III. MATERIALS AND METHODS

The present study was carried out in eighteen clinical cases of dogs with radial fracture presented to Veterinary College Hospital, KVAFSU, Hebbal, Bangalore irrespective of age, breed and sex. Dogs presented with lameness were subjected for thorough clinical examination and type of fracture of radius was diagnosed and confirmed by radiography.

3.1 Occurrence

Occurrence of radius fracture with reference to age, breed and sex was studied among the dogs presented to the Veterinary College Hospital, Bangalore for a period of 20 months (October 2007 to May 2009).

3.2 Grouping of animals

The eighteen clinical cases of dogs with radius fracture were divided randomly into three groups of six animals each viz., Group A, Group B and Group C.

Group A

The radial fracture was reduced and immobilized with Type 1b External Skeletal Fixator (Plate 1).

Group B

The radial fracture was reduced and immobilized with Type 2 External Skeletal Fixator (Plate 2).
Group C

The radial fracture was reduced and immobilized with Type 3 External Skeletal Fixator (Plate 3).

3.3 Case history: In each case, the signalment, anamnesis and symptoms noticed by the owner were recorded.

3.4 Pre-operative considerations: Preoperatively all the animals were subjected for thorough physical examination and life threatening injuries if any were attended. All the animals were prepared by withholding food for 12 hours and water for four hours prior to the surgery either by admitting as inpatient or by suitable instruction to the patient owner.

3.4.1 Physical examination: Animals under the study were evaluated by their general clinical condition, functional limb usage and pain at the fracture site.

3.4.2 Clinical examination

The physiological parameters viz., Rectal Temperature (°F), Respiratory rate (per minute), Heart rate (per minute) and Pulse rate (per minute) were recorded.

3.4.3 Hematological study

All the dogs were subjected for hematological examination viz., Haemoglobin (g%), Packed Cell Volume (%), Total erythrocyte (millions / cmm), Total leucocyte count (thousands / cmm) and Differential leucocyte count (%).
Plate 1: Type 1b external skeletal fixator (Group A)

Plate 2: Type 2 external skeletal fixator (Group B)

Plate 3: Type 3 external skeletal fixator (Group C)
3.4.4 Serum biochemistry

All the dogs were subjected for biochemical evaluation viz., Serum calcium (mg/dl), Serum phosphorus (mg/dl), Serum alkaline phosphatase (ALP) (IU/L), Serum aspartate aminotransferase (AST) (IU/L) and Serum alanine aminotransferase (ALT) (IU/L).

3.4.5 Radiographic examination

After localizing the lesion by physical examination, the dogs were subjected to survey radiography.

3.4.5.1 Plain radiography

Both medio-lateral and anterio-posterior radiographs of the fracture limb were taken including the joints proximal and distal to the bone involved. Radiographs were studied and the fracture configuration and displacement if any, were recorded.

3.4.5.2 Osteomedullography

Contrast radiography of intraosseous structure by injecting Omnipaque-300\(^1\) into the bone marrow of distal fragment to assess the status of fracture healing was performed.

3.5 Surgical procedure

3.5.1 Surgical instruments and materials used for surgery

BP blade No. 11, general surgical instruments, a battery operated power drill\(^2\) with drill bits of different diameters, wrench, transfixation pins of different diameters, Denham

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\(^1\) Omnipaque-300 - Iohexol, 50ml, Nyacomend, Ireland Ltd., Cork, Ireland
\(^2\) Electrix(India) Ltd., Peenya Ind. Area, Bangalore
pins of different diameters, universal clamps, stainless steel connecting bars, pin cutter, Iohexol inj and spinal needle were used for the study (Plate 4 to Plate 12).

3.5.2 Pre-operative preparation

All the patients were fasted for 12 hours and water was withheld for four hours prior to surgery. Ceftriaxone\(^1\) at the dose rate of 20 mg / kg body weight was administered intravenously prior to surgery.

3.5.3 Pre-operative surgical site

The skin was shaved completely by including the joints above and below the surgical site. The antebrachium was scrubbed with povidone iodine solution. The vascular access was retained throughout the surgery by maintaining intravenous infusion with Ringer’s lactate solution to the dogs.

3.5.3 Anaesthesia

Surgery was performed under general anaesthesia. The dogs were premedicated with Atropine sulphate\(^2\) at the dose rate of 0.04 mg / kg body weight subcutaneously and after 10 minutes, Xylazine HCl\(^3\) was given intravenously at the dose rate of 0.5 mg / kg body weight. After 10 minutes, anaesthesia was induced and maintained with 2.5 per cent Thiopentone sodium\(^4\) at the dose rate of 25 mg / kg body weight intravenously given to effect.

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\(^1\) Ceftriaxone Sodium- Intacef injection, 500 mg vial, Intas Pharmaceuticals Ltd., Ahmedabad-380009
\(^2\) Atropine sulphate injection IP. (0.6mg / ml), Harson Laboratories, Akota, Baroda – 20
\(^3\) Xylazine HCl- Xylaxin injection 30 ml vial, Indian Immunologicals Ltd., (20 mg / ml), Guntur dist., Andhra Pradesh
\(^4\) Thiopentone sodium -Thiosol sodium injection, 500 mg, Neon Laboratories Ltd., Mumbai – 93
Plate 4: Battery operated power drill

Plate 5: Different sizes of drill bits

Plate 6: Transfixation pins (Schanz screws)
Plate 7: Centrally threaded pins (Denham pins)

Plate 8: Connecting clamps (Universal clamps)

Plate 9: Stainless steel connecting bars
Plate 10: Contrast agent (Omnipaque injection)

Plate 11: Wrench and Spinal needle

Plate 12: Pin cutter
3.5.4 Position of the dogs for surgery

Animal was positioned on the surgical table after anaesthesia. The animal was restrained on dorsal recumbency with affected limb hung with extension by fixing the manus with bandage sling to the drip stand, as it helped to realign the fracture and to stretch and fatigue the muscles. The limb was completely covered with sterile drape exposing the surgical site. The site was painted with Povidone Iodine (Plate 13 to Plate 14).

3.5.5 Surgical techniques

The fracture was reduced to normal alignment and apposition by open and closed approach. The open approach was followed in animals which had over riding fractures and were reduced before application of external skeletal fixator. Open reduction through medial incision was attempted directly over the fracture site. By applying traction and toggling, the fractured ends were reduced to normal alignment and apposition. In case of open approach the fracture was reduced to normal alignment and apposition by external manipulation following traction of the affected limb.

The fixation pins were driven through the safe corridors of the respective bone fragments most proximally and distally using electrical bone drill after making small nick incision on the skin. The nick incision was widened using a mosquito halsted artery forceps. A minimum of two fixation pins were drilled through each segment of the bone. The tips of the fixation pins were made to project beyond the transcortex and approximately to a length of two threads in case of Schanz screw. Care was taken to ensure that all pins entering bone penetrated both the cortices completely. Wherever half pins were used, the tip of the pins penetrating the opposite cortex was judged by
Plate 13: Preparation of site for surgery

Plate 14: Suspending of limb to the drip stand “Hanging limb”
feeling the tip at the opposite cortex. This was also determined by the resistance offered by the tissue to the drilling which gave an idea about the extent of penetration. Low speed, high torque power drill (150 to 400rpm) was used to drill the pins and the drilling site was irrigated with normal saline to minimize thermal injury.

The most proximal and distal pins were placed first. Then the clamps, corresponding in number to the number of pins to be used in the framework, were connected to the connecting bar. This frame was then applied to the bone by connecting the clamps at either end of the connecting bar to the pins at either end of the bone already drilled. These clamps were tightened taking care that the fractured fragments were in correct alignment and apposition. The remaining pins were applied sequentially, guided through the clamps in the connecting bar and drilled through the bone. All the clamps were then tightened with a wrench. The excess length of the connecting bar was cut using pin cutter.

3.5.6 Application of linear external skeletal fixators for radius fracture.

3.5.6.1 Application of Type 1b external skeletal fixator (Group A)

The Type 1b configuration consisted of two linear half pins fixator fixed to the bone in cranio-lateral and cranio-medial positions less than 90° angle. The first Fixator frame was placed on the cranio-medial aspect with proximal and distal most pin first and remaining pins driven after fixing the connecting bar. A single connecting bar with required numbers of connecting clamps was attached keeping a distance of one cm from the skin. A second frame was placed similarly in cranio-lateral aspect of bone with an angle of 60° to the first frame. The two frames were connected with small articulating
bars with double connecting clamps. Two articular bars were connected, one was connected at the proximal most transfixation pin and the other at distal most transfixation pin of both frames (Plate 15 to Plate 17).

3.5.6.2 Application of Type 2 external skeletal fixator (Group B)

In case of Type 2 configuration, two full pins were placed in the proximal and distal aspects of fractured bone in defined safe corridors. The pins were passed through both the cortices and the soft tissues on either side of bone. Connecting bars were attached to these fixation pins on the medial and lateral aspect of the limb. The connecting bars were preloaded with required number of connecting clamps. The remaining pins were inserted through the clamps. All the clamps were then tightened with the wrench. The excess length of the connecting bar was either cut using pin cutter (Plate 18 to Plate 20).

3.5.6.3 Application of Type 3 external skeletal fixator (Group C)

Type 3 external skeletal fixator is a combination of Type 1 and Type 2 external skeletal fixators. Initially, two full pins were placed in the proximal and distal aspects of fractured bone in defined safe corridors. The pins were passed through both the cortices and the soft tissues on either side of the bone. Connecting bars were attached to these fixation pins on the medial and lateral aspect of the limb. The connecting bars were preloaded with required number of connecting clamps. Remaining pins were inserted through the clamps. All the clamps were then tightened with the wrench. After that two transfixation pins were driven through cranial border of the bone into proximal and distal fragments and these were connected by a connecting bar with preloaded clamps. Remaining pins were inserted to complete Type 1 frame. Finally these frames were
Plate 15: Group A- Insertion of proximal, distal pins in cranio-medial aspect of radius and application of connecting bar

Plate 16: Group A- Insertion of third and fourth pins, followed by insertion of proximal and distal pins in cranio-lateral to the radius

Plate 17: Group A- Insertion of third and fourth pins, finally application of articulating bars
Plate 18: Group B- Insertion of proximal and distal pins (centrally threaded pins)

Plate 19: Group B- Application of connecting bars on either side and insertion of second pin into proximal and distal segments of bone

Plate 20: Group B- Insertion of third pin into proximal and distal segments of bone
connected proximally and distally with extra clamps and rods in the triangle fashion (Plate 21 to Plate 26).

3.6 Post-operative care

Ceftriaxone sodium was used at the rate of 20 mg/kg body weight as intravenous injection on the day of surgery and on the subsequent days for seven days. Systemic administration of Meloxicam\(^1\) was done at the rate of 0.3 mg / kg body weight for three days post-operatively.

The tip of transfixation pins was covered with adhesive tape. Entire implants and the pin entry points were covered with sterile gauze and secured with adhesive tape.

Owners were advised to restrict the movement of the animal for two weeks after surgery and then allow for leash walk.

3.7 Post-operative evaluation

3.7.1 Clinical examination

Clinical parameters, rectal temperature (\(^{\circ}\)F) pulse (per minute), heart rate (per minute) and respiratory rate (per minute) were recorded days 1, 2, 3, 5, 7, 15, 30, 45 and 60 post-operatively.

3.7.2 Hematological study

For the hematological evaluation two ml of blood was collected in lavender top tubes containing EDTA. Blood samples were collected on days 1, 2, 3, 5, 7, 15, 30, 45

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\(^1\) Meloxicam- Melonex inj, Intas Pharmaceuticals Ltd., Ahmedabad-380009
Plate 21: Group C- Insertion of proximal and distal pins

Plate 22: Group C- Application of connecting bars on either side

Plate 23: Group C- Insertion of second pins into proximal and distal segments of bone
Plate 24: Group C- Insertion of third pin into proximal and distal segments of bone

Plate 25: Group C- Insertion of proximal and distal pin anterior to the bone and after application of connecting bar, insertion of second pins in the proximal and distal segment

Plate 26: Group C- Application of articulating bars to connecting bars
and 60 to study the hematological parameters. Total erythrocyte and leukocyte count were estimated as per the procedures described by the Schalm et al. (1975). For the differential leukocyte count, blood smears were prepared by using Giemsa stain and 100 cells were counted using Battlement method and percentage was obtained. Haemoglobin was estimated using Sahli’s haemoglobinometer (Superior Inc., Germany).

### 3.7.3 Serum biochemistry

Two ml of blood sample was collected in red top tubes and allowed to clot in room temperature for serum separation on days 1, 2, 3, 5, 7, 15, 30, 45 and 60 for the estimation of calcium, phosphorus, alkaline phosphatase (ALP), aspartate aminotransferase (AST) and alanine aminotransferase (ALT). The calcium, phosphorus, ALP, AST and ALT were estimated by using ARTOS biochemical analyzer (M/S Swemed diagnostics, Bangalore) using respective diagnostic kit as per manufactures’ instructions.

### 3.7.4 Radiographic evaluation

Plain anterior-posterior and lateral view radiographs were taken. Radiographs were analysed and the fracture configuration and displacement if any, were recorded. Survey radiograph of were done before surgery and immediately after surgery and on 7, 28, 45 and 60 days of treatment. From the immediate postoperative radiograph, the four A’s i.e., Alignment of fragments, Apposition of fragments, Angulation between fragments and Apparatus were assessed. From the postoperative radiograph six A’s i.e., Alignment of fragments, Apposition of fragments, Angulation between fragments, Apparatus, Activity and Architecture at fracture site were assessed.
3.7.5 Osteomedullography

Osteomedullogram was obtained by injecting a contrast agent, Omnipaque at the dose rate of 100mg / kg body weight into the marrow cavity at the medial side of distal fragment of radius after application of tourniquet above the elbow joint. Radiograph was taken at the last phase of injection. The procedure was carried out on 7, 28, 45 and 60 days of treatment (Plate 27 to Plate 32).

3.7.6 Pain evaluation

The fracture site and the pin entry points were gently palpated. The response of the animal to different levels of pain was measured according to University of Melbourne Pain Scale (Firth and Haldane, 1999) on days 0, 1, 2, 3, 5, 7, 15, 30, 45 and 60 after surgery as follows.

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<th>Category</th>
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</tr>
<tr>
<td>a) with in reference range</td>
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</tr>
<tr>
<td>b) percentage increase in heart rate</td>
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</tr>
<tr>
<td>&gt;20%</td>
<td>1</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>2</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>3</td>
</tr>
<tr>
<td>c) percentage increase in respiratory</td>
<td></td>
</tr>
<tr>
<td>&gt;20%</td>
<td>1</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>2</td>
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<tr>
<td>&gt;100%</td>
<td>3</td>
</tr>
<tr>
<td>2. Response to palpation</td>
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<tr>
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<td>0</td>
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<tr>
<td>Guards when touched</td>
<td>2</td>
</tr>
<tr>
<td>Guards before touched</td>
<td>3</td>
</tr>
<tr>
<td>3. Activity</td>
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<tr>
<td>Awake</td>
<td>1</td>
</tr>
<tr>
<td>Restless</td>
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Plate 27: Animal in lateral recumbency showing medial aspect of the radius

Plate 28: Site of skin incision

Plate 29: Pre-drilling bone with needle
Plate 30: Insertion of bent spinal needle into medullary cavity

Plate 31: Injection of normal saline into the medullary cavity

Plate 32: Injection of contrast agent into the medullary cavity
4. Mental status

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<td>Wary</td>
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<tr>
<td>Aggressive</td>
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5. Posture

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<tr>
<td>Sternal recumbency / sitting</td>
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</tr>
<tr>
<td>Abnormal poster/guarding protected area</td>
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</tbody>
</table>

6. Vocalization

<table>
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<tr>
<td>Vocalizing when touched</td>
<td>2</td>
</tr>
<tr>
<td>Continuous vocalization</td>
<td>3</td>
</tr>
</tbody>
</table>

3.7.7 Weight bearing

Weight bearing was assessed and graded as excellent (E), good (G), fair (F) or poor (P) as suggested by Aron et al. (1991) on days 0, 1, 2, 3, 5, 7, 15, 30, 45 and 60 after surgery.

3.8 Implant evaluation

3.8.1 Apparatus stability

The stability of the fixator to maintain the necessary mechanical configuration during treatment was judged by gross observation and detailed physical examination. The external frame was checked for loosening of the fixation pins and for breakage of transfixation pins. Loosening of pins was judged by gently moving the pins laterally.

3.8.2 Patient acceptance

The acceptance of the external fixator by the patients was studied based on tissue reactions and graded as satisfactory or unsatisfactory.
3.8.3 Mutilation

Based on the clinical observation and the history collected from the owner, the incidence of mutilation of the external frame was assessed throughout the observation period.

3.8.4 Pin tract drainage

The pin entry and exit points were inspected for any discharge from the pin tracts and classified as serous or pus discharge.

3.9 Removal of the implants

The implants were removed after complete fracture healing by eight weeks after fixation, confirmed by clinical and radiological evaluation. To remove the implants, animals were sedated with Xylazine hydrochloride at the rate of 1 mg / kg body weight after premedication with atropine sulphate at the rate of 0.04 mg / kg body weight, both given intramuscularly. Transfixation pins were removed by unscrewing them out of the bone (Plate 33 to Plate 34).

3.10 Statistical analysis

The data obtained with respect to hematology, biochemistry and pain score were subjected to statistical analysis by two way ANOVA with the help of computer based statistical programme (Graph Pad Prism) and interpreted as per the procedure described by Snedecor and Cochran (1996) to arrive at a conclusion.
Plate 33: Loosening of clamps with wrench

Plate 34: Removal of pins with power drill