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Clinical and Radiographic Evaluation of Intramedullary Interlocking Nailing for Fracture Repair in Dogs

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ABSTRACT

The study was conducted on 12 dogs of either sex, breed, aged between 1-8 years which were randomly divided into two groups. In group I, fractures were repaired with intramedullary interlocking nailing using open method and in group-II, closed method of fracture repair under C-arm guidance was used. The occurrence of fracture was found to be 1.04%. The non-descript, young male dogs were most commonly affected with fracture. An automobile accident was the most common cause of fracture. Intra-operative haemorrhage was significantly less with closed method. Rectal temperature and heart rate decreased after induction of anaesthesia in both the groups. In both the groups, the exudation decreased on 7th day and no exudation was observed at 14th postoperative day. The mean value of weight bearing score was significantly ($p<0.05$) lower in group-II as compared to group-I. Animals started to take weight from 3rd postoperative day in group-II. Significant increase in radiographic score was observed at different intervals in both the groups. The blood loss was recorded more in group-I as compared to group-II. Thus, on the basis of clinical and radiographic findings, it can be concluded that the closed method of intramedullary interlocking nailing was better than the open method.

HIGHLIGHTS

- Fracture occurrence rate in dogs was 0.78%.
- Closed intra-medullary interlocking nailing in dogs.

Keywords: Dog, fracture, Intramedullary Interlocking Nailing, C-Arm

Fracture is one of the important affection of small animals, which commonly occurs due to any accident, it may be an automobile accident or just falling from height. Fracture can compromise mobility and overall quality of animal life, hence it warrants treatment. Interlocking nails were developed to treat diaphyseal fractures of the femur, tibia, and humerus. Applicable fracture configurations can vary from simple to highly comminuted. Although interlocking intramedullary nails are most frequently used to stabilize closed fractures, using the nails to manage open and contaminated fractures is also justified. Further, the closed method of intramedullary interlocking nailing will help us to minimize bleeding and infection. Therefore, this study was planned to evaluate open nad closed methods of intramedullary interlocking nailing.

MATERIALS AND METHODS

The occurrence of fracture was recorded in dogs and other species. The distribution of fracture was also recorded based on different parameters Complete history, age, sex,

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breed, body weight, bone involved in fracture, cause of fracture and duration passed was recorded. Twelve dogs of 1-8 years of age, irrespective of breed and sex presented for treatment of long bone fracture (except radius-ulna) were selected for the study. These animals were randomly divided into two groups, consisting six animals each. In-group I, dogs were treated with open intramedullary interlocking nailing (IILN) and in group II, dogs were treated with closed intramedullary interlocking nailing (IILN) under C-arm guidance.

Clinical examination

Temperature (ºF) and heart rate (beat/min) were recorded before, during and after surgery to evaluate the clinical status of animal. Intra-operative parameters like easy of fracture reduction, intra operative bleeding, duration of surgery (min), soft tissue trauma and neuropraxia were also recorded for all the animals. Degree of exudation of wound was monitored on day 0, 3, 7 and 14 post-operatively and the exudation, if any was scored as per the score card stated by Bhowmick *et al.* (2013).

Exudation	Grade	Score
Nil	–	0
Mild	+	1
Moderate	++	2
Marked	+++	3

The lameness score was recorded on day 0, 3, 7, 14, 28, 45 and 60 post-operatively. The degree of lameness was analyzed and scored (0-5) as stated by Cook *et al*. (1999).

Degree of lameness	Score
No observable lameness	0
Intermittent, mild weight bearing lameness with no change in the gait	1
Consistent, mild weight bearing lameness with little change in the gait	2
Moderate weight bearing with noticeable change in the gait	3
Severe weight bearing Lameness, toe touching only	4
Non weight bearing	5

Surgical procedure

Anaesthetic protocol

General anaesthesia was induced using injection atropine sulphate @ 0.04 mg/kg I/M as preanaesthetic, followed by injection diazepam hydrochloride @ 0.5 mg /kg I/V and injection propofol @ 4 mg/kg I/V. The animal was intubated and anaesthesia was maintained with isoflurane @ 2-3% MAC using an anaesthetic machine.

Open method

The suitable nail according to the diameter and length of fractured bone was selected on basis of the preoperative radiograph. In the open method, a skin incision was given laterally for femur whereas the skin incision was given medially for the tibia. The procedure was carried out as described by Raghunath and Singh (2003). After insertion of the screws, the C-arm exposure was made to evaluate the location of the screws. The separated muscles were then sutured in a standard manner using polyglactin 910 followed by the routine closure of the skin incision using non absorbable suture material.

Closed method

In closed method, the anatomical site for the insertion of a Steinmann pin was located. A stab incision was given and a small tunnel was created with the help of an instrument awl. Then, an intramedullary pin was inserted through this tunnel. This pin was progressed under the guidance of C-arm, till it reached the proximal segment of bone. Then, the fractured segments were reduced indirectly. After reducing the fracture, the pin was inserted into the distal segment. Subsequently, the pin was removed from bone. In some cases, a reamer of appropriate diameter was inserted through the tunnel hole for the preparation of marrow cavity. The preparation of the cavity facilitated the entry of the nail. Now the nail of appropriate diameter and length was loaded on the Jig and inserted into the prepared marrow cavity in a normograde manner. The holes were drilled in the bone cortices of the proximal and distal segments using the universal drill and sleeve. Then, the screws were fixed in these holes in bone cortices through a nick incision in the skin, fascia and the muscles. The tunnel hole and the nick incision were sutured (Fig. 1).

Postoperative care

In all the animals, inj cefotaxime sodium @ 10 mg/kg body weight I/M bid prior to surgery and up to day 7

was administered and inj. meloxicam @ 0.2 mg/kg body weight I/M o.d was administered for 3 days. A Robert Jones bandage was applied on the affected limb to restrict its movement. Anti-septic dressing was done with 5% povidone iodine solution. Skin sutures were removed on day 8 to 12.

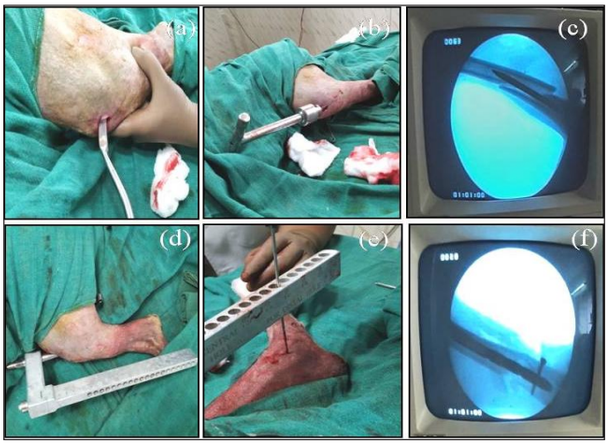

Fig. 1: Intramedullary interlocking nailing by closed method; **(a)** making a tunnel using an awl, **(b)** and **(c)** creating a tunnel and reducing the fracture under C- Arm, **(d)** insertion of nail in normograde manner, **(e)** drilling of hole in bone cortices, **(f)** screw fixation in distal segment

Radiographic examination

Radiographic examination was done prior to surgical procedure to evaluate the type of fracture; then it was conducted after interlocking nailing to assess the level of fracture reduction, alignment of bone fragments and the placement of nail through the bone. Subsequent radiographs were taken post-operatively on day 14, 28, 45 and 60 and were graded using the score card described by Hayashi *et al.* (2008).

Radiographic signs	Score
Presence of recent fracture with no bone formation	0
Irregularity at fragment lines of fracture site	1
Initial/discrete periosteal proliferation	2
Exuberant/ organised periosteal proliferation	3
Osseous callus in evolution with presence of periosteal proliferation	4
Exuberant osseous callus in evolution and discrete radiolucent line at the gap between the fracture fragment	5
Exuberant osseous callus and absence of radiolucent line	6

Comparison between the groups for studied attributes was subjected to unpaired t-test whereas, within group values for each parameter were analyzed by one way ANOVA as described by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The occurrence of fracture in different species of animals was calculated from total number of 8987 animals, which were screened during the sudy. Out of these animals, 94 animals were presented with a fracture of limb, thus the overall occurrence of fracture was recorded as 1.04% (Table 1), whereas the occurrence of fracture in dogs was 0.78%. However, an overall incidence of 1.52% has been reported by Chaurasia (2018). The variation in incidence may be attributed to different time period of study. Further, it was also observed that most of the fractures were seen in Canine (63.82%) followed by Caprine (14.89%), Bovine (10.63%) and other species (10.63%) (Table 2). This finding is consistent with Singh *et al.* (2017) who also reported that most of the fractures (58.82%) were reported in Canine followed by Caprine (19.61%), Bovine (11.76%) and other species (9.81%). Similar findings were also reported by Singh *et al.* (2018). The occurrence of fracture in canine was highest due to the fact that canine was most common species presented to VCC.

Table 1: Occurrence of fracture in different species of animals

Species	No. of animals registered	No. of animals having fracture	Occurrence (%)
Canine	7621	60	0.78
Caprine	636	14	2.20
Bovine	181	10	5.50
Other species	549	10	1.82
Total	**8987**	**94**	**1.04**

Table 2: Distribution of fracture cases in different species of animals

Species	No. of animals having fracture	Per cent
Canine	60	63.82
Caprine	14	14.89
Bovine	10	10.63
Other species	10	10.63
Total	**94**	**100.00**

Signalment

In the present study, out of 12 clinical cases of long bone fractures, eight animals were between 1 to 3 years (66.66%), three animals were between 3 to 6 years (25.00%) and one animal was between 6 to 8 years (8.33%). Maximum number of long bone fractures were recorded in 1 to 3 year age group of dogs, These findings are consistent with Jain *et al.* (2018) who reported that dogs in the age group of 1-6 months showed highest occurrence (49.72%) of fracture followed by 7-12 months (20.11%), 4-5 years (10.65%), 1-2 years (7.69%), 6-7 years (7.10%), 3-4 years (3.55%) and 10-12 years (1.18%). This may be attributed to activeness or playing habit of puppies or young dogs which make them more prone for fracture. Out of twelve cases, more number of male dogs (58.33%) were suffering from fracture than female dogs (41.66%). This may be due to activeness and aggressive nature of male dogs which make them prone for fracture either due to automobile accident, fall from height and animal fight. These finding are consistent with Minar *et al.* (2013), who reported that fracture incidence was higher in male dogs (54%) than the female dogs (46%). Similar findings were also reported by Singh *et al.* (2018). Out of twelve cases of long bone fractures, maximum number of cases were observed in non-descript (41.66%), followed by Spitz/Pomeranian (25%), Labrador (16.66%) and German shepherd (16.66%). The occurrence of fracture was the highest in non-descript dogs which was consistent with Simon *et al.* (2011), who also reported that fracture incidence was highest in non-descript (37.76%) followed by Spitz (29.60%), Labrador (7.55%), Alsatian (6.04%), Doberman Pinscher (3.92%), Boxer (3.02%), Pomeranian (2.71%), Great Dane (2.41%), Pug (1.81%), Dalmatian (1.51%), Dachshund (1.20%) and others (2.00%). This might be due to more number of non-descript dogs and their free roaming habit which make them vulnerable to road accident.

Clinical observation

The body weight of dogs presented with a fracture ranged from 10.0 kg to 27.5 kg. The mean body weight (kg) of dogs in group-I was 18.20±2.23 kg whereas mean body weight of dogs in group-II was 19.38±2.51 kg. It was observed that the tibia was mostly involved in fracture (58.33%) followed by femur (41.66%) however, fracture of humerus was not found during study period and radius bone was not suitable for insertion of an interlocking nail. These finding differed with the study of Singh *et al.* (2018), who reported that fracture was found be most common in femur (31.37%), followed by tibia-fibula (27.73%), radius-ulna (23.24), humerus (8.11%), metatarsal (5.04%) and metacarpal (4.48%). The variation can be attributed to time of study.

Etiology of fracture was fairly variable in all the twelve cases. Automobile accident was the most common cause of fracture in dogs (50.00%) followed by fall from height (41.66%) and dog bite (8.33%). This finding is consistent with Singh *et al.* (2017) who reported that the most common cause of fracture was an automobile accident (50.00%) followed by falling from height (25.00%), hitting (12.50%) and dog bite (12.50%). It can be due to free roaming nature of non-descript dogs which were mostly presented.

Among 12 dogs referred for the fracture treatment, six dogs were presented immediately after injury (50.00%), four dogs came 1-3 days after injury (33.33%) whereas, two dogs were presented after 3 days of injury (16.66%). This finding is consistent with Chaurasia (2018) who reported that five dogs were presented immediately after injury (41.66%), four dogs were presented between 1 to 3 days after injury (33.33%) whereas, three dogs were presented more than 3 days after injury (25%). The socio-economic status may be a contributing factor for variation in presentation of animals for treatment.

Clinical parameters

Rectal temperature

In all dogs, mean values of rectal temperature were found to be reduced after induction of anaesthesia and during the period of surgery (Table 3). The mean values of rectal temperature showed non-significant changes between groups and significant ($p<0.05$) changes within group at different time intervals in both group of dogs. Base line of temperature 101.36±0.35 and 101.6±0.24 ^{0}F, decreased to 97.31±1.03 and 98.3±0.70 ^{o}F during surgery in both the groups. Thereafter, a gradual increase in rectal temperature was observed during recovery of animals from anaesthesia. These finding are in corroboration with

English *et al.* (1991), who reported that a decrease in rectal temperature during anaesthesia may be due to disruption of thermoregulation and heat loss.

Table 3: Mean values of temperature (°F) in different groups

Groups	Interval	Mean value
Group I	Before surgery	101.36^{aA}±0.35
	During surgery	97.31^{aB}±1.03
	After surgery	100.03^{aA}±0.47
Group II	Before surgery	101.6^{aA}±0.24
	During surgery	98.3^{aB}±0.70
	After surgery	100.5^{aA}±0.23

Values with different superscript between group (lowercase) and between interval (uppercase) showed significant difference (P<0.05).

Heart rate

In all the dogs, mean values of heart rate were found to be reduced after induction of anaesthesia and during the period of surgery (Table 4). The mean values of heart rate showed significant (p<0.05) decrease at different time intervals in both the groups. The base line heart rate 104.66±5.92 and 118.33±5.01 (beat/min), decreased to 88.66±4.10 and 95.33±3.22 (beat/min), during surgery in both the groups.

Table 4: Mean values of heart rate (beat/min) in different groups

Groups	Intervals	Mean value
Group I	Before surgery	104.66^{aA}±5.92
	During surgery	88.66^{aC}±4.10
	After surgery	94.66^{aAB}±4.38
Group II	Before surgery	118.33^{aA}±5.01
	During surgery	95.33^{aC}±3.22
	After surgery	107.66^{aAB}±4.81

Values with different superscript between group (lowercase) and between interval (uppercase) showed significant difference (P<0.05).

This may be due to severe hypothermia, cardiac conduction abnormalities and severe myocardial depression as described by Haskins (2015). Thereafter, a gradual increase in the heart rate was observed during recovery of animals from anaesthesia. This finding is in accordance with finding of Patil *et al.* (2017), who also reported a decrease in the heart rate after induction of anaesthesia.

Intraoperative parameters

The time taken for the fracture reduction was observed to be longer in group-II (15±1.82 min) than in group-I (9±2.38 min). The mean value of blood loss in group-I (51.65±1.72 g) was higher than in group-II (20.71±1.96 g), hence the intraoperative bleeding was lesser in group-II. Time taken for orthopaedic surgery was observed to be longer in group-II (140±6.55 min) than in group-I (101±6.41 min) (Table 5). Neuropraxia was observed in two cases of group-I, which was managed with conservative treatment.

Table 5: Mean values of intra-operative parameters in both the groups

Groups	Intra-operative parameters	Mean value	Significance
Group I	Time taken for fracture reduction (min)	9±2.38	
	Intraoperative haemorrhage (g)	51.65±1.72	
	Duration of surgery (min)	101±6.41	
Group II	Time taken for fracture reduction (min)	15±1.82	Non-significant
	Intraoperative haemorrhage (g)	20.71±1.96	Significant
	Duration of surgery (min)	140±6.55	Non-significant

Degree of exudation

In all the dogs, mean value of degree of exudation showed gradual decrease at site of suture line from day 3 onwards up to day 14 postoperatively (Table 6). The mean values of degree of exudation varied significantly (p<0.05) at different intervals in both the groups. Mean value ranged from 0.16±0.16 to 2.00±0.25 at different time intervals in both groups. No exudation was observed on day 14 postoperatively. This finding is in accordance with De´Souza (2012) who observed that complete absence of exudation at fracture site on 15th postoperative day in dogs.

Table 6: Mean values of degree of exudation in both groups at different intervals

Groups	Days	Degree of exudation
Group I	0	$0.00^{aC}\pm0.00$
	3	$2.00^{aA}\pm0.25$
	7	$1.83^{aB}\pm0.40$
	14	$0.00^{aC}\pm0.00$
Group II	0	$0.00^{aB}\pm0.00$
	3	$1.00^{bA}\pm0.36$
	7	$0.16^{bB}\pm0.16$
	14	$0.00^{aB}\pm0.00$

Values with different superscript between group (lowercase) and between interval (uppercase) showed significant difference ($P<0.05$)

Radiographic evaluation

Radiographic assessment of fracture healing illustrated initial bone union by day 14 and complete union by day 45 and 60 post-operatively (Fig. 2). The mean values of radiographic score in group-II were higher than the values in group-I (Table 7).

Table 7: Mean values of radiographic score in both the groups at different intervals

Groups	Days	Radiographic Score
Group I	0	$0.00^{aE}\pm0.00$
	14	$0.50^{aD}\pm0.22$
	28	$2.00^{bC}\pm0.36$
	45	$3.50^{bB}\pm0.22$
	60	$4.83^{bA}\pm0.16$
Group II	0	$0.00^{aE}\pm0.00$
	14	$0.83^{aD}\pm0.16$
	28	$3.00^{aC}\pm0.25$
	45	$4.50^{aB}\pm0.22$
	60	$5.66^{aA}\pm0.21$

Values with different superscript between group (lowercase) and between interval (uppercase) showed significant difference ($P<0.05$).

This finding is in accordance with findings of Patel *et al.* (2007) and Manjunatha and Ranganath (2012). They also reported that static intramedullay interlocking nail fixation was successfully applied in a minimally invasive method for long bone diphyseal fracture in dogs. This resulted in early weight bearing and good bone healing as observed on the postoperative radiographs.

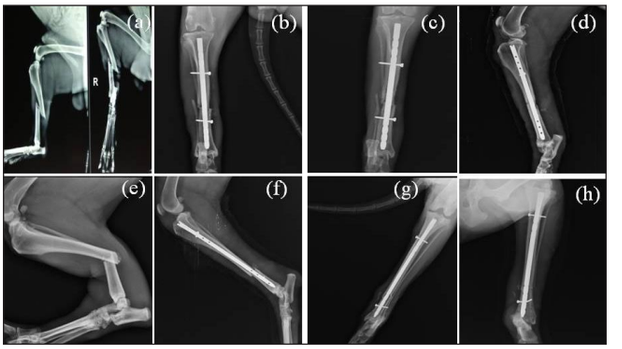

Fig. 2: Pre-operative and post-operative radiographs; **(a)** pre-operative in group I **(b)** at day 0 in group I, **(c)** at day 45 in group I, **(d)** at day 60 in group I, **(e)** pre-operative in group II, **(f)** at day 0 in group II, **(g)** at day 45 in group II, **(h)** at day 60 in group II

Degree of lameness

Table 8: Mean values of weight bearing in both the groups at different intervals

Groups	Days	While standing
Group I	0	$5.00^{aA}\pm0.00$
	3	$4.83^{aAB}\pm0.16$
	7	$4.16^{aB}\pm0.16$
	14	$3.16^{aC}\pm0.30$
	28	$1.83^{aD}\pm0.30$
	45	$1.66^{aD}\pm0.42$
	60	$0.00^{aE}\pm0.00$
Group II	0	$5.00^{aA}\pm0.00$
	3	$3.83^{bB}\pm0.30$
	7	$3.33^{bB}\pm0.33$
	14	$2.50^{aC}\pm0.22$
	28	$1.66^{aD}\pm0.42$
	45	$0.50^{bE}\pm0.22$
	60	$0.00^{aE}\pm0.00$

Values with different superscript between group (lowercase) and between interval (uppercase) showed significant difference ($P<0.05$).

The degree of lameness was calculated based on lameness score as stated by Cook *et al.* (1999). The lameness score

started to reduce significantly ($p<0.05$) from 5.00±0.00 at day 0 to 0.00±0.00 at day 60 in both the groups. There was a consistent decrease in lameness core at different time intervals in both the groups accompanied by improved weight bearing by the animals (Fig. 3). This improved weight bearing was result of fracture healing after anatomical reduction and fixation of fracture segments (Table 8). At day 3, animals were having significant ($p<0.05$) weight bearing on affected limb in group- II, this finding is in accordance with the finding of Mathai *et al.* (2016) and Manjunatha *et al.* (2011) who reported that dogs started weight bearing on day 1 itself and showed complete weight bearing by 4th post-operative day.

CONCLUSION

C- Arm guided closed intra-medullary interlocking may be a better technique than open method as it was less invasive in nature and favored an early recovery as supported by radiographic assessment and early weight bearing. More time was required for closed method than open method.

Fig. 3: Photographs showing pre-operative and post-operative weight bearing; **(a)** pre-operative in group I **(b)** at day 28 in group I, **(c)** at day 60 in group I, **(d)** pre-operative in group II, **(e)** at day 28 in group II, **(f)** at day 60 in group II

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