groups. This indicated that none of the dogs included in the study had any internal hemorrhage due to external trauma to cause significant reduction in the hemoglobin values and neither fracture nor the external skeletal fixation caused significant changes in hemoglobin values. This was similar to observations made by earlier by Pardeshi (2007) and Singh et al. (2008).

5.8.2.2 Packed Cell Volume (PCV) (%)

The mean values ranged from 39.50 ±0.34 to 42.83±0.40, 41.83±1.62 to 44.00±1.29 and 43.16±1.07 to 45.50±0.76 in Group A, B and C respectively. These values were within the normal range in all stages of different groups. This indicated that none of the dogs in the study had any internal hemorrhage due to external trauma to cause significant reduction in the packed cell volume values and neither fracture nor the external skeletal fixation caused significant changes in packed cell volume values. This corroborated with the findings recorded by Pardeshi (2007) and Singh et al. (2008).
5.8.2.3 Total Erythrocyte Count (TEC) (Millions / cmm)

The mean TEC values ranged from 5.25±0.30 to 5.91±0.79, 5.71±0.28 to 6.25±0.38 and 5.54±0.43 to 6.11±0.17 in Group A, B and C respectively during the study period. The values were within the normal range in all stages of different groups. This indicated that none of the dogs included in the study had any internal hemorrhage due to external trauma to cause significant reduction in total erythrocyte count values and neither fracture nor the type of external skeletal fixation caused significant changes in total erythrocyte count values. Similar findings were recorded by Julie (2005) and Pardeshi (2007).

5.8.2.4 Total Leukocyte Count (TLC) (Thousands / cmm)

The mean TLC values ranged from 11.42±0.28 to 12.98±0.61, 11.95±0.43 to 14.18±0.27 and 12.66±0.47 to 14.12±0.33 in Group A, B and C respectively during the study period. Even though there was no statistically significant difference (P≤0.05) in the values within the different stages of each group or between the stages of different groups. Leukocytosis was seen on first, second and third post-operative days in all the groups. These findings were in accordance with the results of Pardeshi (2007). This could be due to inflammatory process (Benjamin, 1998) and trauma at the site of surgery (Srinivasamurthy, 2000).

5.8.2.5 Differential Leukocyte Count (DLC) (%)

The mean neutrophil, lymphocyte, monocyte and eosinophil counts ranged from 69.50±0.50 to 73.00±0.25, 23.50±0.6 to 26.83±0.70, 2.33±0.33 to 3.33±0.42 and 0.66±0.33 to 1.50±0.34 respectively in Group A; 71.33±1.38 to 74.33±1.11, 22.00±0.51
to 25.66±1.80, 2.00±0.25 to 3.00±0.25 and 0.66±0.21 to 2.00±0.36 respectively in Group B and 69.66±0.42 to 73.16±0.40, 24.00±0.73 to 26.00±0.93, 1.83±0.30 to 3.00±0.51 and 0.66±0.33 to 2.00±0.44 respectively in Group C. There was no statistically significant difference ($P \leq 0.05$) in the mean values of the different cells in Group A, B and C during the study period. These findings were in accordance with the results of Julie (2005). However, in the present study, dogs of Group A, B and C showed apparent neutrophilia, lymphopaenia on first, second and third post-operative days. These changes observed post-operatively may be attributed to the response of the body to stress, inflammation (Benjamin, 1998) and trauma at the surgical site (Srinivasamurthy, 2000). Similar observations earlier reported by Pardeshi (2007). The monocyte and eosinophils were well in the normal range in all three groups in the study period. Similar findings were earlier reported by Pardeshi (2007).

5.8.3 Serum biochemistry

5.8.3.1 Calcium (mg / dl)

The mean values of calcium ranged from 10.12±0.21 to 10.98±0.25, 10.82±0.43 to 11.80±0.33 and 10.38±0.16 to 11.19±0.32 in Group A, B and C respectively during the study period. The values were found to be within the normal physiological range in all stages of Group A, B and C dogs. A statistically non significant difference ($P \leq 0.05$) in the values obtained between the different days of study in the same group and the same stages of different groups indicated that the fracture and the type of external skeletal fixation did not interfere with the serum calcium level in the blood. No significant variation in the serum calcium values during fracture healing had been observed by Singh
et al. (1976) and Chandy (2000). However, Kumar et al. (1992) reported a significant decline in plasma calcium during the healing period of 21 days in fractured dogs. There was no association between serum calcium and fractures stabilized with external skeletal fixation as reported by Pardeshi (2007).

5.8.3.2 Phosphorus (mg / dl)

The mean serum phosphorus values ranged from 3.49±0.28 to 3.76±0.32, 3.79±0.33 to 4.61±0.13 and 3.47±0.18 to 3.99±0.11 in Group A, B and C respectively during the study period. The values were found to be within the normal physiological range in all stages of Group A, B and C dogs. A statistically non significant difference (P≤0.05) in the values obtained between the different days of study in the same group and the same stages of different groups indicated that the fracture and the type of external skeletal fixation did not interfere with the serum phosphorus level in blood. No significant variation in the serum phosphorus values during fracture healing had been observed by Singh et al. (1976) and Chandy (2000). However, Kumar et al. (1992) reported a significant decline in serum phosphorus during the healing period of 21 days in fractured dogs. There was no association between serum phosphorus and fractures stabilized with ESF as reported by Pardeshi (2007).

5.8.3.3 Serum alkaline phosphatase (ALP) (IU / L)

The mean values of ALP ranged from 101.51±3.50 to 150.78±2.95, 97.48±1.90 to 148.46±1.91 and 99.86±2.92 to 144.57±1.83 in Group A, B and C respectively. The values did not show any statistically significant variation (P≤0.05) throughout the study period within each group. However, a non significant increase in values was observed in
the Group A, B and C till day 30 after which the values lowered towards the end of the study period. The values came to normal after 30th post-operative day because the stabilization provided by the fixation technique may have been helpful in achieving early healing of fractures. This finding was in accordance with Chandy (2000), Julie (2005), Pardeshi (2007) and Singh et al. (2008).

5.8.3.4 Serum aspartate aminotransferase (AST) (IU / L)

The mean values of serum aspartate aminotransferase ranged from 27.87±2.04 to 34.46±2.52, 37.45±3.13 to 44.10±3.70 and 37.80±1.83 to 42.41±1.31 in Group A, B and C respectively. The values were within the normal physiological range throughout the study period and there was no statistically significant difference (P≤0.05) between the values on different days of the same group or between the groups. However, in all the groups there was a non significant increase in serum aspartate aminotransferase level up to fifth post-operative day. The marked elevation in level could be attributed to muscle trauma at the surgical site caused by pin insertion as opined by Benoni et al. (1984) and Pardeshi (2007).

5.8.3.5 Serum alanine aminotransferase (ALT) (IU / L)

The mean values of serum alanine aminotransferase ranged from 39.05±3.33 to 54.20±6.79, 43.92±4.49 to 48.55±4.53 and 42.68±2.91 to 52.13±5.26 in Group A, B and C respectively during the study period. The values were within the normal physiological range throughout the study period and there was no statistically significant difference (P≤0.05) between the values on different days of the same group or between the different groups. This showed neither fracture nor the external skeletal fixation methods adopted
caused any change in the serum alanine aminotransferase values. Similar conclusions were made by Chandy (2006).

5.8.4 Radiological examination

5.8.4.1 Plain radiography

Survey radiographs of anterio-posterior and medio-lateral views of fractured limb was obtained to know the location and nature of fracture prior to surgery in all the dogs as suggested by Ness and Armstrong (1995).

The radiographs were taken immediately after surgery in all the dogs of Group A, B and C for evaluating reduction of the fractured fragments and proper fixation of the transfixation pins in the bone. Ross and Matthiesen (1993) recommended immediate post-operative radiographs for examination of fracture reduction, placement of pins and joint alignment. Similar opinion was put forth by Butterworth (1993), Johnson et al. (1996) and Pardeshi (2007).

Day 7

Radiographs taken at seventh post-operative day in all the three groups revealed the proper alignment and positioning of fracture segments. In the present study, the radiographs revealed the fracture gap and no callus at the fracture site in all the dogs of Group A, B and C. Since the callus at the fracture site may be of fibrocartilagenous in nature with low mineral content, the callus was not visible on radiography on early days of healing (Binnington, 1990). Similar observations were also noticed by Julie (2005) and Pardeshi (2007).
**Day 28**

In all the groups, the fixator frames were in position. Early signs of fracture healing **viz.** periosteal reaction around fracture, callus and primary bridging of a rigid stable fracture with woven bone were visible in animals of all the groups. Similar observations were noticed earlier by Roush and McLaughlin (1998), Mahendra et al. (2006) and Pardeshi (2007).

**Day 45**

Radiographs taken at 45th post-operative day revealed proper positioning of fixator frame in all the groups. In Group A, there was abundant and radiodense callus at the fracture site and also fracture line was seen delineated with bridging callus compared to Group B and C. Formation of intense periosteal callus could be due to instability at the fracture site during the injury or surgery (Toal and Mitchell, 2002). Johnson and Hulse (2002) opined that excessive periosteal callus was indicative of the fact that the fixation was not perfectly stable. But the stabilization and fracture fixation in the present study was satisfactory with early return of functional limb usage in all the dogs.

In Group B, moderate and radiodense callus completely filling the fracture line was seen. This complete filling was due to mineralization of the callus and delineation of fracture line with the bridging callus leading to clinical union. These findings were in accordance with Gul and Yanik (2006), Mahendra et al. (2006) and Pardeshi (2007).

In Group C, radiographs showed mild periosteal callus at the fracture site and fracture line was faint. Johnson et al. (1996) reported that fracture healing in case of
external skeletal fixator was mainly by endosteal callus and uniting callus formation with a minimal periosteal callus formation. In the present study, Type 3 fixation provided good rigidity for fracture healing, with mild periosteal callus and early remodeling of bone were noticed.

**Day 60**

Radiographs taken at 60\textsuperscript{th} post-operative day revealed proper positioning of fixator frame in all three groups. In Group A, the callus was denser and ends of the bone showed evidence of bone union.

In group B and C radiographs showed callus completely bridging the two fracture fragments. Johnson et al. (1996) observed only minimal callus in fractures healed under external fixator immobilization. Very rigid fixation led to minimal callus and rapid bone remodeling (Heim et al, 1992). In Group C dogs, Type 3 external skeletal fixators provided stable and rigid fixation promoting less callus and early healing. But in Group B and C radiographs were showing severe periosteal reaction all along the bone surface. Johnson et al. (1989) had reported periosteal reaction around the transfixation pins following external fixator application in their study.

**5.8.4.2 Osteomedullography**

In the present study, Iohexol was used as a contrast agent at the dose rate of 100 mg / kg body weight. Similar dose of Iohexol was used for study of tibial fracture healing in dogs (Umashankar and Ranganath, 2008). The procedure followed for
osteomedullography of radius in the present study was as described by the Singh et al. (2006).

In the present study, on day 0 osteomedullographs revealed outflow of contrast agent from medullary cavity at the fracture site without entering to the proximal fracture segment. This confirmed the complete fracture and there was no contact between proximal and distal marrow cavity in all the groups. The results matched with the results of Umashankar et al. (2007).

On day 7, osteomedullograms of radius in Group A, B and C dogs showed accumulation of contrast agent in the medullary cavity of distal fracture segment of the radius, which was due to absence of re-establishment of blood vessels at the fracture site as it was explained by Umashankar et al. (2007).

On days 28, 45 and 60 osteomedullograms showed pooling of the contrast agent at the point of injection into the medullary cavity and noticed more resistance while injecting contrast agent into the bone marrow. Fazili et al. (2006) reported that, in case of normal healing of fracture, an intra-osseous flow of contrast medium crossing fracture was seen within 10-12 weeks after an injury whereas Umashankar et al. (2007) observed the same at about 45th day after an injury. In the present study the contrast agent stasis in the distal segment or difficulty in injecting into the medullary cavity may be due to closure of marrow with the tissue around pins in the marrow cavity.
5.9 Weight bearing

In Group A, three dogs started bearing weight on the affected limbs on second and another three dogs on fourth post-operative day. In Group B and C dogs started bearing weight on either second or third post-operative day. This may be due to rigid stability of the fixation at the fracture site. These findings were in accordance with Ozsoy and Altunatmaz (2003). The grading of functional limb usage was as per the method suggested by Aron et al. (1991) and was found to be simple and efficient. The findings of the study concurred with the author.

5.10 Pain evaluation

There were many pain evaluation system used by various authors in their study (Firth and Haldane, 1999 and Mathews 2000). In the present study UMPS (University of Melbourne Pain Scale) for pain evaluation was followed in dogs developed by Firth and Haldane, (1999), which covered physiological data and behavioral responses and they concluded that the physiological and behavioral responses were reliable to evaluate degree of pain in dogs during post-operative period. But Conzemius et al. (1997) stated that, the physiological parameters including heart rate, respiratory rate, blood pressure and temperature were not consistent or reliable indicators of pain. However, Mathews (2000) graded pain in different levels in that, pain associated with the external skeletal fixation was graded as moderate.

In all the three groups higher pain score was recorded on day 0 which may be due to rise in physiological and behavioral changes, pain at the fracture site and tissue damage. On day 1 and 2 after immobilization with external skeletal fixation, the score
slightly declined compared to pre-operative level and on subsequent days it was much lower in all dogs of different groups. This may be due to reduced physiological and behavioral changes and rigid stabilization of fracture by external skeletal fixator. In all the groups no significant variation was noticed throughout the study period indicating that fixation frames were stable in all the dogs.

5.11 Implant evaluation

5.11.1 Apparatus stability

Stability of the apparatus is essential for early healing. In the present study pin loosening was observed on 45\textsuperscript{th} post-operative day in case no. 5 of Group A animal. This was supported by Whittick (1974) who also found that half pin splintage provided rigid fixation only for three to five weeks and thus necessitated the use of external coaptation when the pin loosened. But in the present study, on 45\textsuperscript{th} day the loosened pin was removed and the fixator left in place till the end of the study. None of the dogs with Type 2 and 3 fixator had pin loosening. However, Johnson et al. (1989) hypothesized that loosening of pins later in the healing period increased the forces across the fracture, thereby increased the stiffness of fracture.

5.11.2 Patient acceptance

There was no tissue reaction to the apparatus and patient acceptance was satisfactory throughout the observation period in all the cases.
5.11.3 Mutilation

No serious mutilation of implants by the animal was noticed but, one case in Group C showed tendency to lick the limb during first few days which later subsided. Animal may mutilate the implants if there was severe pain, itching or irritation. Harari et al. (1998) stated that patient discomfort occurred with loose pins.

5.11.4 Pin tract drainage

Mild pin tract drainage was observed in case no. 3 and 5 of Group A and case no. 2 and 5 Group of B dogs. But appreciable pin tract drainage was not noticed in any of the cases under study. However, drainage of serosanguinous fluid from the pin tracts during the immediate post-operative period was normal which later became thick leading to scab formation at the pin entry and exit points as observed by VanEe and Geasling (1992). All the four cases had pin tract drainage from the proximal pin tracts alone. According to VanEe and Geasling (1992) excessive drainage around a pin can occur due to large amount of muscle mass trying to move across the pin during ambulation.

5.12 Management of complication

5.12.1 Pin loosening

Many authors noticed pin loosening after application of ESF (Mathews et al. 1984; Piermatti and Flo, 1997; Rochat, 2001 and Ozsoy and Altunatmaz 2003). In a single case of Group A, the pin loosening was noticed on 45th day of study period. Nevertheless, by that time there was an appreciable fracture healing, clinically and radiographically.
The loosening did not affect the fracture stability. On 45th day, destabilization of fixator was carried out and the loosened pin was removed.

5.12.2 Pin tract drainage

In the present study, in case no. 3 and 5 of Group A and case no. 2 and 5 of Group B dogs pin tract drainage was noticed. Sequin et al. (1997) reported that pin tract infection was most frequently seen in ESF. Infusion of povidone iodine through the pin tracts prevented pin tract infection in animals. Gemmill et al. (2004) reported that in case of Type II b frames, pin loosening was more likely to affect the full pins rather than half pins. Carneiro et al. (2001) found that both 0.2% iodine and 0.9% normal saline solution were equally efficient in the post surgical treatment of bone percutaneous transfixation in dogs.

5.13 Removal of fixator frame

The fixator frame was completely removed in all the dogs by the end of the 8th week based on radiographic evaluation of clinical union of fracture in the present study. Similar schedule was followed by Kraus et al. (1998), where as Risselada et al. (2007) removed external skeletal fixator after radiographical healing of fracture which occurred at an average of 45 days post-operatively. A wide variation on the time for fixator removal had been followed by many authors. The mean time for fixator removal noticed by Johnson et al. (1989) was at 10th week, Johnson et al. (1996) was at 14.7 weeks, Harari et al. (1998), Johnson and DeCamp (1999) at 6 weeks and Julie et al. (2007) at 6 weeks.
Dogs were sedated for removal of fixator frame and it was convenient and well tolerated by animals as observed by VanEe and Geasling (1992). In the present study, pins were removed with ease by power drill but Harari et al. (1998) used Jacobs chuck for removal of threaded and non threaded pins.

Staged disassembly of the external skeletal fixation was done on sixth week to allow gradual loading of the healing bone on the similar lines of other workers (Aron et al., 1991; VanEe and Geasling, 1992; Anderson and Aron 1998; Harari et al. 1998; Johnson and DeCamp, 1999; Lauer et al., 2003 and Canapp, 2004).