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Elastic stable intramedullary nailing using Titanium elastic nails for the management of tibial fractures in dogs[#]

Ankush Kumar[1*], R. N. Chaudhary[2], Ramniwas[3] and Priyanka[3]
Department of Veterinary Surgery and Radiology
Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, India

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Abstract

The present study was conducted on six dogs, selected randomly irrespective of their age, sex and breed; diagnosed with tibial diaphyseal fracture. For the repair of fracture of tibia, Titanium elastic intramedullary nailing was performed in all the cases. Clinical, orthopaedic, radiographic and haemato- biochemical examinations were performed pre-operatively, just after the surgery, at 15th, 30th and 60th post-operative days. Gradual improvement in weight bearing on the operated limb was shown by all the cases starting from 4th to 7th post-operative day followed by complete weight bearing on 30th post-operative day in four cases and all the dogs had shown complete weight bearing without lameness while moving on 60th post-operative day. Satisfactory fracture alignment was shown in the post-operative radiograph at 15th, 30th and 60th days after the surgery. Slight migration of the nails at site of insertion in three cases were observed on clinical examination, which were easily managed by cutting the extra length of the nail outside the skin along with regular antiseptic dressing of the wound. The haemato-biochemical parameters were found within the normal clinical range at different time intervals of examination. On the basis of this study, it was found that the Titanium elastic stable intramedullary nailing has good efficacy for the repair of diaphyseal fracture of tibia without having any systemic adverse effects in dogs.

Keywords: *Dogs, ESIN (elastic stable intramedullary nailing), titanium elastic nail (TEN)*

A healthy musculoskeletal system with normal function, is important for the survival and well-being of the individual. However, this system is commonly affected by many orthopedic conditions like fractures, injuries to tendons and muscles, joint diseases, metabolic alterations and neoplastic or infectious diseases (Piermattei *et al.*, 2006; Souza *et al.*, 2011). In dogs,

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1. *M.V.Sc. scholar*
2. *Associate Professor and Head*
3. *Assistant Professor*

**Corresponding author: dr.ankushgill@gmail.com, Ph. 8728862446*

orthopedic conditions are common, especially those caused by trauma (Ali, 2013; Elzomor *et al.*, 2014). Long bone fracture is a common orthopaedic condition found in dogs (Phillips, 1979; Schwarz, 1991; Harasen, 2001). In dogs, incidence of fractures of hindlimb is higher as compare to fractures of forelimb (Minar *et al.*, 2013; Balagopalan *et al.*, 1995; Sousa *et al*., 2011;) where femur is most commonly affected followed by tibia and fibula (Minar *et al.*, 2013; Ali, 2013; Jain *et al.*, 2018; Singh *et al.*, 2015). In orthopaedics, the main aim of fracture fixation is to achieve the fastest possible healing and allow early limb mobility (Aron, 1998; Shahar, 2000). Elastic stable intramedullary nailing (ESIN) has become a popular method in medical sciences for osteosynthesis of diaphyseal fractures in children (Lascombes *et al.,* 2006) because of its various advantages like avoidance of growth plate injury in paediatric fracture treatment, early bridging of callus and rapid restoration of bone continuity which leads to early limb function, direct mobilisation to maintain joint movement and muscle tone as well as normal circulation (Ligier *et al.,* 1988; Mazda *et al.,* 1997; Flynn *et al.,* 2001; Flynn *et al.,* 2004; Hunter, 2005; Lascombes *et al.,* 2006). The use of titanium alloys has been increasing for ESIN because of their low Young's modulus of elasticity, appropriate mechanical properties, excellent biocompatibility and good corrosion resistance (Uhthoff *et al.*, 1981; Cui *et al.*, 2011). The present study was conducted to evaluate the efficacy of elastic stable intramedullary nailing using titanium elastic nails (TEN) for the management of tibial fractures in dogs.

Materials and methods

On the basis of history, clinical and radiographic examination, six dogs with diaphysial fracture of tibia were selected randomly irrespective of their age, sex and breed. In all the dogs, fixation of fracture was done by ESIN technique by using titanium elastic nails. Thorough clinical, orthopaedic, radiographic and haemato-biochemical evaluations were performed in all the animals at different time intervals of observation i.e., pre-operative, just post-operatively, at 15th, 30th and 60th post-operative days. Pre-operative radiographic evaluation of diameter of isthmus of the fractured bone was done for selection of diameter of the TEN (Fig. 1).

The surgical procedure was performed under general anaestheisa by using combination of Inj. Atropine sulphate @ 0.04 mg per kg b.wt (pre-anaesthetic), Inj. Xylazine hydrochloride @ 1 mg per kg b.wt and Inj. Ketamine hydrochloride @ 5 mg per kg b.wt intramuscularly for induction followed by maintenance of anaesthesia by using isoflurane inhalant anaesthetic agent (1-5%).

Close reduction method was used in two cases and open surgical method was performed in four cases for reduction of the fracture fragments followed by passing of the nails from one fracture fragment to the other via the pre-drilled hole at the metaphyseal cortex (Fig. 2). At the metaphyseal cortex, two holes were drilled on medial and lateral surface of the bone each at an oblique angle to the bone by using bone awl. For the open surgical method, the animal was placed in lateral recumbency with affected limb lowermost followed by skin incision over medial surface of the affected limb. After the skin incision, dissection of the subcutaneous fascia was performed bluntly in order to avoid damage to the dorsal branches of saphenous vessel and the nerve passing through the surgical site followed by exposure of the shaft of tibia. After passing of both the nails through the pre-drilled holes into the opposite metaphyseal cortex, the exposed portion of the nail at the insertion site was bent slightly away from the bone before cutting it near the surface of the bone with the help of nail cutter. Around 1-2cm of the exposed portion of the nail was left outside the bone to facilitate removal of the nail at the time of complete healing of the fracture. The exposed portion of the nail was covered with the subcutaneous tissue followed by application of a single horizontal mattress or simple interrupted suture with silk (# 1) for the closure of the skin wound. Once the fracture has been healed, removal of the nail was performed by giving stab skin incision at the nail insertion site followed by pulling the nail with the help of extraction plier for TEN. The skin wound at the nail removal site was closed by applying simple interrupted suture with silk (#1). Inj. meloxicam @ 0.3 mg per kg b.wt and Inj. Cefotaxime @ 20-

25 mg per kg b.wt were injected intramuscularly for pre-emptive analgesia and prophylactic antibiotic respectively. Scoring for the bone formation and bone union were performed on the basis of extent of bridging callus formation and disappearance of the fracture line as per Lane and Sandhu (1987) (Table 1 and 2). C-arm system (Allengers®-HF49R, Chandigarh, India) was used for the intra-operative radiographic examinations and for pre and post-operative radiographic examination, Siemens® X-ray machine and Konika Minolta® Computerised Radiographic System were used. In the study,

Table 1. Bone formation scores as per Lane and Sandhu (1987)

Description	Score (0-4)
No evidence of bone formation	0
Bone formation in 25% of the gap	1
Bone formation in 50% of the gap	2
Bone formation in 75% of the gap	3
Bone formation in 100% of the gap	4

Titanium elastic stable intramedullary nailing instrument set along with the titanium elastic nails having different diameters were used

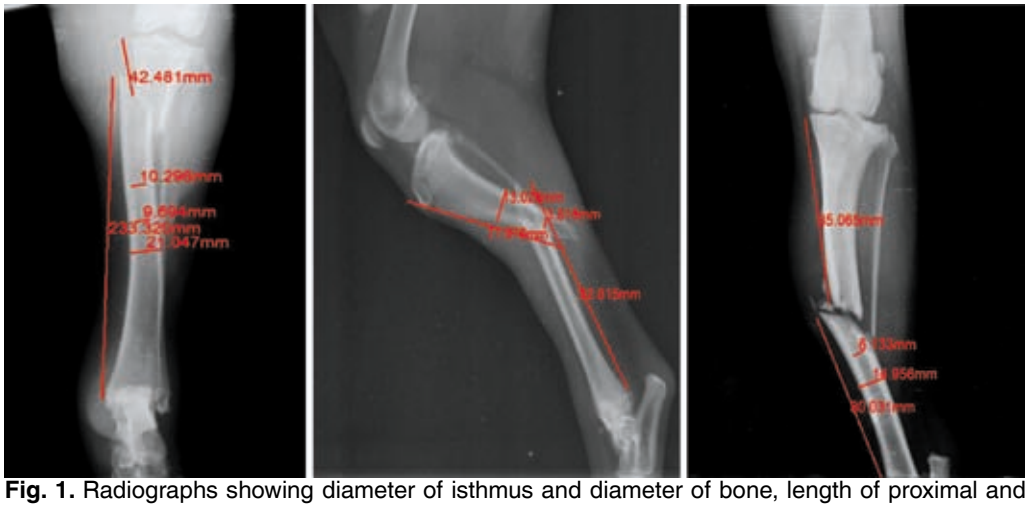

Fig. 1. Radiographs showing diameter of isthmus and diameter of bone, length of proximal and distal fragments of fracture

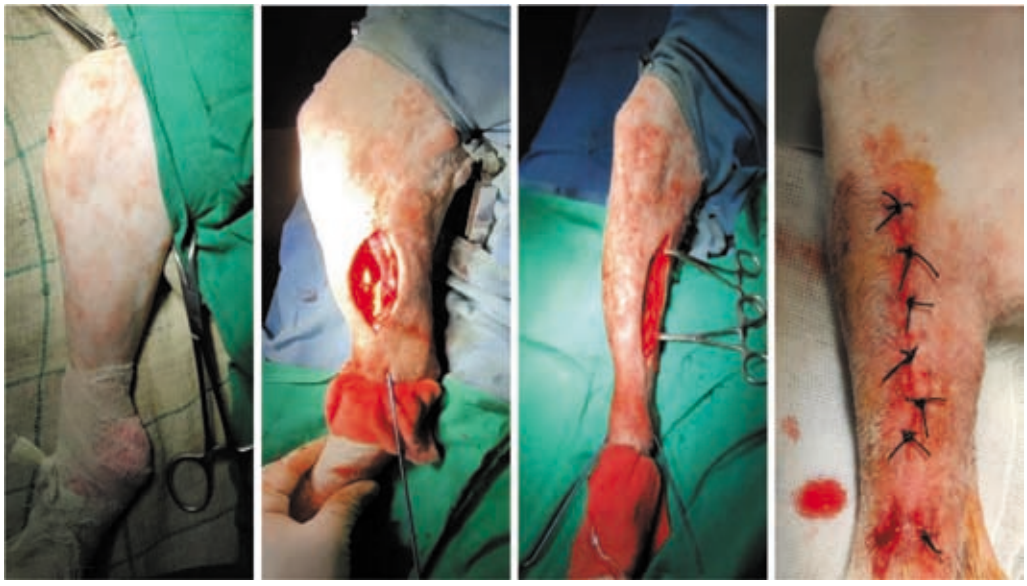

Fig. 2. Intraoperative photographs showing titanium elastic stable intramedullary nailing in dog with fracture of tibia at mid diaphysis

Table 2. Bone union scores as per Lane and Sandhu (1987)

Description	Score (0, 2, 4)
With complete fracture trace	0
With incomplete fracture trace	2
Absence of fracture trace	4

for the fracture repair. Statistical analysis of haemato-biochemical data was done by SPSS software.

Results and discussion

In the study, out of six dogs, five dogs had body weight more than 15kg and one dog had body weight in between 12.5kg. Etiology of fracture, bone affected, type of fracture and location of fracture for all the cases are given in table 3. Intraoperative C-arm radiography was performed for the confirmation of proper anatomical reduction of the fracture fragments and proper placement of the titanium elastic nail which revealed satisfactory anatomical reduction and proper placement of titanium elastic nails in the present study (Fig. 3). Gradual improvement in weight bearing on the operated limb was shown by all the cases starting from 4th to 7th post-operative day followed by complete weight bearing on 30th post-operative day in four cases and all the dogs had shown complete weight bearing without lameness while moving on 60th post-operative day. Satisfactory fracture alignment was shown in the post-operative radiographic examinations at 15th, 30th and 60th days after the surgery (Fig. 4). As per the scoring system given by Sahu *et al*. (2017), scoring for weight bearing on the operated limb while standing and walking at different time intervals of examination had shown increase in the mean ± S.E. from 0±0.00 at 0th day to 3.00±0.00 and 4.00±0.00 at 60th post-operative day respectively (Table 4). As per the scoring system given by Lane and Sandhu (1987), evaluation of bone formation score and bone union score was done on radiographic examinations. There was an increase in the mean ± S.E. of bone formation score (BFS) and bone union score (BUS) from 0±0.00 at 0th day to 3.67±0.21 and 3.00±0.45 at 60th post-operative day respectively (Table 5). As per staging system given by Hammer *et al.* (1985), stages of bone union of all the dogs at different time intervals were recorded which had shown achievement of bone union in 66.67 per cent cases on 30th post-operative day while it was achieved in all the cases by 60th post-operative day.

On clinical examination, satisfactory surgical wound healing was observed in all the cases and on 60th post-operative day, full range of motion of both the proximal and distal joints without any crepitation was found in all the cases. Slight migration of the nails at site of insertion in three cases were observed on clinical examination (Fig. 5) which were easily managed by cutting the extra length of the nail outside the skin along with regular antiseptic dressing. Although these migrated nails lead to open wound formation at the insertion site, there was no infection observed with povidone iodine application at the site during the post-operative period. The nails were removed on 60th post-operative day after assessment of weight bearing on clinical examination and fracture healing status on radiographic examination. Evaluation and grading of post-operative functional limb usage was done on the basis of degree of lameness and classification system developed by Fox *et al.* (1995) on 60th post-

Table 3. Etiology of fracture, bone affected, location of the fracture and the type of fracture in Dogs

Sl. No.	Etiology of fracture	Bone affected	Location of fracture	Type of fracture
1	Being stepped by buffalo	Right tibia	Proximal diaphysis	Oblique
2	Fall from height	Right tibia	Mid diaphysis	Oblique
3	Hit by wooden stick	Left tibia	Mid diaphysis	Transverse
4	Hit by wooden stick	Right tibia	Mid diaphysis	Comminuted
5	Automobile accident	Right tibia	Mid diaphysis	Transverse
6	Fall from height	Right tibia	Proximal diaphysis	Oblique

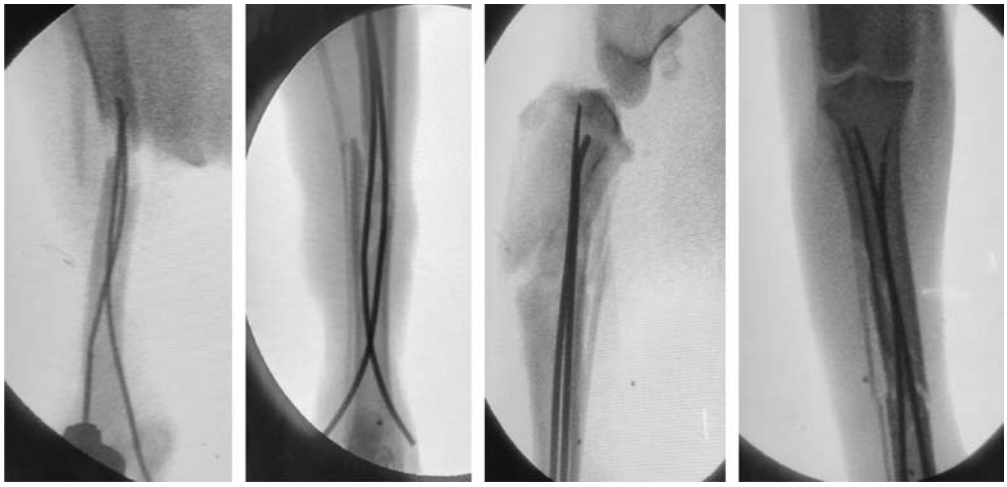

Fig. 3. Intraoperative C-Arm radiographs of different dogs during repair of fracture of tibia by using ESIN by using TENs

Fig. 4. Postoperative radiographs of tibia in dog treated with ESIN by using TENs on 15th, 30th and 60th post-operative day respectively

Table 4. Mean ± S.E. of weight bearing scores observed during standing and walking at different time intervals of examination

Mean ± S.E.	0th day	15th day	30th day	60th day
During standing	0.00±0.00	2.17±0.17	3.00±0.00	3.00±0.00
During walking	0.00±0.00	2.17±0.31	3.67±0.21	4.00±0.00

Table 5. Mean ± S.E of bone formation scores (BFS) and bone union scores (BUS) observed at different time intervals of examination

Time Interval	0th day	15th day	30th day	60th day
BFS	0±0	1.33±0.21	2.83±0.17	3.67±0.21
BUS	0±0	1.33±0.42	1.67±0.33	3.00±0.45

operative day. Grading of functional limb usage was found to be excellent in four cases, good and fair in one case each (Table 6).

At different time intervals of examination, the haematological parameters were found within the normal clinical range but statistically significant decline in the mean value of neutrophils (%) and total leucocyte count and significant increase in the mean value of lymphocytes (%) were observed at 15th post-operative day as compare to their respective immediate post-operative values (Table 7). This was an indication of resolution of inflammation and surgical stress post-operatively as observed by Maiti *et al.* 1999. Although all the serum biochemical parameters were within the normal clinical range, there was statistically significant decline from 30th to 60th post-operative day in the mean values of serum calcium level and significant increase in the mean values of serum sodium levels at 15th post-operative day as compare to immediate post-operative period (Table 8). The calcium level in blood was raised statistically initially during the fracture healing due to the calcium mobilization from different sites of the body via blood at the fracture site followed by decline in the level when the fracture had almost healed. The statistical rise in the serum sodium level after the surgery was due to the returning of the patients to their normal feeding habit, as in case of stress and pain animals had lack of appetite and even anorexia in many cases and also all the dogs remained off-fed for 12-24h prior to the surgery.

Fig. 5. Photographs showing migration of nail observed on clinical examination in three cases

Conclusion

On the basis of clinical, orthopaedic and radiographic evaluations, it was concluded that Titanium elastic stable intramedullary nailing for the management of transverse or short oblique fracture of diaphyseal region of tibia in dogs had good clinical outcome with early post-operative functional limb usage and weight bearing. However, nail migration at the insertion site was the main complication which was managed easily without any severe complication. The haemato-biochemical parameters remained within normal limits which indicated that there were no any systemic adverse effects caused by the titanium elastic nails used for the repair of tibial fractures in dogs.

Table 6. Functional limb usage (Fox *et al.,* 1995) in dogs treated with ESIN by using TENs

Functional limb usage grading	Number of cases (n)
Excellent	4
Good	1
Fair	1

Table 7. Mean ± S.E. values of different haematological parameters of all the cases at different time intervals of examination

Time interval	Pre-operative	Immediate post-operative	15th day	30th day	60th day
Haemoglobin (mg/dl)	12.77±0.77	11.68±0.50	12.57±0.50	12.92±0.51	13.42±0.62
TEC (x10^6/ µl)	6.17±0.15	6.42±0.21	6.69±0.23	7.12±0.41	8.12±1.03
TLC (x10^3/µl)	13.93^{ab}±1.09	14.88^{a}±1.13	10.72^{bc}±0.61	9.69^{c}±0.94	8.95^{c}±0.87
Neutrophils (%)	77.28^{a}±1.39	80.97^{a}±1.41	64.17^{b}±1.34	63.43^{b}±1.35	62.50^{b}±1.22
Lymphocytes (%)	15.87^{b}±1.32	13.25^{b}±1.30	26.42^{a}±1.48	28.05^{a}±1.47	29.32^{a}±1.46
Monocytes (%)	4.30±0.63	4.12±0.38	7.28±0.62	6.85±0.21	6.28±0.45
Eosinophils (%)	1.85±0.30	0.95±0.30	1.63±0.26	1.05±0.20	1.40±0.19
Basophils (%)	0.70±0.15	0.72±0.18	0.50±0.10	0.62±0.14	0.50±0.14

Means with different superscripts (a, b, c) vary significantly (p<0.01) within group

Table 8. Mean ± S.E. values of different serum biochemical parameters of all the cases at different time intervals of examination

Time interval	Pre-operative	Immediate post-operative	15th day	30th day	60th day
ALT (IU/L)	26.20±3.96	24.52±4.50	27.62±3.85	23.87±4.57	28.30±4.49
AST (IU/L)	28.18±2.92	28.02±3.45	23.02±2.81	30.33±3.59	28.15±4.18
ALP (IU/L)	82.83±13.40	67.83±11.67	67.17±10.64	55.67±10.85	42.00±4.29
Creatinine (mg/dl)	0.66±0.06	0.58±0.06	0.63±0.03	0.52±0.08	0.67±0.08
BUN (mg/dl)	10.84±1.53	10.26±1.19	9.84±0.95	8.74±1.12	9.21±1.34
Total protein (g/dl)	4.49±0.47	4.15±0.37	4.65±0.39	4.88±0.62	5.00±0.38
Albumin (g/dl)	2.44±0.21	2.29±0.14	2.58±0.16	2.37±0.30	2.62±0.24
Globulin (g/dl)	2.06±0.29	1.85±0.28	2.07±0.25	2.51±0.34	2.38±0.23
A:G ratio	1.28±0.13	1.43±0.21	1.36±0.13	0.96±0.05	1.15±0.13
Calcium (mg/dl)	9.52^{ab}±0.21	9.17^{b}±0.43	9.72^{ab}±0.22	10.55^{a}±0.27	9.13^{b}±0.31
Phosphorus (mg/dl)	4.00±0.30	3.87±0.39	3.62±0.47	3.83±0.77	3.15±0.37
Sodium (mEq/L)	158.70^{ab}±4.97	141.55^{b}±4.40	168.00^{a}±5.26	157.87^{ab}±3.77	140.87^{b}±3.70
Potassium (mEq/L)	4.47±0.34	4.20±0.31	4.79±0.46	5.00±0.56	4.75±0.54
Chloride (mEq/L)	124.17±4.14	116.30±4.25	128.73±4.07	121.77±2.85	124.23±3.16

Means with different superscripts (a, b) vary significantly ($p<0.05$) within group

Conflict of interest

The authors declare that they have no conflict of interest.

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