



Designing and clinical application of caps for intramedullary pinning to manage long bone fracture in dogs

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ABSTRACT

Study was carried out to design and evaluate clinical application of caps for intramedullary pinning to manage long bone fractures in dogs. Cannulated cancellous caps made of 316 L stainless steel with dimensions of 10 mm × 25 mm (length) cap for 4 mm, 4.5 mm and 5 mm steinmann pin and 8 mm × 25 mm (length) cap for 2.5 mm and 3 mm steinmann pin were designed. A total of 14 cases of dogs presented with simple transverse, short oblique fractures of long bones were equally divided into groups A and B having 7 animals in each. Simple intramedullary pinning was done in group A, whereas, in group B designed caps were fixed at entry point at trochanteric fossa after intramedullary pinning to prevent proximal migration of pins. Posture, gait, perception of pain and lameness scores were assessed during 15, 30 and 60 day, postoperatively. Caps offered rigid fixation along with intramedullary pin resulting in mild or moderate callus formation. Excellent postoperative functional recovery without any pin migration, seroma formation and valgus limb deformity were observed in group B. Results of present preliminary study suggested that designed capped intramedullary pinning offers stable internal fixation and prevented pin migration, sciatic injury and seroma formation.

Keywords: Cap, Dog, Fracture, Intramedullary pinning

Intramedullary pinning (IMP) remains as one of the most popular internal fixation techniques in small animal orthopaedics for the management of long bone fractures (Ozsoy 2004). Intramedullary pin acts fundamentally as interior support of medullary canal of long bone that shares weight bearing with bones maintaining axial alignment of the fracture fragments and counteracting bending forces (Beale 2004). Potential complications reported with this technique were like pin migration (Libardoni *et al.* 2018), seroma formation (Vannini *et al.* 1988), sciatic injury (Palmer 1988), damage to intra-articular structures (Howard 1991), angular limb deformities and epiphyseal trauma in young dogs (Black and Withrow 1979). The effectiveness of orthopedic plates and interlocking nailing fixation to prevent rotation is well established. However, the high cost of bone plates, interlocking nails, and expertise required limits their routine use in veterinary orthopedics at field level. Keeping in view these considerations, the study was envisaged with objective to design and evaluate clinical application of caps for intramedullary pinning to manage long bone fractures in dogs. As per authors knowledge this is first of its kind study where a cap is used to prevent pin migration for fracture management of dogs.

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MATERIALS AND METHODS

Self-tapping cannulated cancellous 316 L stainless steel caps were designed to accommodate assorted size intramedullary (IM) pins. These designed cannulated cancellous caps provide support to the IM pin at the point of insertion after normograde pinning. These caps were fully cannulated and had cancellous threading for hold in cancellous bone. Caps with internal cannulation diameter of 3.1 mm and 5.2 mm were designed, to hold pins of 3 mm and 5 mm diameter, respectively. Caps were provided with hexagonal head top and sharp chisel ends at bottom to facilitate insertion during application (Table 1, Fig. 1).

Pre clinically, the novel technique was standardized by a cadaveric study using sheep tibia. Suitable size intramedullary pin was passed into appropriate length of bone using Jacob's chuck. Intramedullary (IM) was slightly withdrawn more than the length of non cannulated portion of screw (8 mm) and was cut at that point using hexagonal screw driver. Thereafter, designed screw was placed over cut end portion of pin as cap and inserted using hexagonal screw driver (Fig. 1).

Fourteen clinical cases of dogs presented at the referral polyclinic, ICAR-IVRI, Izatnagar with simple transverse /short oblique fractures of femur and tibia were included in the study. The cases were randomly divided into two groups A and B having at least seven animals

Table 1. Different dimensions of cannulated cancellous caps

Cap	Major diameter (mm)	Minor diameter (mm)	Thread depth (mm)	Length (mm)	Internal cannulation (mm)	Cannulation depth (mm)	Corresponding size pin size (mm) used (mm)
8	8	6	1	25	3.2	17	2.5 and 3
10	10	8	1	25	5.2	17	4, 4.5 and 5

in each. Simple intramedullary pinning was done in group A, whereas in group B designed caps were applied along with intramedullary pin to prevent pin migration (Fig. 2). Preoperative data including signalment, etiology, prior treatment given (if any) and time elapsed between occurrence to presentation were recorded. A thorough clinical examination was for each animal. Physiological parameters, soft tissue status, perception of pain, posture, gait and lameness were recorded. Pre-operative radiographs were taken in two views to classify fractures.

All dogs were injected with atropine sulphate (Atropine sulphate, Hindustan pharmaceuticals, Barauni, India) at a dose rate of 0.04 mg/kg body weight IM followed by intravenous infusion of butorphanol (Butrum-1, Aristo Pharmaceuticals Pvt. Ltd., Raisen, India) at a dose rate of 0.05 mg/kg body weight and diazepam (Calmpose, Ranbaxy Laboratory limited, Baddi, Himachal Pradesh, India) at a dose rate of 0.5 mg/kg per kg body weight applied consecutively after an interval of 5 min between injections. Anesthetic induction was done by intravenous administration of 1% propofol (Neorof, Neon Laboratories Limited, Mumbai, India) 'till effect' 5 min after administration of pre-anesthetics. Anesthesia was maintained with isoflurane 2% (Sosrane, Neon Laboratories Limited, Mumbai, India).

The surgical area was scrubbed with chlorhexidine and was painted with povidone iodine before the start of surgery. Based on preoperative radiographs diameter and length of steinmann pin was predetermined. Normograde

insertion of intramedullary pinning was carried out using Jacob's chuck. Sister pin helped in assessing length of pin passed into medullary cavity. After cutting the pin to the required length, pin was withdraw slightly and secured with specially designed screws at tip. Muscle, fascia and skin incision were sutured as per standard protocol. Intraoperatively, duration of surgery, soft tissue status, technical difficulty and complications, if any, were noted.

Postoperative antibiotic, analgesics with alternative day antiseptic dressing of wound was followed in all dogs. Restricted movement along with immobilization of affected limb by Robert-Jones bandage was advised to owners.

Surgical wound healing was evaluated on 15th postoperative day and was graded as satisfactory or not. Postoperative evaluation of pain (Cross *et al.* 1997), posture and lameness (Patra 2015) was done at 15, 30 and 60 postoperative days and scored. Post-operative pain was graded as: 1 (severe-animal not allowing manipulation of limb), 2 (moderate- animal will not allow manipulation through normal range of motion; acknowledges pain), 3 (mild- animal allows manipulation of limb through normal range of motion, but acknowledges pain by turning head or pulling away) and 4 (no pain response on manipulation of limb). Lameness score was assigned as: 1(non-weight bearing lameness); 2 (severe weight bearing lameness "toe-touching" only); 3 (moderate weight bearing lameness, obvious lameness with noticeable "head-bob" and change in gait); 4 (consistent mild weight bearing lameness with little change in gait); 5 (intermittent mild weight bearing

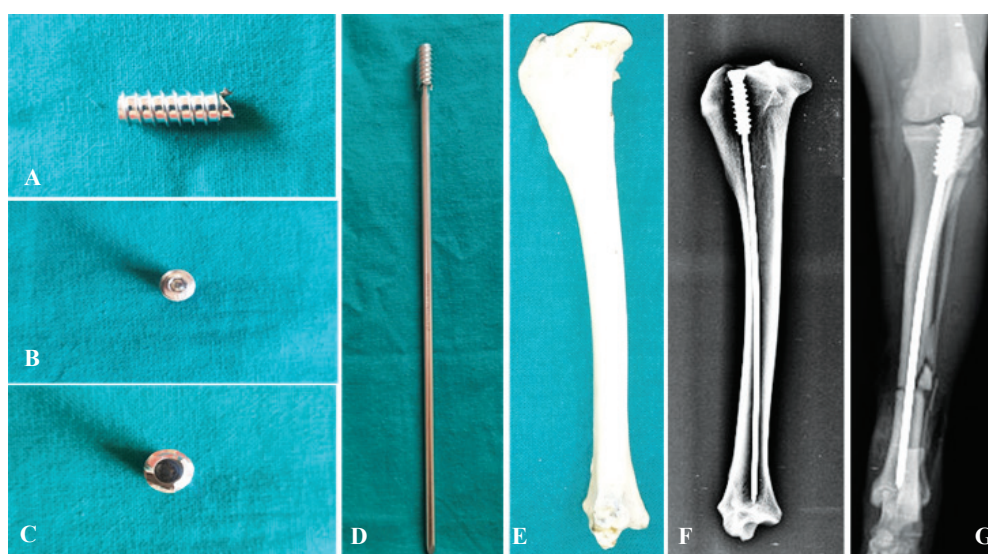


Fig. 1. Cannulated cancellous caps having full length threading with dimensions of 10 mm × 25 mm, 8 mm × 25 mm (Side: A; Top: B and Bottom: C view, D: Full assembly for internal fixation, E: Fixation of capped intramedullary pin in bone model, F: Corresponding radiograph of bone model after fixation, G: Application of capped intramedullary in tibial fracture).

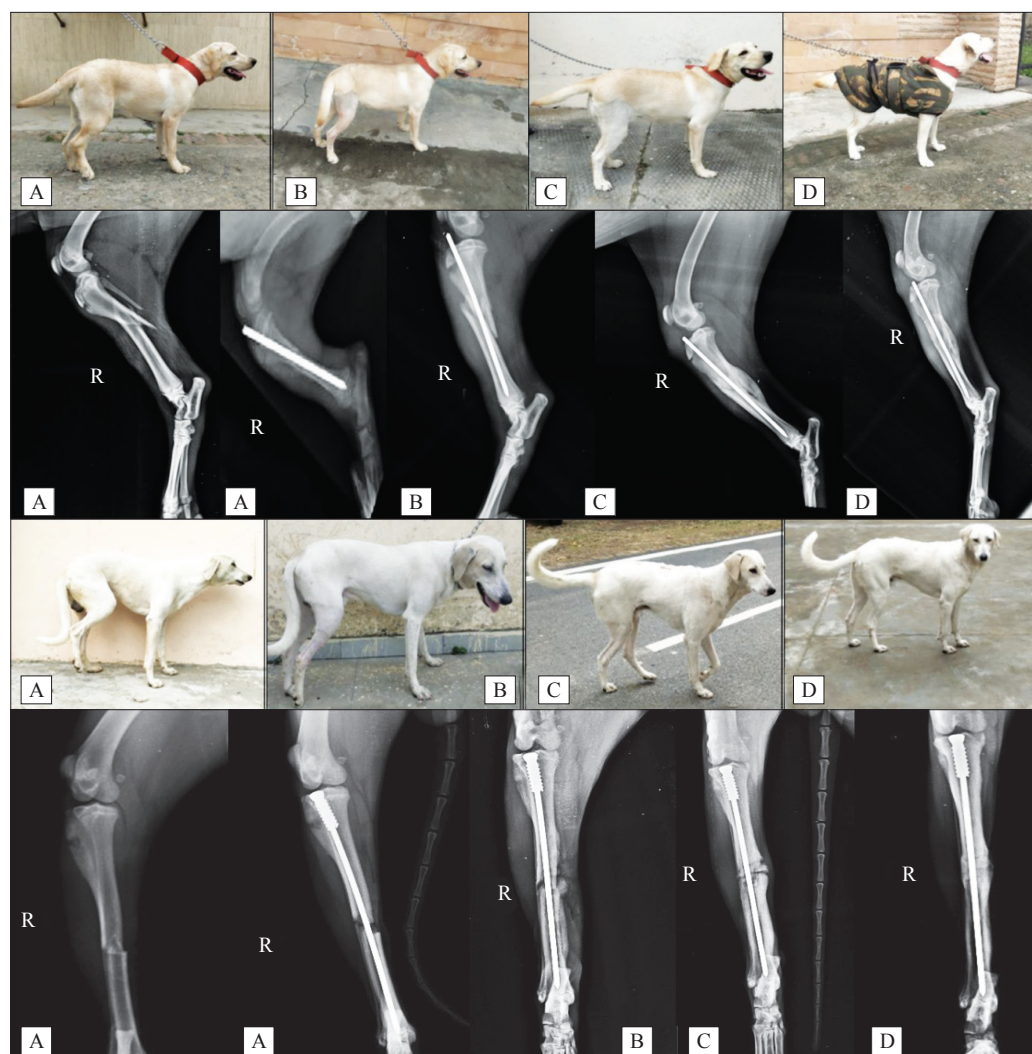


Fig. 2. Photographs and corresponding radiographs of a dogs (Groups A and B) showing weight bearing in tibial fractures while standing and radiographic healing status preoperative and post-fixation (A), at 15 (B), 30 (C) and 60 (D) days, postoperatively.

lameness with little if any change in gait); 6 (no observable lameness).

Orthogonal cranio-caudal and medio-lateral radiographs of the operated limb were evaluated to assess the radiographic healing, callus formation, status and position of implant and complications, if any. Radiographic appearance of fracture site was scored as: 1 (Presence of fracture line with sharp fracture edges); 2 (Presence of fracture line with hazyness at the fracture edges); 3 (Faintly visible fracture edges with cortical continuity); 4 (Obliteration of fracture line with complete cortical continuity). Amount of callus formation was scored as: 1 (cortical continuity with severe callus); 2 (cortical continuity with moderate callus); 3 (cortical continuity with mild callus); 4 (cortical continuity with minimum callus). Complications like pin migration, severe malalignment, severe arthrosis in the surrounding joints, nonunion, osteomyelitis, muscle contractures and implant failure were graded as major, whereas, conditions like slight malalignment, hypertrophic callus, mild arthrosis in the surrounding joints and delayed union of the fracture were graded as minor complications (Dvorak *et al.*

2000). Functional recovery was evaluated and graded on 60 day postoperatively and scored as: 'very good' (fracture healed with normal leg usage); 'good' (fracture healed with persisted slight lameness); 'satisfactory' (Delayed union with apparent lameness); and 'unsatisfactory' (fracture failed to heal due to fixation failure or infection). Status and position of implant was scored as: 1 (Completely migrated pin / Complete failure of implant); 2 (Partially migrated pin with slight loss of bone alignment); 3 (Slight pin bending with bone in alignment); 4 (Pin in normal position and bone in normal alignment).

Analysis of data and plotting graphs were made using Graphpad prism version 8.4.3(686). In both the groups, mean $\pm$ SE represent parametric values while median and inter-quartile range (IQR, 25% to 75% quartile) represent non-parametric values. Single measurements of continuous variables between group A and B was compared using two way analysis of variance (ANOVA) and post hoc Turkey's HSD test. Within the group non-parametric values at different time period were evaluated by Wilcoxon signed rank test. Between the groups at different time period,

Table 2. Nature of fractures, area of diaphysis involved, orientation and number of fragments, size of imp used and auxiliary implants used for the management in both the groups

Dog	Nature of fracture	Diaphysis involved	Orientation/ complexity	No. of fragments	Approx % of medullary cavity occupied	Auxillary implant used
A I	Closed	Mid	Oblique	2	69.44	Nil
A II	Closed	Mid	Transverse	2	72.72	Nil
A III	Closed	Mid	Transverse	2	52.23	Nil
A IV	Closed	Mid	Oblique	2	56.25	Nil
A V	Closed	Mid	Transverse	2	42.25	Nil
A VI	Closed	Mid	Transverse	2	51.47	Nil
A VII	Closed	Mid	Transverse	2	54.54	Nil
B I	Closed	Mid	Transverse	2	67.56	Nil
B II	Closed	Distal	Oblique	2	62.50	Nil
B III	Closed	Distal	Transverse	2	51.72	Nil
B IV	Closed	Mid	Segmental	3	44.77	Nil
B V	Closed	Mid	Transverse	2	62.5	Nil
B VI	Closed	Mid	Transverse	2	57.69	Nil
B VII	Closed	Distal	Oblique	3	62.5	Nil

Mann-Whitney U test was used to compare non-parametric values, while parametric values compared using unpaired 't' test.

RESULTS AND DISCUSSION

Many researchers had overcome the potential deficiencies and instabilities associated with intramedullary pinning either by using threaded intramedullary pin (Chanana *et al.* 2018) or in the form of tie in configuration of intramedullary pin with external skeletal fixator (Camuzzini *et al.* 2002). Some of the demerits associated with these were implant instability in threaded pin (Denny and Butterworth 2000) while, pin breakage, pin tract infection and interference with quadriceps function in external fixators (Braden *et al.* 1973). Complications are associated with protruded portion of pin after intramedullary fixation such as penetration into surrounding joint or nerve, seroma formation and injury to skin or soft tissues with or without infection (Schrader

1991). It was hypothesized that cannulated cancellous cap effectively increases pin stability against rotational and axial tension forces and will reduce IMP induced complications. Selection of appropriate dimensions of caps was made based on radiographic evaluation of 20 dogs referred to limb radiography unrelated to the present study. Cancellous type of threading for designed cap increased the holding strength in porous bone by filling trabecular holes with compressed bone (Schatzker *et al.* 1975). Inserted intramedullary pin into the medullary cavity itself act as pilot hole for insertion of designed cannulated cancellous cap. As designed caps were self-tapping type found easy to insert using hexagonal screw driver over pin. Cap covers the sharp cut end portion of pin and prevented pin migration, sciatic injury and seroma formation complications associated with intramedullary pin.

The age of dogs included in both the groups ranged from 3 to 12 months, while highest number of cases was

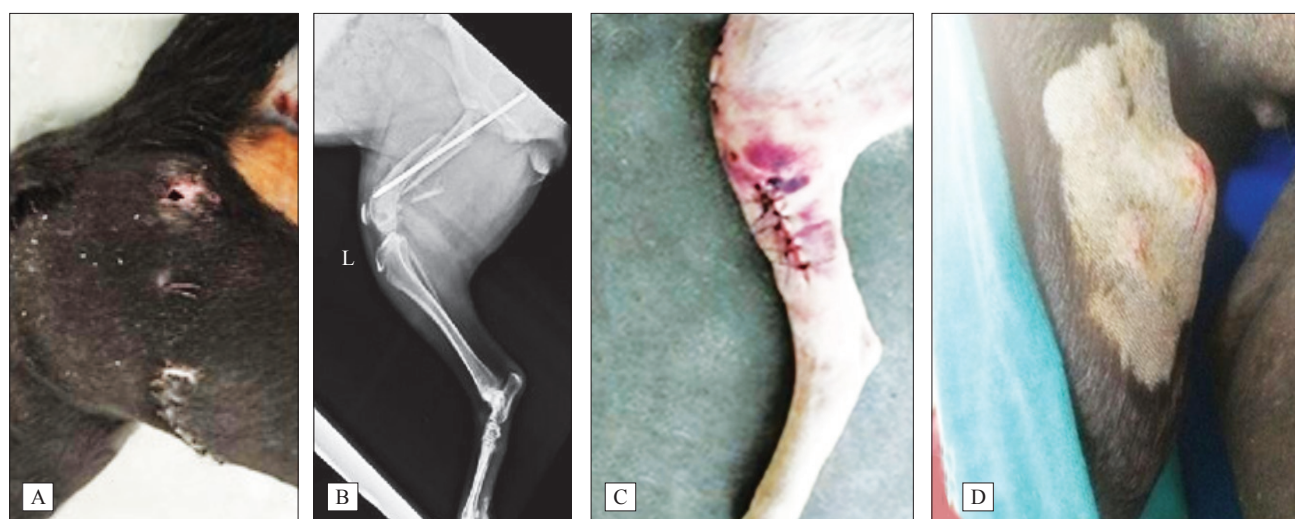


Fig. 3. Complications like pin migration (A and B), wound dehiscence (C) and seroma formation (C) observed after simple intramedullary pinning in group A.

Table 3. Functional recovery and complications observed in dogs of groups A and B

Dog	Grade recovery	Type of complication opinion	Functional	Client
AI	Minor	Slight angulation of tarsal joint (Tarsus valgus)	Very Good	Satisfied
AII	Minor	Short term angulation of tarsal joint (Tarsus valgus)	Excellent	Satisfied
AIII	-	-	Very good	Satisfied
AIV	Major	Completely migrated intramedullary pin	Fair	Indifferent
AV	-	-	Excellent	Satisfied
AVI	Minor	Decreased range of motion of stifle joint	Excellent	Satisfied
AVII	Major	Pin migration and seroma formation	Fair	Satisfied
BI	Minor	Wound dehiscence	Excellent	Satisfied
BII	-	---	Excellent	Satisfied
BIII	-	-	Excellent	Satisfied
BIV	-	-	Excellent	Satisfied
BV	-	-	Excellent	Satisfied
BVI	-	-	Excellent	Satisfied
BVII	-	-	Excellent	Satisfied

from age group of 3 to 6 months (7) followed by 10 to 12 months (5) and 7 to 9 months (2). The mean $\pm$ SE age in group A and B was 7.28 ± 1.44 and 7.42 ± 1.39 months, respectively, with no significant difference between the groups. Higher numbers of cases were recorded in male (9) than female (5) and fall from height was most common cause of fractures in both groups. Dogs were of non-descript (5), Labrador retriever (4), Indian spitz (4) and Rottweiler (1) breeds in both the groups. The mean $\pm$ SE body weight in group A and B was 14.00 ± 3.45 and 14.86 ± 3.26 kg, respectively, and no significant difference between the groups was observed. The mean $\pm$ SE of time lapse in groups A and B was 2.28 ± 0.35 and 1.28 ± 0.47 days, respectively, without any significant difference between the groups. No significant difference was observed between the groups on pre operative soft tissue status, posture, gait and lameness score. Fall from height was the most common cause of fracture, predominantly in male dogs (Kumar *et al.* 2007). Furious nature with wandering habit of male dogs makes them more susceptible to automobile injuries and fractures (Uwagie *et al.* 2018). Fracture cases were reported sooner in majority of the cases because of awareness among the pet owners about the welfare of the animals. Fractures were mostly seen at the mid-diaphysis in both tibia and femur (Elzomor *et al.* 2014).

Configuration of fractures of groups A and B are depicted in Table 2. Intra-operatively, soft tissue damage was mild in all cases except two cases showing moderate soft tissue inflammation. Fracture reduction was easy in ten cases, moderate difficulty in reduction and manipulation was required in four cases. Dimensions and configurations of implants used in both the groups are presented in Tables 2. Intramedullary pin size varies from 3 to 5 mm occupying 57% of medullary cavity on average. Technical difficulty to decide appropriate length of pin and during cap insertion was faced. Average time taken for intramedullary pinning along with cap insertion was 41.57 ± 3.12 min (mean $\pm$ SE). Cannulated cancellous caps of 8mm and 10mm

accommodating corresponding intramedullary pin size were selected. Variation of IMR size was attributed to use of smaller pins occupying about 50% of medullary cavity to function as rush pin in most of tibia fractures (Piermattei *et al.* 2006). Normograde insertion of intramedullary pin was carried out in all cases to prevent the chances of sciatic nerve injury and pin migration observed in retrograde fashion (Sissener *et al.* 2005). Mean time required for surgery was 41.57 ± 3.12 min which was relatively a lower duration as cited in the literature; ranged from 30 to 90 min for intramedullary pinning of tibial fractures in dogs (Priyanka *et al.* 2019).

Satisfactory wound healing on day 15 was noticed in all cases except in one dog of group A, which later healed by second intention. Reduction in pain perception scores during initial days of follow up and reached pain free range of motion in most of dogs on day 30. Postoperative posture and gait scores were improved gradually showing weight bearing while standing, walking and running on day 15 and reached maximum scores in most dogs on 60 day postoperatively. Lameness scores showed parallel shift with stance and gait score during the current study with excellent final score on day 60 except in two dogs showing moderate weight bearing lameness with noticeable change in gait (Fig. 2). The ultimate goal of internal fixation is to rigidly hold fracture fragments until bony healing while allowing the animal to walk and bear weight (Spencer *et al.* 2012). Early functional usage of limb with touching the paw on ground was seen at postoperative day 15. Postoperatively on day 60, all dogs exhibit pain free range of motion and no observable lameness except in two dogs of group A showing mild pain and moderate weight bearing lameness with noticeable change in gait. Pain and lameness in these two dogs was ascribed to pin migration (Sawyer *et al.* 2015).

Radiographic healing in all dogs was excellent on postoperative day 60, showing obliteration of fracture line with complete cortical continuity except in two animals

where delayed healing due to pin migration was observed in group A (Fig. 2). Fractures were healed by secondary bone healing but comparatively increased fracture stability with less amount of callus was noticed in animals treated along with cap (Fig. 2). Postoperative radiographs taken revealed no change in pin position and bone alignment in cases treated with cap, whereas pin migration were observed in two dog of group A. Insufficient axial or rotational stability has led to more callus formation in animals treated with simple intramedullary pin. Internal splinting independent of compression results in flexible fixation, is advocated to induce callus formation (Perren 2002). Instability near fracture site is in direct relation to amount of callus formation except in young dogs (Piermattei *et al.* 2006). Dogs managed with capped intramedullary pinning had mild to moderate callus, may be due to increased implant stability offered by cannulated cancellous. Primary bones healing of small gaps occur under rigid internal fixation (Marsell and Einhorn 2011).

Functional recovery was graded as Excellent (3), Very good (2) and Fair (2) in dogs of group A (Table 3). Persisting to apparent lameness ascribed to severe exercise lead to major complication of pin migration in two animals of group A. Many researchers reported pin migration as major complication (Asma *et al.* 2014) associated with IMP. Minor complications like tarsus valgus in two dogs, seroma formation (Fig. 3) and short term decreased range of joint motion in one dog each were seen in animals of group A. Pin associated minor complications like tarsus valgus, soft tissue irritation or seroma formation were observed in dogs treated with intramedullary pin (Reems *et al.* 2003). Excellent recovery without any major complications was observed in all the cases of group B (Table 3).

From the results it can be concluded that capped intra medullary pinning offered stable internal fixation of long bone fractures with excellent postoperative recovery. Capping of intramedullary pin also prevented complications like pin migration, sciatic injury and seroma formation but study on large number of cases is required to further validate the findings of present study.

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