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Management of femur fracture with intramedullary pinning and external skeletal fixator tied-in configuration in dogs

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Abstract
Eight dogs irrespective of type of complete fracture of femur presented to Department of veterinary surgery and radiology, VCC, RIVER, Puducherry was taken for the study. Anamnesis and animal particulars were documented. Pre-operative clinical and radiographic evaluation was done. Physiological and Haematological parameters were recorded. All the dogs were anaesthetized and the fractures were stabilized with IM+ESF tied-in configuration technique. Povidone iodine impregnated gauze was placed in pin-skin interface and the entire implant was protected with crepe bandage. Post-operatively, clinical, radiological, assessment of weight bearing, neurological status, pain evaluation and implant evaluation was done. Implant removal was done based upon fracture healing by clinical and radiographic union.

Keywords: Femur fracture, tied-in configuration, dog

Introduction
Femur is the most frequently fractured long bone in dogs comprising almost half of all long bone fractures [7]. Femoral fractures are often related to trauma due to severe impact from automobile accidents and jump from a height. Most of the femur fractures are unstable, and are also closed fractures because of the abundant overlying muscle, unless caused by penetrating injury such as gunshot wound [5]. There are many methods for fixation of long bone fractures in dogs like intramedullary (IM) pinning, bone plating, interlocking nailing etc. [8]. The main concept of fracture treatment is to achieve the fastest possible healing and enable the patient to use the affected limb for walking early [27]. IM pinning is commonly used for management of femur fracture. These pins have unique biomechanical advantage of resisting bending forces applied from any direction because of their round structure [11]. ESF further provide versatile rigid fixation, avoid metal implants at the fracture site, allow easy access to the injured area for wound management and is easily removed after healing is complete [31]. Failure to withstand the shear forces in oblique fracture, torsion forces in all type of fractures and axial compression forces in oblique and comminuted fracture could be effectively resisted when IM pinning was used in conjunction with ESF. The IM pin is easy to place and resists bending force equally well in all directions because of its proximity to the neutral axis of the bone; however, alone it poorly stabilizes the disruptive forces of shear, torsion and compression. In contrast, the ESF is best able to resist the forces of shear, torsion and compression but poorly resists bending forces [28].

Materials and Methods
Eight dogs with complete femur fracture with the history of trauma and non-weight bearing on the affected limb were taken for the present study. Signalment including breed, age, sex, weight, limb involved and etiology were recorded. Confirmatory diagnosis and AO/ASIF classification of fractures were made by pre-operative cranio-caudal and medio-lateral radiographs (Table 1). On the day of presentation, crepe bandaging with medial splint was done till the date of surgery. Cortex to cortex ratio at is thumus region of bone was measured from radiographs to access medullary cavity diameter.

Whole blood was collected. Dogs were fasted 12 hours prior to surgery. On the day of surgery, animals were pre-medicated with Inj. Atropine sulphate[i] @ 0.04 mg per kg body weight and Inj. Xylazine hydrochloride[b] @ 1 mg/kg body weight administered intravenously. Induction and maintenance were done by administering Inj. Ketamine hydrochloride[c] @ 5 mg/ kg body weight intravenously and Inj. Diazepam[ii] @ 0.2 mg/ kg body weight intravenously. A skin incision was made along the cranio-lateral aspect of the femur (Fig 1a). Retrograde IM pinning was done (Fig 1b). ESF was placed in the distal aspect of fractured bone, in the defined safe corridors in cranio-caudal direction (Fig 1c). The pins were passed through both the cortices and the soft tissues on either side of bone. The connecting Steinmann pins were attached to IM pin and ESF on the cranial and caudal aspect of the limb. The connecting pins were preloaded with required number of connecting clamps. The remaining pins were inserted through the clamps. All the clamps were then tightened with a wrench. The excess length of the pins was cut using a pin cutter and IM+ESF tie-in configuration frame was stabilized (Fig 2a). Muscle layers were sutured with absorbable polyglactin 910 size 0 with interlovking suture pattern (Fig 2b). Skin was closed using disposable stainless- steel skin staples (Fig 2c). The diameter of pins was determined by pre-operative radiographs, weight of the dog and intraoperative assessment. Pin that filled 30% medullary cavity was selected. Post-operatively the dogs were administered with Oral administration of Tab. Amoxycillin and Potassium Clavulanate[iii] (20 mg/ kg body weight), Tab. Meloxicam[f] @ 0.1 mg/kg body weight, and multi vitamin syrup were advised for six more days postoperatively. The pin entry points were covered sterile gauge impregnated with povidone iodine solution and the entire implant was protected using a crepe bandage until complete removal of theESF. Restricted movement was advised for first two weeks of surgery followed by leash walking for the following weeks until healing was confirmed radiographically. Skin staples were removed after 10-15 days of surgery.

Post-operatively recovery was determined by radiographic and clinical assessment at suitable intervals. Immediate post-operative radiographs and radiographs taken at 2nd, 4th, 8th week and after removal were evaluated for fracture reduction, implant position, complication related to bone or implant failure and bone healing. Healing was considered complete when callus was radiographically visible. Weight bearing was assessed and graded using the four-scale lameness grading system which included 1- No functional limb usage; limb carried most of the time, 2-Slight functional limb usage; limb carried during running but set down when walking, 3-Moderate functional limb usage and partial weight bearing; lameness evident, 4Complete, normal functional limb usage. (Harari *et al*. 1996). Neurological status, Pain evaluation and pain evaluation was done on 3, 7, 15, 30 and 42 post-operative days after surgery.

Result and discussion

In the present study, a total of 8 cases of canine femoral fractures were stabilized with IM+ESF tiedin configuration of which one oblique fracture was additionally stabilized with orthopaedic wiring. Higher incidence of femur fracture was found in female (75%) as compared to male (25%) with a mean age of 1 year and 8 months (5 months to 6 years) and mean body weight of 10.2 kgs (5 to 14 kgs) (Table 1). Higher incidence in younger dogs might be due to the fact that they might become nervous or excited on seeing motor vehicles therefore more prone to accident [14]. All the animals affected were mongrel breed (100%) and automobile accident (87.5%) contributed the most common aetiology of femoral fracture in dogs. The incidence of fracture in mongrel dogs might be due to their higher population size, being let loose and their wandering nature [30]. Mean time since fracture to presentation of animal to the hospital was 2.5 days with a range of 1 to 3 days (Table 2). Left limb was found most commonly affected (75%) as compared to right limb (25%). Among the type of fractures, Diaphyseal transverse (87.5%) fracture were more common followed by oblique fracture (12.5%) [1] (Table 3). Pre-medication with Inj. Atropine sulphate @ 0.04mg/kg body weight and Inj. Xylazine @ 1mg/kg body weight, induction and maintenance with combination of Inj. Ketamine @ 5 mg/kg and Inj. Xylazine @ 1mg/kg and Inj. Diazepam @ 0.2 mg/kg body weight administered intravenously when needed was found to be satisfactory in all dogs for surgical intervention [13]. For fracture reduction with Intramedullary pinning, cranio-lateral aspect provides satisfactory exposure to fracture site with minimal soft tissue and vascular trauma [20]. Retrograde pinning method was found to be easy to apply and satisfactory in maintaining the anatomical alignment of the fracture fragments following reduction and counteracting the bending forces of nature [10]. ESF was inserted in distal end of the femur in defined safe corridors [16] in cranio-caudal direction. In this study, IM pin was left protruding through the skin was tied-in with ESF using conventional orthopaedic clamps and was found to be satisfactory in stabilizing the frame. The tied-in construct was found to be rigid and stable in all the dogs and offered rotational stability in all dogs [22]. Intramedullary pin was found to be 1/3rd (30-35%) of the diameter of medullary cavity of the bone and was found to be satisfactory [29] and mean value of IM pin diameter was 2.3 mm (2 to 3mm). ESF used was found to be 1/3rd (30-35%) of the medullary cavity of the bone and was found to be satisfactory [9] and the mean value of ESF pin diameter was 2.3 mm (2 to 3 mm). Mini orthopaedic clamps (Jezz clamps) was used as linkage device in connecting IM pin to ESF to stabilize the IM+ESF tied-in configuration frame and was found to be satisfactory and found to be lesser in weight and maintains the rigidity of the fixator (Table 4). Soft padded bandage was applied around the fixator for the removal of drainage around the pins, to protect the surgical wound and to prevent self-mutilation and this method gives satisfactory result [3]. The entire implant was protected with crepe bandage until the removal of fixator [4]. Pinskin interface was cleaned with povidone iodine each time when the bandage was changed and this prevented infection in pin-skin interface in all the dogs [4]. Post-operatively oral administration of Tab. Amoxicillin and potassium clavulanate @ 20 mg/kg and tab. Meloxicam @ 0.1 mg/kg body weight for 7 days provided satisfactory results [6, 23]. In this study, partial weight bearing was noticed on the operated limb from day 7 in six cases and day 28 in two cases (Table 5). Early limb usage in the present study might be attributed to mechanical stability of the fracture provided by rigidity of tied-in fixation [18]. On pain evaluation as per Melbourne pain scale, higher pain score was recorded on day 0, which might be due to rise in physiological and behavioural changes, pain at the fracture site and soft tissue injury. On day 42, it was much lower in all dogs which might be due to rigid stabilization of fracture by implant [19]. Evaluation of immediate post-operative radiograph revealed 70-80% alignment of the fixator and apposition of the fracture site [23]. On 2nd week, post-operative radiograph revealed endosteal and periosteal callus formation, mild periosteal reaction, with fading fracture gap except in one case where no callus formation was noticed [33]. On 4th week, bridging callus was noticed with good alignment of the fracture and pin in position and smooth mineralizing callus formation (fig 4a) noticed [15]. On 8th week, progressive healing of the fracture site with endosteal and periosteal callus formation, progressive gap reduction, with fracture line disappeared and showed restitution of cortico-medullary continuity with adequate radio-density was noticed (Fig 4b). This is indicative of secondary healing with hard callus formation[2]. The clamps were checked and tightened at regular intervals to ensure constant stability of the tied-in configuration frame throughout the study period [17]. Granulation tissue around the intramedullary pin-skin interface was noticed in all cases [24]. Tissue acceptance was graded as satisfactory as there was no tissue reaction to the apparatus in all cases [25]. Mild serosanguinous discharge was noticed in all cases during the initial post-operative period for 5 to 7 days [32] and by the end of 2nd week scab formation was noticed in pin-skin interface [33]. IM+ESF tied-in configuration was removed on 8th week based on clinical and radiographical union of the fracture site [23].

Table 1: Animal Particulars

Case no.	Breed	Age	Sex	Body weight
1	Mongrel breed	4 months	F	5 kgs
2	Mongrel breed	18 months	F	13 kgs
3	Mongrel breed	8 months	F	14 kgs
4	Mongrel breed	6 years	F	11 kgs
5	Mongrel breed	3 years	M	14 kgs
6	Mongrel breed	5 months	F	6 kgs
7	Mongrel breed	14 months	F	12 kgs
8	Mongrel breed	7 months	M	7 kgs

Table 2: Anamnesis

Case no.	Etiology	Duration of Lameness	Previous injury or orthopaedic disease	History of systemic disease and medications undertaken
1	Automobile accident	3 days	Nil	Nil
2	Automobile accident	2 days	Nil	Nil
3	Automobile accident	1 day	Nil	Nil
4	Fall from height	3 days	Nil	Nil
5	Automobile accident	3 days	Nil	Nil
6	Automobile accident	2 days	Nil	Nil
7	Automobile accident	3 days	Nil	Nil
8	Automobile accident	3 days	Nil	Nil

Table 3: Pre-operative Radiographic examination

Case no.	Bone Affected (R/L)	Type of fracture	AO Classification
1	Femur (R)	Transverse	32A3
2	Femur (L)	Transverse	32A3
3	Femur (L)	Transverse	32A3
4	Femur (L)	Transverse	32A3
5	Femur (L)	Oblique	32A2
6	Femur (L)	Transverse	32A3
7	Femur (R)	Transverse	32A3
8	Femur (L)	Transverse	32A3

Table 4: Details of bone and implant diameter

Case no.	Bone involved	Diameter of Medullary cavity (mm)	Intramedullary pin diameter (mm)	External Skeletal Fixator diameter (mm)	Stainless Steel Connecting Clamps size
1	Femur (R)	6.5	2.0	2.0	Small
2	Femur (L)	8	2.5	2.5	Medium
3	Femur (L)	10	3.0	3.0	Medium
4	Femur (L)	8	2.5	2.5	Medium
5	Femur (L)	6.5	2	2	Small
6	Femur (L)	8	2.5	2.5	Medium
7	Femur (R)	8	2.5	2.5	Medium
8	Femur (L)	6.5	2	2	Small

Table 5: Post-operative Weight bearing (Lameness scoring as per Harari *et al*., 1996)

Animal no.	1 week	2 weeks	4 weeks	6 weeks	Full weight bearing
1	2	2	3	4	After removal
2	2	2	3	4	After removal
3	2	2	3	4	After removal
4	1	1	2	3	7 days after removal
5	2	2	3	4	After removal
6	2	2	3	4	After removal

7	1	1	2	3	7 days after removal
8	2	2	3	4	After removal

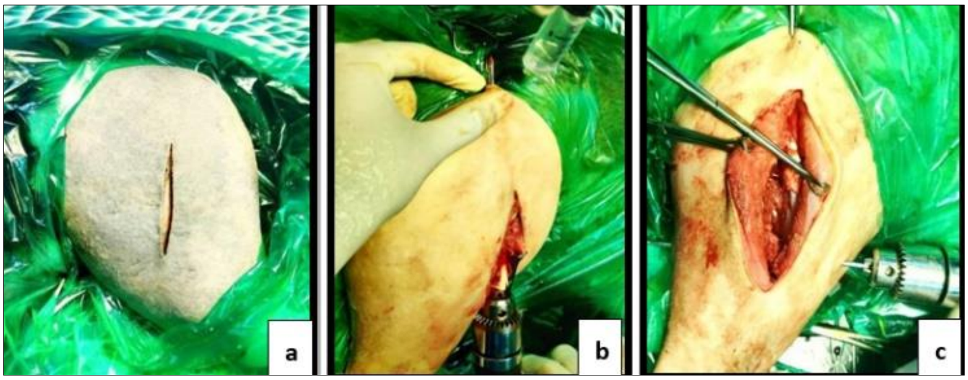

Fig 1: a) Cranio-lateral incision of femur b) Retrograde IM pinning c) ESF application

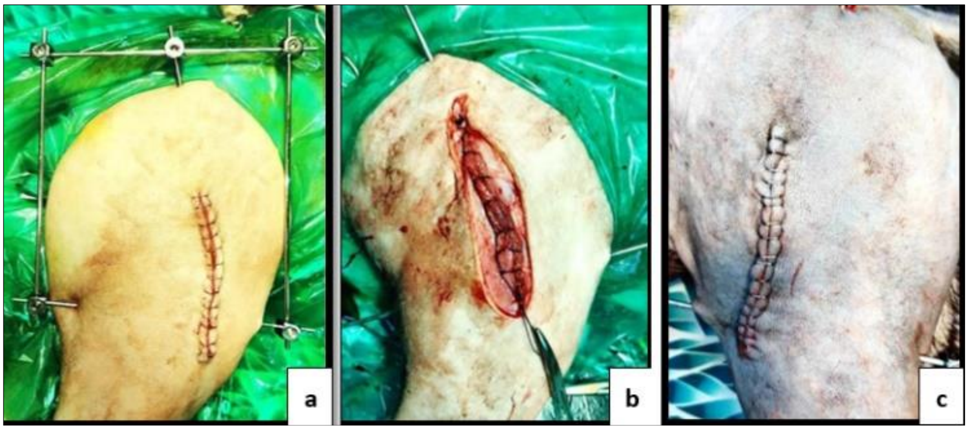

Fig 2: a) IM+ESF tied-in configuration b) Muscle suturing c) Skin stapling.

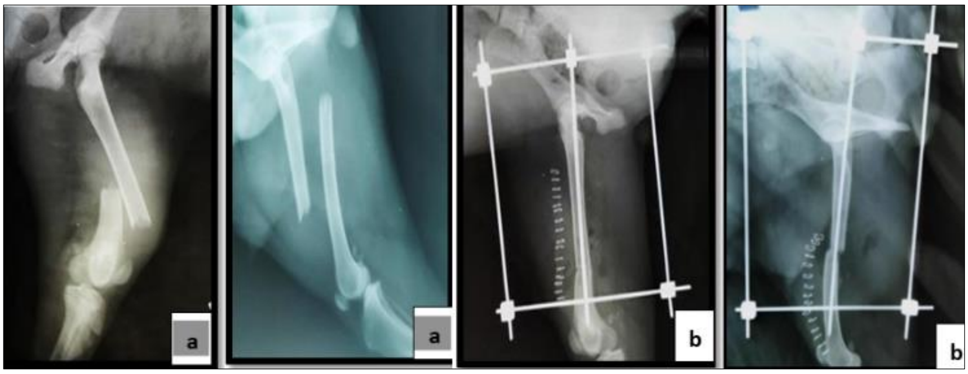

Fig 3: a) Pre-operative radiograph b) Immediate post-operative radiograph with IM+ESF tied-in configuration

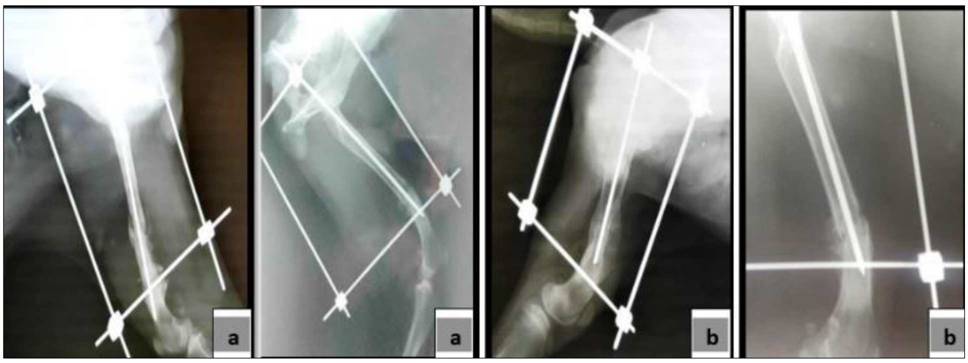

Fig 4: a) 4th week b) 8th week medio-lateral radiographs showing sequence of fracture healing

Fig 5: a) Complete bone union of femur fracture b) complete weight bearing noticed

Conclusion

Femoral shaft fracture can be treated satisfactorily with IM+ESF tied-in configuration technique and was found to be most economical and less time consuming and less invasive as compared to plating techniques and premature loosening of the IM could be prevented when tied-in with ESF. Early return to function observed in the study reduced the chance of fracture disease and encourages callus formation. The tied-in construct was found to be rigid and stable in all the dogs and offered stability against bending, shearing, compression and rotational forces irrespective of type of fracture in all dogs and tissue acceptance was graded as satisfactory. Sometimes, willingness of the owner for simple technique was the important considerations while selecting this technique.

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