Management of Segmental Fractures of Tibia and Femur by Static Intramedullary Interlocking Nailing in Twelve Dogs

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ABSTRACT

The objective of the study was to evaluate the suitability of static intramedullary interlocking nailing for stabilization of segmental tibial and femoral fractures in dogs. In the study period between 2002 to 2012, a total of 216 cases of long bone fractures were stabilized with static intramedullary interlocking nailing of which 12 fractures with 8 tibial and 4 femoral were segmental type with two level fracture lines having intact/split intercalary segment. In 8 fractures the intercalary segment was intact tubular, in one there was incomplete longitudinal split in the intercalary segment and in 3 cases the intercalary segment was having complete longitudinal split. Along with static intramedullary interlocking nailing, in eight cases adjunctive stabilization with full cerclage wiring was done. A rapid return of function was noted in all the cases by 10th post operative day with complete fracture union in 11 cases with variable healing times for proximal and distal fracture lines. Out of three open fractures, one resulted in non union.

INTRODUCTION

Segmental fracture is a fracture of long bone at two levels, with the intermediate fragment having an intact tubular or split structure and usually caused by high-energy trauma and is associated with severe soft-tissue injuries[1,2]. Presently no comprehensive classification and management of such type of long bone fractures has been reported in veterinary literature and only a scarce literature of retrospective nature on the management of such fractures of humerus, femur and tibia have been encountered in human medicine[3,2,4,5,6]. Due to high instability, severe

associated soft-tissue injuries and disruption of periosteal and intramedullary vascularity from the fractured ends, the management of segmental fractures remain challenging. The stability offered by most implants is compromised, when the intermediate fragment is split or either level of the fracture is comminuted[2]. The use of plate to achieve osteosynthesis of segmental fractures necessitates a wide operative exposure and extensive stripping of soft tissues, resulting in increased loss of blood and a longer operating time and also failure of the plate to hold fractured fragments is common due to its eccentric position[7,8]. Interlocking nails are an alternative to bone plates, which because of intramedullary position makes them more resistant to compressive, torsional and bending forces and requires a relatively simple surgical approach as compared to bone plate, making it more suitable for achieving early union in the devitalized fractures[9]. The aim

Table 1. *Signalment of the cases*

Case no.	Breed	Age (mths.)	Wt (kg)	Sex	Bone involved	Etiology	Fracture configuration
1.	Labrador	60	27.5	F	Left tibia	Automobile accident	Complete tubular intercalary segment with a incomplete split and one bone chip at distal fracture line
2.	Sheep dog	5	18	F	Right femur	Abuse	Complete tubular intercalary segment
3.	German Shepherd	24	10	M	Left femur	Fall from height	Complete split of intercalary segment
4.	Cocker Spaniel	30	10	F	Right femur	Fall from height	Complete tubular intercalary segment and also splits in proximal and distal main fragments
5.	Labrador	66	25	M	Left tibia	Automobile accident	Complete split of intercalary segment and also split in proximal and distal fragments, few irreducible wedges at distal line
6.	Labrador	36	30	M	Left tibia	Automobile accident	Complete tubular intercalary segment
7.	Saint Bernard	9	27.5	M	Left tibia	Fall from height	Complete tubular intercalary segment
8.	American Eskimo	144	7	M	Left tibia	Automobile accident	Complete tubular intercalary segment
9.	German Shepherd	12	30	M	Left femur	Automobile accident	Complete split of intercalary segment
10.	Sheep dog	72	25	M	Left tibia	Automobile accident	Complete tubular intercalary segment
11.	Labrador	60	22	M	Left tibia	Automobile accident	Complete tubular intercalary segment
12.	German Shepherd	32	20	F	Left tibia	Automobile accident	Complete tubular intercalary segment

***Table 2**. Intraoperative findings and post-operative evaluation*

Case no.	Implant used	Earliest weight bearing post surgery (days)	First sign of periosteal reaction	Complete radiographic union (weeks)	Limb function	Clinical outcome
1.	7-14-1-3 2 FCW[a]	3	2nd week	16	Complete	Excellent
2.	8-14-1-2	3	2nd week	12	Complete	Excellent
3.	8-16-2-1 FCW	5	2nd week	12	Complete	Excellent
4.	8-14-2-1 FCW	4	2nd week	12	Complete	Excellent
5.	7-16-2-2 3 FCW	3	3rd week	8	Complete	Excellent
6.	6-16-2-1 3 FCW	5	2nd week	8	Complete	Excellent
7.	7-18-3-2	3	2nd week	14	Complete	Excellent
8.	6-12-1-1 2 FCW	3	2nd week	Non union up to 24 weeks	Partial weight bearing	Osteomy-elitis
9.	8-16-2-1 6 FCW	2	2nd week	16	Complete	Excellent
10.	8-14-1-2 1 FCW	3	4th week	8	Complete	Excellent
11.	7-16-2-2	3	2nd week	12	Complete	Excellent
12.	6-14-2-1	3	2nd week	12	Complete	Excellent

[a] 7 (Diameter of the nail in mm), 14 (Length of the nail in cm), 1 (Number of proximal interlocking screws), 3 (number of distal interlocking screws), FCW (Number of full cerclage wiring).

of this study is to report the management of segmental fractures of tibia and femur with interlocking nail fixation in dogs presented during the period 2002-2012.

MATERIALS AND METHODS

The study included 4 femoral and 8 tibial segmental fractures during 2002-2012 period in dogs which were stabilized with static intramedullary interlocking nailing. All cases were presented with history of trauma and non weight bearing lameness on the affected limb. Signalment including breed, sex, age, weight, bone and limb involved and etiology were recorded (Table 1). Tentative diagnosis was made by palpation of the bone involved. Confirmation was made by radiography of the involved bone in mediolateral and craniocaudal views to assess the location and type of fracture. Dogs were administered pre-operative analgesics and were supported with modified Robert Jone's bandage till the date of surgery. The dogs were preanaesthesized with a combination of butorphanol @ 0.2 mg/kg, acepromazine @ 0.05 mg/kg and glycopyrolate @ 0.01 mg/kg. Anaesthesia was induced with 5% thiopentone @ 10 mg/kg and maintained by Isoflurane inhalation anaesthesia (1-2%). Open method of fracture repair with standard surgical approach to bones was performed using the external aiming device[10]. The diameter and length of nails were determined by pre-operative radiographs, size and weight of the dog and intraoperative assessment. Largest nail that fitted into the medullary cavity was selected. Nails varying from 6 mm to 8 mm diameter, having 4 proximal and 4 distal holes and lengths ranging from 12 cm to 18 cm were used (Table 2). After appropriate reduc-

Figure 1. *Pre operative craniocaudal radiograph of Dog 6 revealing segmental fracture with intact tubular intercalary segment.*

Figure 2. *Pre operative mediolateral radiograph of Dog 1 revealing segmental fracture with incomplete longitudinal split in intercalary segment.*

tion of proximal, intermediate and distal fragments nail was locked with cortical screws. Ancillary support with full cerclage wiring was provided with minimum disturbance to the soft tissue attachments in fractures where the major bone fragments and intercalary segments had fissures or splits in their longitudinal axis. Intraoperative findings like fracture configuration, displacement and overriding of bone fragments, extent of bone loss, extent of soft tissue damage, adhesions of soft tissue to bone, ease of fracture reduction were recorded.

Post-operatively, the operated limb was given external support in the form of modified Robert Jone's bandage with antiseptic dressing of the suture line which was changed on alternate days for 2 weeks. Post-operatively, the animals were administered antibiotics and analgesics for 7 and 3 days respectively. The clients were advised to restrict the activity of the animal for first 2 weeks and later dogs were allowed leash walk. Post-operative recovery was assessed by regular telephonic contact with the clients and by radiographic and clinical examination at suitable intervals (Table 2). The dogs were evaluated for extent of weight bearing (complete, partial and non weight bearing) while standing, walking, running and extent of limb usage. The radiographs taken immediately after surgery and subsequently at monthly intervals were evaluated for fracture reduction, implant position, complications due to implant failure, time taken for initiation of callus formation and time taken for complete bone healing. Healing was considered complete when the callus was radiographically visible in two views at both the fracture levels.

RESULTS

In the study period of 10 years, a total of 216 cases of canine long bone fractures were stabilized with intramedullary interlocking nailing of which 12 cases (8 tibia and 4 femur) fulfilled the inclusion criteria of this study (5.5%). Out of twelve cases, 8 were male and 4 were female dogs with an average age of four years and average body

weight of 21 kgs. In majority of the cases, the etiology of fracture was automobile accident (n=8) followed by fall from height (n=3). Out of 12, nine were closed and three were open fractures involving 8 tibial and 4 femoral bones. The intercalary segment was intact tubular in 8 cases (Fig. 1) and an incomplete longitudinal split of intercalary segment was seen in one case (Fig. 2). In three dogs, the intercalary segment was with complete longitudinal split dividing the segment into two halves (Fig. 3). Longitudinal splits were also found in both the proximal and distal fragments in two cases. Open fracture reduction was done and in 10 out of 12 cases, the reduction of fracture fragments was difficult owing to displaced intercalary segments and overriding of the fragments. After fracture reduction, 8 mm diameter nails were used in five dogs, 7 mm in four dogs and 6 mm in three dogs. Static intramedullary interlocking nailing was done in all the cases and in majority of the cases (n=9) the intercalary segment was stabilized by passing over the snuggly fitting interlocking nail without disturbing the soft tissue attachments and in rest of two cases, as the proximal fracture line was within the range of four proximal locking holes of the interlocking nail, the intercalary segment was also locked along with the main proximal and distal fracture segments. In 8 cases, additional stabilization with full cerclage wire was done to reduce the longitudinal splits.

Immediate post operative radiographs revealed anatomical reduction, good cortical contact and stable implant in all the cases. The suture line healed normally without any complications and sutures were removed on 12 - 14th post operative day. In all the cases partial weight bearing was noticed by 3rd-5th post operative day and nearly complete weight bearing by 10th post operative day with near normal ambulation and limb function. The 10th to 15th day post operative radiographs showed stable implant and evidence of periosteal reaction at the fracture sites. There was no evidence of axial rotation or compression at either of the fracture lines in all the cases. In dog 5, the

Figure 3. *Pre operative mediolateral radiograph of Dog 3 revealing segmental fracture with complete longitudinal split in intercalary segment.*

30th post operative day radiograph revealed a broken full cerclage wire and bent first proximal interlocking screw, with no effect on the fracture stability or limb function. In rest of the dogs no implant related complications were observed. The average follow up period of all the cases was about 24 weeks and complete fracture healing was considered when both the fracture lines healed and the intercalary segment was incorporated in the bony column. The average complete radiographic union time of both the fracture lines was 10.5 weeks in eight cases and 15.3 weeks in three cases. In all the eleven cases in which complete fracture union was achieved (Fig.4, 5 and 6), the initiation and completion of fracture healing was observed at different time intervals for proximal and distal fracture lines (Fig. 7). In dog 8 with

Figure 4. *(a) Pre operative, (b) immediate and (c) 12 weeks post operative mediolateral radiographs of Dog 4 showing sequence of fracture healing.*

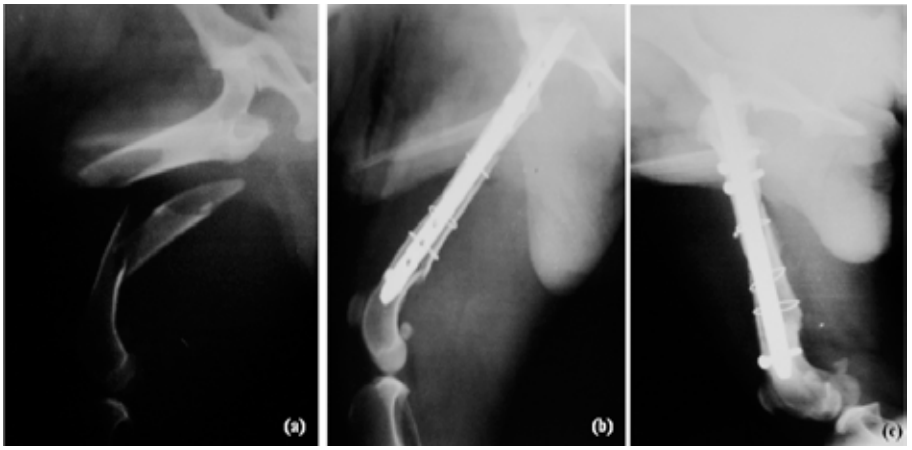


Figure 5.*(a) Pre operative, (b) immediate and (c) 16 weeks post operative mediolateral radiographs of Dog 9 showing sequence of fracture healing.*

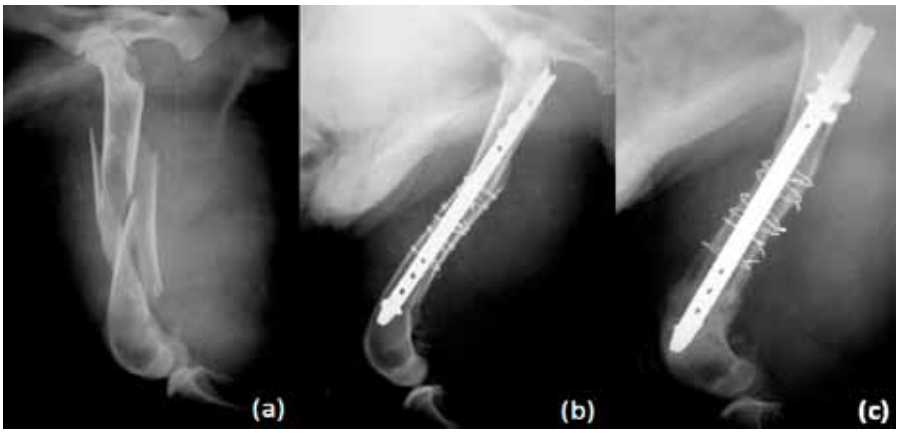


Figure.6. *(a) Pre operative and (b) 16 weeks post operative mediolateral radiographs of Dog 1 showing complete fracture healing of segmental tibial fracture.*

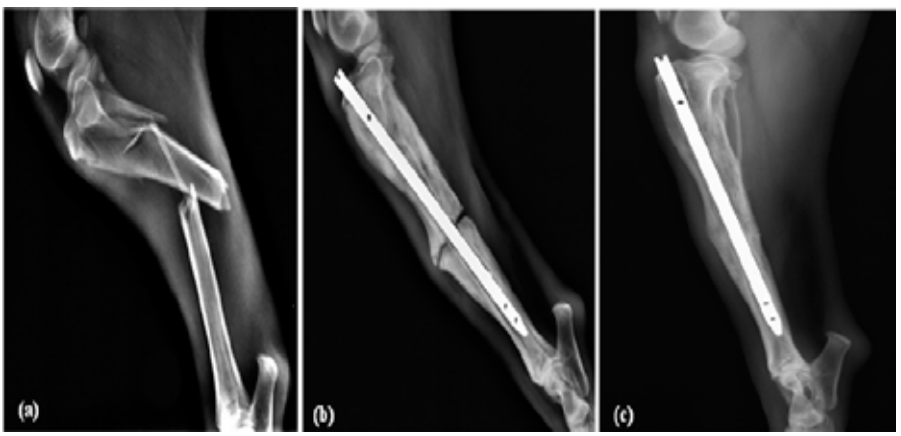
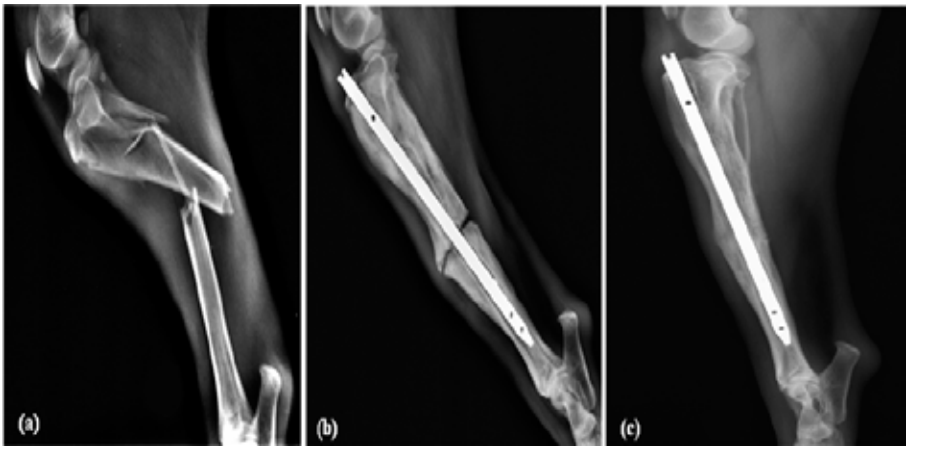


Figure 7. *(a) Pre operative, (b) 8 weeks and (c) 14 weeks post operative mediolateral radiographs of Dog 7 showing initial fracture healing of proximal fracture line followed by distal fracture line.*



compound segmental tibial fracture, the follow up radiographs revealed signs of osteomyelitis with draining tract on the medial aspect of tibia. The dog was treated with broad spectrum antibiotics based on culture sensitivity examination, but the radiographs taken at 24 weeks follow up period revealed severe bone lysis and bone loss at the mid diaphyseal region exposing the implant (Fig. 8) and the dog showed partial weight bearing. In rest of the dogs, there was no rotational deformity, limb shortening or gait abnormality and the final clinical outcome was graded as excellent with complete weight bearing while standing and walking (Fig.9)

DISCUSSION

Long bone segmental fractures are considered as a separate clinical entity from the normal fracture for a number of reasons as they are caused by high-energy trauma, and are frequently associated with severe soft tissue injuries, are part of multiple injuries, most of them are open, have a high complication rate, prognosis is often poor and may need more than one surgical intervention[1]. In the present study of dogs such fractures were recorded in femur and tibia of which tibial fractures had higher incidence with high energy trauma as etiology in all the cases. Severely comminuted or segmental fractures treated non-operatively using closed reduction and splinting may predispose to an unsatisfactory outcome as bone distraction and loss of fracture reduction could lead to delayed or non-union of the fracture[11,12]. Such highly unstable and vascular compromised segmental fractures require implants which could resist all the forces acting on the bone and at the same time preserving its vascularity intact. Intramedullary pinning provides axial alignment and resists bending forces but not the shear and rotational forces[13]. Bone plating resists tension, compression, shearing and rotational forces, and depending upon their placement resist bending forces[14]. However, it requires extensive soft tissue exposure and periosteal stripping15 thus disrupting the local biological substrate of the fracture. Fogerty et al[3] (2009) recorded a high non-union rate of 27.2%, 23.5% and 50% in segmental humeral fractures in humans stabilized by non-operative closed reduction, plate fixation and intramedullary pinning, respectively. Less surgical exposure and dissection is needed to place intramedullary interlocking nails compared to placement of bone plates. Therefore, the use of intramedullary interlocking nailing may result in preservation of more periosteal vascularity[16] promoting biological osteosynthesis[17]. Closed locking nailing has been reported to yield satisfactory results for

Figure 8. *(a) Immediate and (b) 24 weeks post operative mediolateral radiographs of Dog 8 showing non-union of tibial fracture with severe bone loss at diaphysis.*

humeral, femoral and tibial segmental fractures in humans with a union rate of above 90% and with a low risk of problems such as mal-union, delayed or non-union and infection[3,2,4,5,6]. In the present study, interlocking nailing of segmental fractures of femur and tibia by open reduction method using external aiming device yielded 92% union rate with a mean fracture union time of 12 weeks without any post operative soft tissue healing complication. Also, the use of the aiming device eliminates the harmful effect of an increased dose of radiation with the image intensifier to both orthopaedic surgeon and the patient[18]. It also ensures high quality fracture care and has the added advantage of reduced cost[19] to the animal owner. In previous studies of segmental fractures in humans a variable time of union of proximal and distal fracture lines have been found, in which one site of the segmental fracture went on to union but the other site did not. Melis et al[20] (1981) reported a slower fracture healing of the distal fracture in 38 segmental tibial fractures treated with a reamed unlocked intramedullary nail, while Merianos et al[21] (1988) reported no difference in union rate in 22 cases treated with Ender nails. Huang et al[5] (1997) and Wu and Chen4 (1997) found that in segmental fractures of tibia and femur repaired by interlocking nails the distal fracture united 3 weeks to 3 months earlier than the proximal one. Similar variation in the initiation and completion of fracture healing for proximal and distal lines has been found in the present study. This can be attributed to compromised biology or biomechanics of attempted simultaneous healing in two sites[3].

Dueland et al[22] (1999) used a range of 6mm to 8mm diameter interlocking nails for fixation of diaphyseal long bone fractures in 126 dogs with a high success rate. Similar range of snuggly fitting nails were used in our study, with good implant stability and due to which all the dogs showed early partial weight bearing within 1st week post operatively, with complete weight bearing at the end of the 2nd post operative week. Static interlocking nail acts as load bearer which is responsible for load transfer across the fracture defect in highly unstable fractures thus allowing early weight bearing and limb function[23,24]. Out of 3 compound fractures, one progressed to non-union. Open fractures associated with severe soft tissue injury have a less favourable biological environment, which may delay healing or may lead to non union[25]. Eleven out of 12 segmental fractures healed completely with cortical and medullary continuity. Similar outcome with interlocking nailing in comminuted long bone fractures was reported in earlier studies[26].

In conclusion, long bone segmental fractures are very rare complicated fractures in dogs which if stabilized by static intramedullary interlocking nailing after complete anatomical reconstruction can lead to satisfactory clinical outcome.

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