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Evaluation of End-threaded Positive and Negative Profile Intramedullary Pins for Management of Long Bone Fractures in Dogs

Mukesh Shivhare[1], Surbhi Kuldeep Tyagi[1], Vivak Malik[1], Vineet Kumar[1], Chetan Kumar Singh[1], Prafull Kumar Singh[1]

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ABSTRACT

Background: Intramedullary pinning (IMP) is the most commonly used internal skeletal fixation technique. Threaded pins (also called Schanz Screws) provide a comparatively better holding strength than non-threaded tipped intramedullary pins. The present study was planned to evaluate and compare the efficacy of positive and negative profile end threaded intramedullary pins in the management of long bone fractures in dogs.

Methods: Eleven clients owned dog suffering from fracture of long bones were randomly divided in to two groups. Animals of group I (n=5) and group II (n=6) were treated with end threaded positive and negative profile intra medullary pin, respectively. The intramedullary pinning was done using 3 to 5.5 mm diameter pins under general anesthesia, the time taken for surgery, size of end threaded intramedullary pin used in each case was noted down. Radiographs were taken preoperatively, immediately after fixation and then at regular intervals till signs of radiographic healing were evident.

Result: There was no significant difference between the two groups in terms of time taken for fixation/surgery and in healing time, with a gradual improvement in weight bearing postoperatively in both the groups. There was mild periosteal callus formation in all the cases when observed radiographically and the pins were removed after radiographic healing was evident in an anticlockwise manner using Jacob's chuck and key, under mild sedation. There was no complication like implant failure or pin tract sepsis or pin migration or pin breakage in any of the cases of two groups. However, passing the positive profile end threaded intramedullary pin in distal fragment is comparatively smoother and easier as compared to negative profile end threaded intra medullary pin.

Key words: Fracture, Internal skeletal fixation fixation, Negative profile intramedullary pin, Positive profile intramedullary pin.

INTRODUCTION

Intramedullary pinning (IMP) is the most commonly used internal skeletal fixation technique and the different types of intramedullary pins are; (1) Smooth Intramedullary pin (IMP)- These are also called as Steinman pins and are the most commonly used intramedullary pins. They can be used either as (a) Single IMP or (b) Stack/multiple IMP. (2) Threaded Intramedullary pin (IMP)-These are relatively lesser used than smooth IM Pins and can be (a) Fully threaded or (b) End threaded IMP.

End threaded IMP are also called Schanz screws and can be (1) Positive profile end threaded and (2) Negative profile end threaded IMP. In positive profile pin the major diameter is greater than the pitch diameter where as in negative profile pin the major diameter is lesser than pitch diameter. These end threaded IM pins have potential advantages over smooth IM pins.

Threaded pins (also called Schanz Screws) provided a comparatively better holding strength than non-threaded tipped intramedullary pins (Ogurtan, 2006) and had been used for the repair of diaphyseal fractures (Kaur *et al.,* 2015) and management of distal third and supracondylar fractures of long bones in dogs (Kaur *et al*., 2016), with fewer implant related complications. The end threaded pin can resist bending, compression and rotational forces, better than smooth intramedullary pins and their use had been suggested in veterinary orthopaedics (De Camp *et al*., 2016). An initial study had suggested advantages of positive profile end threaded pins over negative profile end threaded pins (Chanana *et al*., 2018).

Nevertheless, reports on a direct clinical comparison between positive and negative profile end threaded pins are meagre. The present study is therefore designed to

[1]Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Sciences, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, Uttar Pradesh, India.

Corresponding Author: Surbhi Kuldeep Tyagi, Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Sciences, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, Uttar Pradesh, India.
Email: surbhiivri@gmail.com

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standardize the technique of application of end threaded intramedullary pins for management of long bone fractures in dogs with the objectives; to evaluate the efficacy of positive and negative profile end- threaded intramedullary pins for the management of long bone fractures in dogs and to compare the positive profile and negative profile end-threaded intramedullary pins for the management of long bone fractures in dogs.

MATERIALS AND METHODS

Selection of patient

Eleven clients owned dogs suffering from fracture of long bones amenable to intramedullary pinning, presented at VCC, COVAS, SVPUAT-Meerut, during the period of May 2020 to June, 2021, were taken as subject of the study. Animals of group I (n=5) were treated with end threaded positive profile intramedullary pins and animals of group II (n=6) were treated with end threaded negative profile intramedullary pins.

Implants used

The end threaded intramedullary pins made of 316 L stainless steel were used. In positive profile end threaded intramedullary pins, the main diameter (MD) was lesser than the pitch diameter (PD) (MD>PD). Whereas, in negative profile end threaded intramedullary pin, the main diameter is equal to the outer pitch diameter and the inner diameter is less (MD=PD). The pins were chosen so that approximately two third of the medullary canal was occupied and were inserted with the help of Jacob's chuck and key.

Preoperative observations

History

Anamnesis of the case regarding breed, age, sex and body weight of the animal, cause of the fracture, time since injury and primary treatment given, if any, was recorded.

Clinical examination

Clinical examination was conducted to determine the degree of lameness, bone involved, location of the fracture, type of fracture, presence of any wound.

Radiographic examination

Fractured limb was subjected to radiographic examination to confirm the type and location of fracture.

Intraoperative observations

Surgical fixation of fractures

As a part of patient preparation, the food and water were withheld for 12 hours and 6 hours, respectively, before surgery. Preoperative antibiotic (ceftriaxone @ 25 mg/kg) and analgesics (meloxicam @ 0.2 mg/kg, IM) were administered. The surgical site was prepared by hair clipping, shaving and scrubbing. Animals were pre-medicated with glycopyrrolate (@0.005 mg/kg), xylazine (@ 1.0 mg/kg) and pentazocine (@ 1 mg/kg); Induction of general anaesthesia was achieved by 1% propofol (@ 4-6 mg/kg) via intravenous route (IV) given "till effect" and maintenance was done with isoflurane using small animal anaesthesia machine through semiclosed circle system.

Retrograde intramedullary pinning was done in femur and humerus fractures, normograde pinning via tibial plateau was done in tibia and in one case of radius fracture normograde pinning via distal end (antigrade) of bone (styloid process) was done. End -threaded intramedullary pins (Schanz screws) of 3 mm to 5.5 mm diameter with length ranging from 12 to 18 cm were selected for this method according to the size of the bones.

The seating of end threaded intramedullary pin was a very important part of its placement. After the pin was introduced in clockwise rotating motion, crossed the fracture site and reduced the fracture, it was seated firmly in the distal fragment. The distance to be travelled by the pin was measured before its introduction into the distal fragment using the radiograph. The seating was achieved, by rotating the end threaded pins so that it may interdigitate with the cancellous bone. The positive profile pins were self -tapping and allowed adequate seating of the pin in the distal aspect of the bone. In one of the case, a full cerclage wiring was done (case no. 2 of Group II) to support the immobilization and to maintain the alignment. The time taken for surgery (in minutes) was recorded. The diameter of intramedullary pins used for the fixation was also recorded. Complication, if any, observed during the procedure of fixation was also noted.

Postoperative observations

Clinical observations

Broad spectrum antibiotic and anti-inflammatory drugs were continued, in prescribed doses for 5 days along with regular antiseptic dressing. Suture line, weight bearing and wound (if any) was evaluated and managed as per standard protocols. Skin sutures (polyamide suture) were removed after 10-12 days.

Radiographic observations

Radiographs were taken immediately after the fixation and thereafter, at 12th, 30th and/or 45th day, post-operatively.

Pin removal

After the evidence of radiographic healing the intramedullary pins were removed, if possible. Healing time was recorded based on the radiograph findings. These pins were removed using Jacob's Chuck in an anticlockwise manner (opposite to the direction of insertion of the IMP).

Statistical analysis

Descriptive statistics was used to describe the data in the form of statistical parameters like frequency, mean, S.E. of mean, number of observations. The group means were compared using student's t-test assuming equal variances between the groups. Data was analysed using data analysis pack of Microsoft excel.

RESULTS AND DISCUSSION

Pre-operative observations

A higher incidence of fracture was observed in German Shepherd and Non-descript dogs, with the Mean±S.E. values of age (months) of animals of group I and II as 18.20± 10.51 months and 10.00 ± 2.14 months, respectively. Road traffic accident (RTA) being the major cause of fracture among animals in the present study similar to findings of earlier studies (Braden *et al*., 1995; Aithal and Singh, 1999; Harasen, 2003; Yaqub, 2001; Tyagi *et al*., 2021).

The number of males (n=6) was slightly more than females (n=5) in the cases reported. This might be probably because of more active and aggressive nature of males, in addition, there was a preferential keeping of male dogs by the pet owners, which could have also contributed to their more number (Aithal *et al*., 1999; Kumar, 2007; Gill *et al*., 2018; Tyagi *et al*., 2021). Higher incidence of femur fractures (n=6) was recorded; followed by fracture of tibia (n=3); radius and humerus (n=1) each.

Intra-operative observations

An open reduction with a lateral approach was the technique of choice for diaphyseal, epiphyseal or metaphyseal femoral fracture repair; craniolateral approach was preferred for humeral fracture repair and medial approach was used for tibial fracture repair.

End threaded positive profile and negative profile intramedullary pins, made of stainless steel (316-L), were used (3-5.5 mm in both group) (Table 1 and 2). The end threaded intramedullary pins were inserted in a clockwise manner using Jacob's chuck and key. While both the pins were passed easily in the distal segment fitting in the cancellous bone, the positive profile end threaded pin was easier to pass and fit in the distal segment as they were self-tapping having screw like action, as also reported by Chanana *et al.* (2018).

The pins were used alone except in one case where it was used in conjunction with full cerclage wire (as per the necessity of that case). The pins were cut at the nearest point (leaving 5-10 mm) to where they exited the bone to minimize irritation caused by the pin end. Altunatmaz *et al.* (2012) had also left 5 -10 mm pin outside the bone proximally to enable the removal of pin following fracture healing.

Post-operative observations

Post-operatively the surgical wound was cleaned and Modified Robert Jones bandaging was applied in each case. In one case (Case no. 5, group I), modified Thomas splint was applied post operatively for 5 days. The Robert Jones bandage was changed on alternate day upto 5-10 days. In all the cases regular antiseptic dressing with liquid povidone-iodine solution was done and the sutures were removed 10-12 days, post-operatively. Antibiotics, anti-inflammatory drugs along with oral calcium were given to the animals. Surgical wound healed with first intention in all the animals. No complication of wound healing was observed.

Table 1: Clinical observations of the cases treated with positive profile end-threaded pins group (I).

Breed	Age (months)	Sex	B. Wt. (Kg)	Cause of Injury	Time since injury (Days)	Open/ Closed fracture	Bone involved	Location of Fracture	Fixation technique	Ancillary fixation	Duration of surgery (min.)	Time for healing (days)	Size of IMP (mm)
German Shepherd	7	F	23	RTA	15	Closed	Tibia	Mid diaphyseal transverse fracture	Normograde	None	27	60	4.5
ND	60	F	15	Hit by wooden stick	7	Closed	Tibia	Mid diaphyseal transverse fracture	Normograde	None	27	45	3.5
ND	6	F	6.4	RTA	2	Closed	Femur	Mid diaphyseal transverse fracture	Retrograde	None	33	55	4
Labrador	12	M	15	RTA	30	Open	Radius	Distal 1/3rd diaphyseal transverse fracture	Antigrade	None	25	Non union	3
German Shepherd	6	M	25	RTA	5	Closed	Femur	Proximal 1/3rd Diaphyseal, slight oblique fractur	Retrograde	None	32	29	5.5

The smooth intramedullary pins provide three point fixation, they were anchored at the point of introduction, has contact with the isthmus of the medullary canal and was impacted/screwed into the distal cancellous bone (Newton and Nunamaker 1985). This was true for end threaded negative profile pins also as their main diameter (MD) was equal to their pitch diameter (PD). However, in case of end threaded positive profile intramedullary pins, it seemed to have only two point fixation. As the main diameter (MD) of end threaded positive profile intramedullary pin was less than pitch diameter (PD), the first fixation was at point of introduction/proximal end of bone and the second was at distal end of the bone (cancellous bone). As the main diameter was less it did not come in contact with bone diaphysis in marrow cavity and pitch diameter was more and this was the area of seating of intramedullary pin in cancellous bone (Contact point).

Weight bearing

The weight bearing and locomotion seemed to be dependent on soft tissue trauma during fracture fixation and irritation caused by the ends of pins or migration of pin. In all the cases partial weight bearing was noticed on 7th-14th post-operative day and nearly complete weight bearing was observed in between 40 to 60 post-operative day (except for 2 cases where lameness was observed).These findings were similar with those reported by Altunatmaz *et al.* (2012) where the authors used fully threaded intramedullary pins in the treatment of various long bone fracture. Chanana *et al*. (2018) also reported weight bearing between 5-15 days after the operation and functional recovery was seen to increase gradually, with full weight-bearing without any signs of complication after day 20.

Two cases showing lameness in our study were from both groups I and II and (One in each group). In one case in a dog with tibia fracture (Case- 5, group II) the pin was touching the patellar ligament leading to lameness throughout the healing period. However, the dog started very good weight bearing after two days of pin removal. In another case (Case 4, group I), there was fracture of radius and was presented after 30 days of fracture. The delayed presentation of the case was due to COVID-19 outbreak. This particular case was highly infected and regular cleaning and antiseptic dressing of the limb was done with povidone-iodine solution for 7 days which further delayed the surgery. Regular radiographs were taken which showed non-union up to 150 days and there was constant lameness. The late presentation of case seems to be the reason for non-union and thus the non-weight bearing from the affected limb.

Healing and callus formation

The Mean±S.E. values of time for healing (days) were 47.25 ± 6.83 and 54 ± 3.96 days for group I (n=4; one case was of non-healing and thus was omitted from the calculation of healing time) and group II (n=6), respectively. The healing time in group I (Positive profile IMP) was lower than in group II, but the difference was non-significant.

Table 2: Clinical observations in cases treated with negative profile end threaded pins group (II).

Breed	Age (months)	Sex	B. Wt. (kg)	Cause of injury	Time since injury (days)	Open/ closed fracture	Bone involved	Type and location of fracture	Fixation technique	Ancillary fixation	Duration of surgery (min.)	Time for healing (days)	Size of IMP (mm)
Boxer	9	M	20	RTA	15	Closed	Femur	Mid diaphyseal transverse fracture	Retrograde	None	24	45	5
German Shepherd	3	M	17	RTA	7	Closed	Femur	Mid diaphyseal oblique fracture	Retrograde	Full cerclage wiring	35	50	4.5
German Shepherd	6	M	15	RTA	2	Closed	Femur	Proximal 1/3rd diaphyseal, slight oblique fracture	Retrograde	None	32	45	4.5
Boxer cross	18	M	25	Fall from height	30	Closed	Femur	Distal 1/3rd diaphyseal transverse fracture	Retrograde	None	36	55	5.5
ND	12	F	13.5	RTA	5	Closed	Tibia	Proximal 1/3rd diaphyseal, slight oblique fracture	Normograde	None	27	70	3
ND	12	F	15	RTA	14	Closed	Humerus	Mid diaphyseal transverse fracture	Retrograde	None	20	60	4.5

A radiographic follow-up carried out regularly after surgery when a bridge of periosteal callus was seen on post-operative radiographs, it was classified as healed (Fig 1-4). In all the cases healing was evident with a moderate degree of periosteal callus. The pins were not removed till there is evidence of callus formation with healing and proper weight bearing.

Complications/Pin migration

In our present study, pin migration was not observed at any stage in the animals of any of the groups. Rotational forces were overcome by the implant used as the threads were embedded in distal cancellous bone firmly. The results of this study were in relevance with the findings of Ozsoy (2004) who conducted a study to examine the use of full threaded Steinmann pins for adequate rotational stability and prevention of pin migration when applied in normograde fashion in fractures of the femur, humerus and tibia of cat. However, an earlier study had reported migration of an end threaded negative profile pin (Chanana *et al.,* 2018). There was no pin migration in any of the cases and there was no bone shortening or fragment collapse in our study. In present study, no any radiological or clinical complications were seen in the healing period of fractures belonging to skeletally immature patients. When a proper size of intra medullary pin was used, possibility of pin migration was reduced. The compression of the fractured segment at the fracture line was evident as the positive profile pin was screwed in to the distal fragment ensuring near normal continuity of the bone length and contour.

It had been reported that the partially threaded pins having a negative profile ending create a weak point in the pin-thread junction and the pin-thread junction must not be near the fracture line (Olmstead *et al*., 1995; Denny and Butterworth, 2000). Positive profile pins do not have this problem because the threads were raised above the core diameter of the pin. Thus, there were no stress riser (weak point) at the thread non-thread interface (Gilley and Gold, 2006) and the implant appeared very sturdy. However in the present study no such complication was observed and pin breakage was recorded neither in group I nor in group II.

Method of implant application and removal

Technique of implant application was same in both the groups and removal of implant was done with the help of Jacob's chuck and key in an anti-clockwise rotation because of firm grip attained by threads of pins in the cancellous bone at the time of pin removal. A similar procedure was reported by Piermattei *et al*. (2006) and Chanana *et al.*

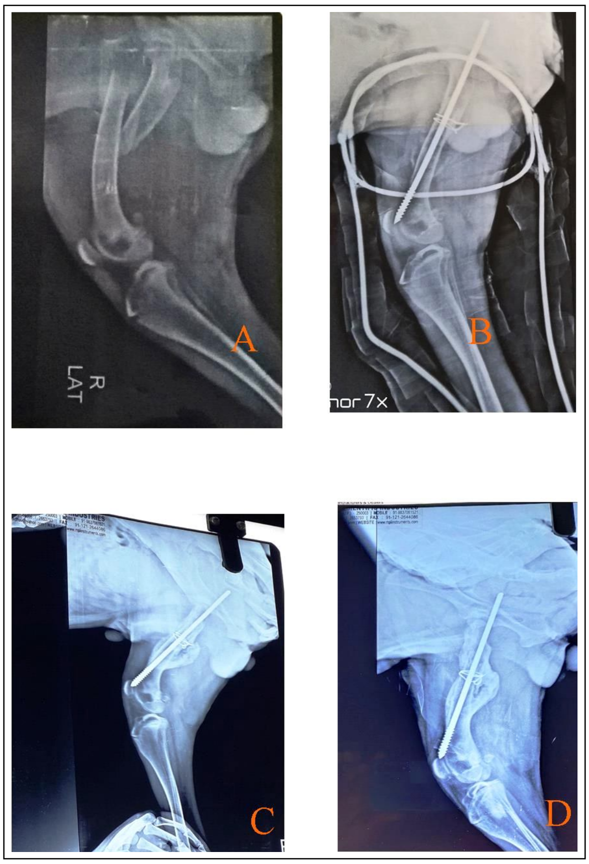

Fig 1: Preoperative (A); Immediate postoperative (B); 30 day follow up (C); 45 day follow up radiographs of case no.5 (Group-I).

Fig 2: Preoperative (A and B) and Immediate postoperative (Cand D) radiograph of case no. 2 (group I).

Fig 3: Preoperative (A); Immediate postoperative (B); 15 day follow up (C); 45 day follow up radiographs of case no. 4 (Group-IID).

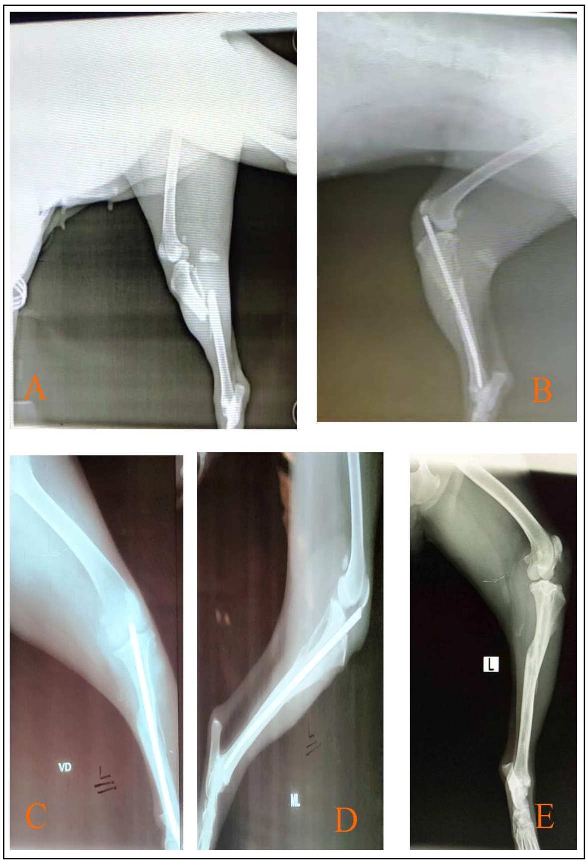

Fig 4: Preoperative (A); Immediate postoperative (B); 75 day follow up (C)and (D); After pin removal (E) follow up radiographs of case no. 5 (Group-II).

(2018) *i.e*. on removing a threaded pin after fracture healing, it was necessary to "unscrew" the pin because bone was grown into the threads and not because the pin was threaded into the bone.

There was no evidence of axial rotation or compression or tension at either of the fracture lines in any of the case. The end-threaded intramedullary pins fitted into the medulla like a screw it provided more effective rotational stability by gripping the spongy bone in the distal diaphysis at the same time. The end threaded intramedullary pin of both profiles (positive and negative) provide a sufficient degree of fixation. Also the complications associated with end threaded negative profile intramedullary pin, which had been reported in an earlier study (Chanana *et al.,* 2018) were not observed in the present study. There were no case of pin migration in the present study which was the most common complication associated with simple steinmann intramedullary pinning.

Conclusion

There was no significant difference between the positive and negative end threaded intra medullary pinning techniques in terms of healing time or fracture fixation. However, passing the positive profile end threaded intra medullary pin in distal fragment was comparatively smoother and easier as compared to negative profile end threaded intra medullary pin. Both the positive and negative profile end threaded intra medullary pin were efficient for the management of long bone fractures in dogs as they resisted pin migration, pin breakage and fixation failure, were easily available, economical and can be used with the same instrumentation as for smooth intramedullary pinning.

Conflict of interest: None.

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