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Open and closed intramedullary pinning of tibial fractures in dogs

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Abstract
This clinical study was conducted on 12 dogs presented with simple non - articular tibia fracture to compare open and closed intramedullary pinning. Selected cases were closed, transverse, oblique and spiral fractures of tibia. Routine clinical and radiographic examination was conducted for diagnosis, assessment and planning of surgical procedure. Both open (6) and closed (6) intra-medullary pinning techniques were used for fracture repair. Full cerclage wiring was used for extra support in three cases. Clinical evaluation was carried out routinely at periodic intervals for signs of swelling, exudation and weight bearing in all the dogs. Cases were evaluated on the basis of clinical and radiographic results obtained immediately after surgery and on the 30th, 45th, 60th days post-surgery. Post-operative radiographs showed progressive healing of fracture site with callus formation. The results of present clinical study revealed that closed intramedullary pinning of tibia took lesser time for fracture healing compared to open reduction. Open method of intramedullary pinning is equally effective though wound dehiscence was a common drawback.

Keywords: intra-medullary pinning, tibia, fracture, dogs

Introduction
Fracture of the long bone is a commonly encountered orthopedic problem in young dogs (Nunamaker and Newton, 1985) [10]. The femur is the most frequently affected long bone, followed by the tibia, radius-ulna, and humerus (Kallianpur *et al*., 2018) [9]. The majority of tibia fractures are due to road accidents, various traumatic incidents, or gunshot injuries (Boone *et al*., 1986) [2]. Tibia fractures are the second most common fracture in the pelvic limb, with the highest incidence in young nondescript dogs of one and a half to six months of age (Simon *et al*., 2010) [15]. The fracture repair techniques such as bone plate, external fixator, interlocking nail, intramedullary pin, and external coaptation are currently practiced in tibia fracture repair (Li *et al*., 2015) [8]. The primary goal of fracture fixation is to achieve early fracture healing and patient mobility (Shahar, 2000) [14]. Intramedullary pinning is a cost-effective, simple technique that requires minimum exposure and operative time. Thus, the present study was undertaken to evaluate the open and closed type of intramedullary pinning in the healing of tibia fracture in dogs.

Materials and Methods
The open and closed intramedullary pinning techniques were used in 12 dogs presented with diaphyseal tibia fracture. Animals were selected irrespective of breed, sex or age after routine clinical and radiographic examinations. The fracture site was temporarily stabilized with Robert-Jones bandage until the day of surgery after initial evaluation of the patient at the time of presentation. Food was withheld for 12 hours and water for 6 hours prior to surgery. The affected limb was aseptically prepared and painted with povidone iodine lotion. Antibiotic prophylaxis was done with ceftriaxone @20mg/kg intravenously. Normal saline was infused @ 20ml/kg/hr intravenously throughout the duration of surgery. Atropine sulphate at the rate of 0.04 mg/kg body weight was administered subcutaneously as pre-anesthetic medication followed by intravenous administration of Butorphanol @ of 0.02 mg/kg and Diazepam at 0.5mg/kg body weight. General anaesthesia was induced with intravenous administration of Thiopentone sodium @ 10 mg/kg body weight. Following induction, the dogs were intubated and anaesthesia was maintained with 2% Isoflurane. The dogs were positioned in lateral recumbency with the fractured limb in lower side. The distal extremity of the limb was covered with sterile drapes.

The entire operative site was painted with 5% povidone iodine solution and draped.

Sterilized standard orthopedic set, a general instrumentation set and stainless Steinman pin were used in the study. Closed intramedullary pinning was attempted initially in all the cases. Closed reduction was carried out in six cases after reducing the fracture fragments with gentle manipulations without opening the site. The Steinmann pins were inserted by using a Jacob's chuck, after making a small nick incision at the proximal end of tibia between the medial tuberosity and the medial patellar ligament. The required size of Steinman pin was selected by measuring the medullary cavity diameter of the bone from anterio-posterior radiographs of the same or contra-lateral bone. Excess pin from the proximal side is cut as close to skin. In another six cases, open reduction and intramedullary pinning in a normograde fashion was performed. During direct open reduction, the incision was made at the fracture site to expose the fragments and to bring them into anatomical alignment, and steinmann pin was inserted as described for closed method. In three cases cerclage wiring was done to stabilize the spiral fractures. Pin that was snuggly fitting to 60-70% of the medullary cavity was selected. Ancillary support with full cerclage wiring was provided in three oblique fractures. Incision site closed by two layer, underlying muscle, fascia and subcutaneous tissue sutured with 1-0 polyglactin 910 using simple continuous pattern and skin was closed with no. 1 polyamide using horizontal mattress pattern. Intra-operative observations like extent of soft tissue damage (mild, moderate and marked), extent of overriding of main segments (mild, moderate and marked), ease of fracture reduction (Easy, moderate and difficult) were recorded. The suture line was covered with a thin layer of sterile gauze bandage dipped in 5% povidone iodine solution. Over this, a thick layer of cotton pad was wrapped. This was covered with sterile gauze bandage and finally, a layer of surgical paper tape was applied. The dressing was replaced every alternate day until the sutures were removed on the 10th day. Ceftrioxone sodium was administered at the rate of 20 mg/kg body weight as intramuscular injection twice daily for 7 days post operatively. Post-operatively meloxicam was administered once a day at the rate of 0.3 mg/kg by intramuscular injection for 3 days. Owners were advised to restrict the movement of the animal for the first 2 weeks after surgery and then to allow leash walking for the next few weeks.

Surgical wound healing was evaluated on 15th postoperative day and was graded as satisfactory or not. Postoperative evaluation of pain (Cross *et al*., 1997) [7] and lameness (Cook *et al.*, 1999) [3] were made on 15, 30 and 60 day postoperative and were given scores. 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 lameness with little if any change in gait); 6 (no observable lameness). Plain anterio-posterior and medio-lateral radiographs of the operated tibia was obtained immediately after surgery and on the 15th, 30th, 45th and 60th post-operative days to assess the progress of bone healing. Radiological fracture healing was scored based on callus formation and/or elimination of the fracture line or gap as recommended by Cook *et al*. (1999) [3] on 0-3 score : 0- Complete radiographic healing, 1- Appropriate progression towards healing, but not completely healed, 2- Inappropriate progression towards healing, 3- No evidence of healing. Complications like pin migration, severe misalignment, severe arthrosis in the surrounding joints, nonunion, osteomyelitis, muscle contractures and implant failure were graded as major: where as conditions like slight misalignment, hypertrophic callus, mild arthrosis in the surrounding joints and delayed union of the fracture were graded as minor complications.

The data were statistically analyzed using SPSS software version 22.0 (SPSS, Inc., Chicago, IL). The parametric variables and nonparametric variables were expressed as Mean ± SE, median ± SE and range, respectively. Independent samples "*t*" test was used to compare the parametric data at different time intervals post fixation. Wilcoxon Signed Ranks Test was used for non-parametric data to check significant difference ($p< 0.05$) between follow-up intervals.

Results and Discussion

In the present study, the age of the dogs presented with fractures of tibia ranged from 4 to 36 months. Dogs were of Pitbull terrier (1), Bull mastiff (1), German shepherd (1), Indian Spitz (2), Labrador Retriever (2) and Non descript (5) breeds. All the twelve cases (female- 4, male-8) were weighing from 10 to 24 kg. Most of the fractures (8 cases) were caused due to road accident. All the dogs showed symptoms like sudden onset of pain, swelling, lifting of the limb, non-weight bearing and crepitation was also noticed at the fracture site. The details regarding breed, age, sex, weight, etiology, side involved, method used, time lapse on presentation and configuration of fracture the limb involved, type and location of fracture in all the dogs are presented in Table 1.

Table 1: The details of cases included in study on the day of presentation

Case no	Breed	Age (Months)	Sex	Body weight (kilograms)	Etiology	Side affected	Method Used open/closed	Time lapse in presentation (days)	Configuration of fracture
1	Labrador Retriever	12	F	24	DF	L	Close	1	Short oblique
2	Indian Spitz	18	F	12	DF	L	Close	2	Short oblique
3	Pitbull terrier	8	M	18	RTA	L	Close	3	Short oblique
4	Non- descript	4	F	6	RTA	R	Close	2	Transverse
5	Labrador Retriever	14	M	21	RTA	L	Close	2	Transverse
6	Non- descript	6	M	9	RTA	R	Close	1	Transverse
7	Indian Spitz	18	M	12	FFH	R	Open	5	Short oblique
8	German Shepherd	25	F	24	RTA	L	Open	5	Short oblique

9	Bull mastiff	26	M	29	RTA	L	Open	2	Spiral
10	Non descript	36	M	14	FFH	R	Open	2	Long Oblique
11	Non descript	18	M	12	RTA	R	Open	4	Short oblique
12	Non descript	10	M	19	RTA	L	Open	2	Long oblique

(F- Female; M-Male; DF-Dog fight; RTA-Road traffic accident; FFH- Fall from height) (L-Left; R- Right)

The patient preparation and anesthetic protocol followed for the surgery proved satisfactory for the surgical interventions carried out. Normograde pinning with or without cerclage wiring, open or closed reduction provided satisfactory alignment of fracture fragments. Intra-operatively, soft tissue damage was mild in all cases except two cases showing moderate soft tissue inflammation. Closed fracture reduction was easy in four cases but moderate difficulty in reduction and manipulation was required in another two cases. In another six cases where closed method attempt failed necessitated opening of site and additional surgical exposure. Toggling of fracture fragments was done and pinning was done with and without cerclage wiring in three cases each to stabilize fractures. Additional stabilization with cerclage wiring was done for the spiral/ long oblique types of fractures. Average time taken for intramedullary pinning was 37.57±3.12minutes (mean ± SE).

Satisfactory wound healing on day 15 was noticed in all cases except in one dog, which later healed by second intension. Median and IQR values of postoperative pain, lameness and radiographic healing scores of each method during follow up periods are shown in table 2. By the 15th postoperative day all the animals of both treatments showed no pain response on limb manipulation (scored as 4). The significant improvement ($p< 0.05$) in the pain mean ranks of both treatments was observed after 15th postoperative day. The median pain score of both treatments subsequently remained at the maximum score of 4 till the end of the follow-up evaluation. With both treatments significant ($p< 0.01$) reduction in median pain scores were observed from preoperative to 15 and 30 day and reached minimum score on day 60. No significant difference was observed between the two methods at any corresponding interval. 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 (Fig. 1 and 2).

Table 2: Median and IQR values of pain, lameness and radiographic healing scores in the animals treated with open and closed intramedullary pinning

Parameter	Method used	Interval (days)			
		0	15	30	60
Pain Score	Closed IM(n=6)	1.0 (1-2)^a	3.5 (3-4)^b	4.0 (3-4)^b	4.0 (4)^b
	Open IM(n=6)	1.0 (1)^a	3.5 (2-4)^b	4.0 (3-4)^b	4.0 (3-4)^b
Lameness score	Closed IM(n=6)	1(1-2)^a	4(3-5)^b	5(3-6)^b	6(3-6)^b
	Open IM(n=6)	1(1)^a	2(1-4)^a	5(3-6)^b	6(6)^b
Radiographic healing scores	Closed IM(n=6)	--	2(1-2)^a	3(2-4)^b	4(2-4)^b
	Open IM(n=6)	---	2(2-3)^a	3(2-4)^a	4(3-4)^b

Values with different alphabets differs significantly ($p< 0.05$) from base line value.

In animals treated with closed method, significant ($p< 0.01$) improvement in median scores from preoperative to 15 day postoperatively noticed which reached excellent on day 60 postoperative. In open methods animals median scores improved nonsignificantly from preoperative to day 15 postoperative and improved significantly ($p< 0.01$) from day 30 and reached maximum on day 60. No significant difference for lameness scores was observed between treatment methods at the corresponding intervals. 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. 3 and 4).

Significant ($p< 0.01$) improvement in median scores for radiographic healing was observed from 15 day to 30 and 60 day and reached maximum score on 60 day in animals treated with closed method. In open method treated animals median scores remain non-significant from 15 day to 30 day postoperative and improved significantly from 60 day and reaching maximum on 60 day (Table 2). No statistical difference was observed between the both the treatment methods at the corresponding interval. Radiographic healing in all dogs was excellent on postoperative day 60 in cases treated with closed method, showing obliteration of fracture line with complete cortical continuity (Fig. 5, 6 and 7). Comparatively more amount of callus was noticed in animal treated with open reduction. Delayed healing due to pin migration was observed and fractures were healed by secondary bone healing (Fig. 8 and 9). Delayed healing due to pin migration and fractures were healed by secondary bone healing.

Functional recovery in all the dogs was graded as excellent except in two dogs, where fracture was repaired using open method showed slight persisting to apparent lameness ascribed to severe exercise and minor pin migration. Minor complications like seroma formation and wound dehiscence in one case each were observed with open reduction method (Fig. 10).

Incidence of fracture was more in males due to the fact that males are relatively more aggressive (Kaur, 2015) [7]. Non-descript breeds were found to be more affected due to automobile accident in our study. Ben Ali in 2013 also reported automobile accidents the major cause of fractures in dogs. Diaphyseal spiral and oblique fractures were more common. The normal anatomic twists and curves of the tibia are responsible for oblique or spiral nature of fractures (Sinibaldi, 1983) [16]. Boone *et al* in 1986 [2] also reported spiral and oblique fracture patterns of tibia in dogs. To minimize soft tissue injury closed intramedullary pinning was attempted in six cases and very less mild tissue damage was observed. Intra-operatively, degree of soft tissue damage was moderate in four cases and severe in two cases where open

reduction of fractures was done. Early healing was observed without any complications in closed reduction. Similarly, soft tissue condition and local blood circulation were very important for bone reconstruction and healing of fractures (Frigg and Ulrich, 2003) [6]. Reduction was found easy in 9cases and moderately difficult in 3 cases due to displaced and overriding of fragment. Easy reduction in cases was due to mild degree of overriding in these fracture cases, while reduction was difficult in cases with marked overriding.

Time taken for completion of surgery was 37.57±3.12 minutes. Intramedullary pin was advantageous because it required lesser exposure and caused lesser trauma to the periosteum which is needed for bone healing. In 6 animals, closed reduction was done which resulted in very good fracture fixation and healing. For proper stabilization of fracture fragments by intramedullary pinning, pin occupancy of 60-70% of medullary canal helped to resist the bending forces and maintained axial alignment as reported (Schrader, 1991) [13]. The dimensions of the pin should be 60-70 % of the isthmus of the medullary canal. A lesser intramedullary occupancy of pins did not offer adequate strength or bending stiffness to maintain stability (Schrader, 1991) [13]. Immediate post operative radiographs revealed anatomic reduction with good cortical contact and stable implant in all the cases.

In most of the cases homogenous callus formation with obliterated fracture line and complete fracture union was observed on follow up examinations. Callus formation with discernible fracture line and complete bone union were also observed. Fractures treated by intramedullary pinning must unite by peripheral callus because the pin blocks the endosteal callus and new bone does not develop from the vascular cortical ends (Fossum, 2007) [5]. In two young animals intramedullary pins were entrapped inside the medullary canal and were left in place. It has been reported that intramedullary pins can be left in place unless there is loss of function or pin loosening (Priyanka *et al.*, 2019) [12].

Minor complication such as seroma formation and wound dehiscence in one case each were noticed. This may be due to the fact that pins provide poor axial stability and are liable to migration and arthrosis due to some amount of rotational deformity which may be present after implant placement (Smith, 1985) [17]. In rest of the animals there was no complication or gait abnormality. Implants were removed once satisfactory healing and functional usage of the operated limb occurred. Seven animals started weight bearing on operated limb after the pin removal. Another two cases did not turn up for implant removal. Excellent limb usage was seen in 10 cases and fair in two cases.

Fig 1: Photographs of dog treated with closed method showing weight bearing while standing on before surgery (A) and at 30 (B) and 60 days (C) post surgery.

Fig 2: Photographs of dog treated with closed method showing weight bearing while standing on before surgery (A) and at 30 (B) and 60 days(C) post surgery.

Fig 3: Photographs of dog treated with open method showing weight bearing while standing and walking on preoperative (A) and at, 30 (B) and 60 (C) day postoperatively.

Fig 4: Photographs of dog treated with open method showing weight bearing while standing on preoperative (A) and at 30 (B) and 60 (C) day postoperatively.

Fig 5: ML radiographic views of dog treated with closed method at preoperative (A), post-fixation (B) and at 15 (C), 30 (D) and 60 (E) days postoperatively.

Fig 6: CC radiographic views of dog treated with closed method at preoperative (A), post-fixation (B) and at 15 (C), 30 (D) and 60 (E) days postoperatively.

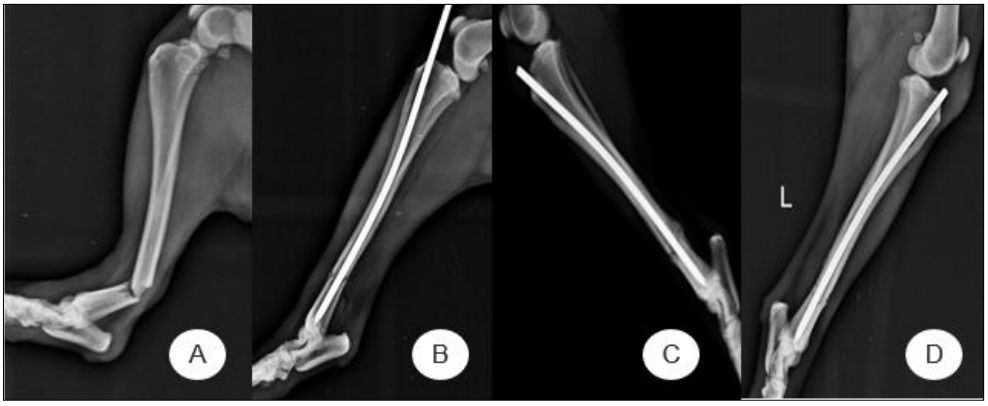

Fig 7: Mediolateral radiographic views of transverse distal diaphyseal fracture of tibia (A) treated with closed method just after surgery (B), 15 (C) and 30 (D) days post surgery.

Fig 8: Mediolateral radiographic views of a dog treated with open reduction at preoperative (A), post-fixation (B) and at 30 (C) and 60 (D) days postoperatively.

Fig 9: Mediolateral radiographic views of tibia with short oblique diaphyseal fracture (A) treated with open method just after surgery (B) and at 15 (C) and 30 (D) days post surgery.

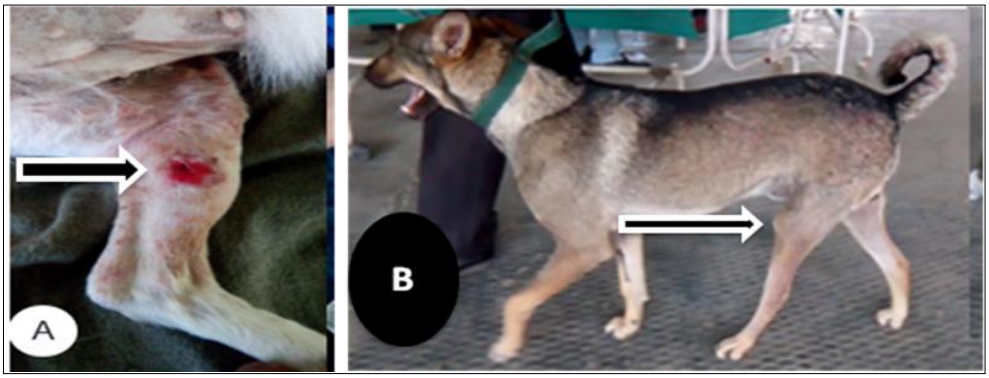

Fig 10: Minor complications like wound dehiscence (A) and seroma formation (B) were observed with open reduction method

Conclusion

From results of present study it was concluded that closed intramedullary pinning technique is useful to treat simple fractures of tibia in light weight dogs. In nutshell intramedullary pinning is an economical and less time consuming technique when cost of operation is important for considerations while selection of surgical technique.

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