RESEARCH ARTICLE

Post-operative evaluation of Titanium Elastic Stable Intramedullary Nailing for Long Bone Fractures in Dogs

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Abstract

The study was conducted on ten clinical cases, diagnosed with long bone diaphyseal fractures selected randomly irrespective of their age, sex and breed. All the fractures were repaired with titanium elastic stable intramedullary nailing. Post-operative clinical and radiographic evaluations of the repaired bone were done immediately after the recovery from anaesthesia, and at 15th, 30th and 60th post-operative days. The results showed significant improvement in the weight bearing and functional limb usage score. Slight migration of the nail at the insertion site was observed in four cases which were easily managed without any serious complication. On radiographic evaluation a significant increase in bone formation score and bone union scores were observed post-operatively. Overall, the outcomes were favourable in dogs with respect to weight bearing, functional limb usage, bone formation, bone union and callus index with titanium elastic stable intramedullary nailing.

Key words: Dogs, ESIN (elastic stable intramedullary nailing), Fracture, Titanium elastic nail.

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Introduction

Fracture in animals invariably causes pain and suffering apart from loss of function of affected limb (Vardhan *et al*., 2017). The primary goals of fracture healing are regeneration of mineralized tissue at fracture site and to restore the integrity and mechanical strength of the fractured bone (Marsell and Einhorn, 2011). Healing of fracture is characterized by the production of a new organic matrix (osteoid) and its subsequent mineralization, that ultimately leads to bridging the gap between two bony fragments (bridging callus) (Johnson and Watson, 2000). The time required for normal fracture healing depends on several local and systemic parameters, mainly fracture site, age of the animal, type of fixation, stabilization, and blood supply to fracture ends (Komnenou *et al*., 2005).

In medical science, elastic stable intramedullary nailing (ESIN) is a common and well-accepted method of repair of diaphyseal fractures in children and adolescents due to its various advantages like avoidance of growth plate injury, minimal invasiveness, early bridging of callus and rapid restoration of bone continuity, which leads to early ambulation, the ability to maintain joint movement and muscle tone as well as normal circulation (Hunter, 2005; Lascombes *et al.,* 2006). Amongst the materials available for implant, the titanium-based materials for implantation due to its outstanding characteristics such as high strength, high immunity to corrosion, low density (high specific strength), enhanced biocompatibility, complete inertness to body environment, low modulus and high capacity to join with bone and other tissues (Niinomi, 2003). Titanium and its alloys have been used successfully for orthopedic and dental implants in medical sciences. The objective of this study was to evaluate the efficacy of titanium elastic stable intramedullary nailing for long bone fractures in dogs.

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Materials and Methods

On the basis of history, clinical and radiographic examinations, ten dogs with diaphysial fracture of long bones were selected randomly irrespective of their age, sex and breed for elastic stable intramedullary nailing (ESIN). All the fractures were repaired with ESIN technique using titanium elastic nails (TENs) after the consent of owners. Post-operative care included antiseptic dressing of the surgical wound with povidone-iodine solution (0.2%) and application of modified Robert Jones Bandage (RJB) for 14 post-operative days (Fig. 1). For analgesia, Inj. Meloxicam was given intramuscularly @ 0.3 mg per kg b.wt. once a day for 3 days and for antimicrobial prophylaxis, Inj. Cefotaxime was administered intramuscularly @ 20-25 mg per kg b.wt. once daily for five

days. The movement of the animal was restricted for the first 5 post-operative days followed by gradual increase in the exercise. Skin sutures were removed after 12 days of surgery.

Post-operative clinical and radiographic evaluations were performed in all the operated dogs at different time intervals, *i.e.,* just after recovery from anaesthesia (0^{th}) and on 15^{th}, 30^{th} and 60^{th} post-operative days. The animals were examined for weight bearing and functional limb usage. Scoring of weight bearing while standing (Score 0-3; Carrying the limb off the ground surface - 0; Touching the toe on the ground surface - 1; Touching the paw on the ground surface - 2; Full weight bearing on the limb - 3) and while walking (Score 0-4; Carrying the limb off the ground surface - 0; Occasional touching of toe/paw on the ground surface - 1; Frequent touching of toe/paw on the ground surface - 2; Touching of the toe on every step along with partial weight bearing -3; Touching of the paw on every step along with complete weight bearing - 4) was done as per Sahu *et al.* (2017).

Post-operative functional limb usage was evaluated on the basis of degree of lameness and was graded using classification system developed by Fox *et al.* (1995) at 60^{th} post-operative day as Excellent - Weight bearing without lameness, Good - Slight lameness, Fair - Slight to moderate lameness principally after exercise, and Poor - Intermittent or consistent non-weight bearing lameness.

The radiographic assessments of fracture healing were done at designated time intervals. Scoring for the bone formation and bone union were done on the basis of extent of bridging callus formation (Score 0-4; No evidence of bone formation - 0; Bone formation in 25%, 50%, 75% and 100% of the gap as 2, 3, 4, respectively) and disappearance of the fracture line (Score 0, 2, 4; Complete fracture trace - 0; Incomplete fracture trace - 2: Absence of fracture trace - 4) as per Lane and Sandhu (1987).

Different stages of bone union at different time intervals were evaluated using radiographic staging system developed by Hammer *et al.* (1985) (Table 1).

Table 1: Radiographic staging system used in evaluation of the different stages of bone union at different time intervals

Grade	Callus Formation	Fracture Line	Stage of Union
1	Homogenous bone structure	Obliterated	Achieved
2	Massive- Bone trabeculae crossing the fracture line	Barely discernible	Achieved
3	Apparent-Bridging of fracture line	Discernible	Uncertain
4	Trace- No bridging of fracture line	Distinct	Not Achieved
5	No callus formation	Distinct	Not Achieved

On the basis of radiographic examinations, the callus index was calculated for the evaluation of the stability at the fracture site as follows-

$$\text{Callus Index} = \frac{\text{Diameter of the callus at the fracture site}}{\text{Diameter of the bone just proximal or distal to the fracture site}}$$

Results and Discussion

The dogs initiated bearing weight on the operated limb from 2^{nd}-7^{th} post-operative days with a mean of 4.20±0.55 days followed by gradual improvement. There was complete weight bearing while standing in seven dogs at 30^{th} post-operative day (Fig. 2), however, all the ten dogs showed complete weight bearing while movement without lameness on 60^{th} post-operative day (Fig. 3). Early weight bearing after fracture repair helps in early rehabilitation (Brumback *et al.* 1988). Singh *et al.* (2015) also observed early weight bearing by using Titanium elastic intramedullary nailing in long bone fracture in dogs.

Gradual improvement in the mean weight bearing score during standing was observed from 0.00±0.00 on 0^{th} day to 3.00±0.00 on 60^{th} day after the surgery and during walking from 0.00±0.00 on 0^{th} day to 4.00±0.00 at 60^{th} post-operative day (Table 2). Grading of functional limb usage was found to be excellent in seven cases, good in two cases and fair functional limb usage in one case (Fig. 4).

Fig. 1: Postoperative photographs showing Modified Robert Jones Bandage (RJB) in dogs treated with titanium elastic stable intramedullary nailing

Fig. 2: Initial weight bearing on the operated limb on 30^{th} post-operative day

Fig. 3: Complete weight bearing while moving on 60th post-operative day

Table 2: Weight bearing scores during standing (0-3) and during walking (0-4) observed in all the cases under study (n=10)

Weight bearing Score (Mean ± SE)	Post-operative days			
	0th day	15th day	30th day	60th day
During standing (0-3)	0.00±0.00	2.30±0.15	3.00±0.00	3.00±0.00
during walking (0-4)	0.00±0.00	2.60±0.31	3.70±0.15	4.00±0.00

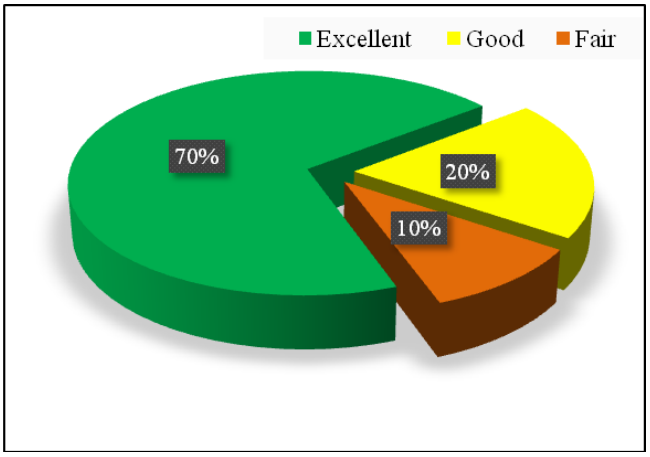

Fig. 4: Post-operative functional limb usage in dogs treated with titanium elastic stable intramedullary nailing with percentage

Radiographic examinations at different time intervals post-operatively revealed satisfactory anatomical reduction and fracture alignment in all the dogs (Fig. 5). There was improvement in the bone union score (BUS) and bone formation score (BFS) from 0±0.00 at 0th day to 3.70±0.32 and 3.70±0.15 at 60th post-operative day, respectively (Table 3). As compared to rigid fixation, dynamic fracture fixation technique causes micro-movement conferred by the elasticity of the fixation at the fracture site promotes faster external bridging callus formation leading to early fracture union (Asif *et al.,* 2011; Saha *et al.,* 2015). Callus index in the dogs ranged from 1.42 to 2.04 on 60th post-operative day (Table 4). Altunatmaz *et al.* (2012) also reported excessive callus formation in 16 dogs out of 77 dog's fracture treated by Titanium elastic nail. The stages of bone union recorded as per Hammer *et al.* (1985) showed the achievement of bone union in 70% dogs on 30th post-operative day and complete in all the dogs on 60th post-operative day. There was slight migration of the nails at the insertion site in initial 7-15 post-operative days in four cases, which were easily managed by cutting the extra length of the nail outside the skin along with regular antiseptic dressing of the wound with povidone iodine solution. After the achievement of bone union on radiographic evaluation and weight bearing on clinical examination, the nails were removed from all the dogs on 60th post-operative day.

Table 3: Mean ± S.E of bone union scores (BUS) and bone formation scores (BFS) at different time intervals of examination

Time Interval	0th day	15th day	30th day	60th day
BUS	0±0	1.20±0.32	3.00±0.33	3.70±0.32
BFS	0±0	1.90±0.28	2.80±0.25	3.70±0.15

Table 4: Extent of callus formation (callus index) of all cases at 60th post--operative day

Case no.	1	2	3	4	5	6	7	8	9	10
Callus index	1.42	1.52	1.65	1.68	1.52	1.85	1.72	1.54	1.44	2.04

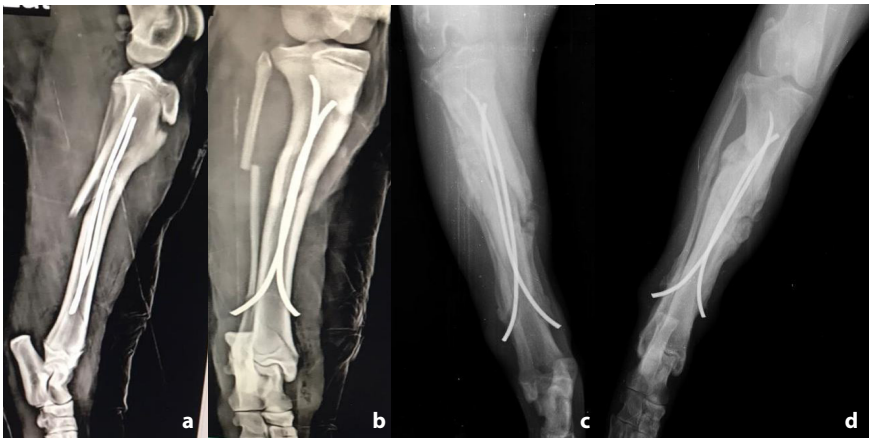

Fig. 5: Radiographs of the dog treated with titanium elastic stable intramedullary nailing just after the surgery (a) and at 15th (b), 30th (c) and 60th (d) post-operative days.

Conclusion

On the basis of post-operative clinical and radiographic evaluations, it is concluded that the long bone diaphyseal fracture repaired with titanium elastic nailing in dogs has good efficacy with respect to weight bearing, functional limb usage, bone formation, bone union and callus index. So it might be a technique of choice for repair of transverse diaphyseal long bone fractures in young growing dogs.

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