Minimally invasive interlocking nailing for canine Tibial fractures: clinical and radiographic insights

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Abstract

Twelve dogs with non-weight bearing lameness as a result of long bone diaphyseal fractures were selected and randomly divided into two groups of six each. In group-I the fractures were managed by open reduction and application of intramedullary interlocking nails whereas, in group-II they were managed by closed reduction and application of intramedullary interlocking nails under C-arm guidance. Periodical clinical and radiographic evaluation was performed in order to expose the superiority of the techniques in terms of fracture healing. Both groups showed progressive improvement in limb function and fracture healing, with group-II demonstrating comparatively faster radiographic healing and earlier resolution of lameness during the initial postoperative period; however, the final clinical and radiographic outcomes were comparable between the two groups by the end of the study. It is concluded that both open and minimally invasive intramedullary interlocking nailing are effective and reliable techniques for the management of tibial fractures in dogs, with the minimally invasive approach offering the added advantage of faster early recovery.

Key words: Long bone fractures, Intramedullary interlocking nailing, Minimally invasive, clinical evaluation, radiographic evaluation.

Introduction

In the past, treating long bone fractures often involved methods that required long-term immobilization and resulted in poor outcomes (Narendra Bhargav et al., 2025). To improve this, the surgeons had started using open reduction and internal fixation (ORIF) in the late 1950s, as recommended by the AO Foundation (Johnson et al., 2005). ORIF allowed for precise alignment and strong fixation of broken bones, but it also caused significant surgical trauma, disrupting the blood supply and leading to complications like delayed healing, implant failure, and infections. For instance, humeral and tibial fractures in dogs treated with traditional techniques had complication rates of up to 40% and 18%, respectively (Kirkby et al., 2008). Due to these issues, a new approach called "Open But Do Not Touch" (OBDNT) emerged. This method still aimed for strong bone fixation but with less direct manipulation of the fracture site. However, the focus was still on mechanical stability (Johnson et al., 2005). Over the last 20 years, there has been a shift towards techniques that prioritize the biological aspects of healing. This led to the development of minimally invasive osteosynthesis (MIO) (Perren, 2002). MIO avoids exposing the fracture site, preserving the natural healing environment and allowing for faster recovery. Instead of directly handling the broken bone fragments, small incisions away from the fracture site are used to place implants. MIO focuses on restoring bone alignment rather than achieving perfect anatomical precision. It uses longer, flexible implants that bridge the fracture site without disturbing it. These principles are now widely used in human medicine and are becoming more common in veterinary care (Guiot and Dejardin., 2011). This article will explore the benefits of minimally invasive nail osteosynthesis for treating long bone fractures in pets.

Materials and methods

Twelve dogs that were presented to surgery ward of SVVU Super Speciality Veterinary Hospital, Visakhapatnam with signs of non-weight bearing lameness (fig-1 and 2) that resulted from fracture of tibia-fibula bones were included in the present study. Preoperative radiographic evaluation (fig - 3 and 4) was done to localize the seat of fracture, to identify the type of fracture and to find out relation between the fracture fragments. The cases were randomly divided into two groups with six animals each. In group I animals the fractures of long bones were managed with open reduction and application of intramedullary interlocking (fig-5) nail with the approaches as suggested by Piermattei (1993) whereas in group -II the fractures were managed with minimally invasive interlocking nail osteosynthesis technique that included closed reduction and application of intramedullary interlocking nail under the guidance of c-arm as suggested by Baderiya et al., (2021) and de Lucena et al., (2023) (fig-6 and 7). All the animals premedicated with intramuscular injection of combination of injection Butorphanol @ 0.2mg/Kg body weight, Acepromazine @ 0.05mg/Kg body weight and Glycopyrollate @ 0.01mg/Kg body weight thirty minutes prior to induction of anesthesia. General anesthesia was induced by intravenous injection of Propofol @ 4mg/Kg body weight (till effect) and was maintained by using Isoflurane inhalation anesthesia. The interlocking nails were locked with one proximal and one distal screw in all the cases. The reduction of fracture fragments and position of the implants were confirmed by immediate postoperative radiography (fig-8 and 9) Post-operatively, the operated limb was supported with modified Robert- Jones bandage which was changed on alternative days in addition to wound dressing, until the suture removal. Immediate post-operative radiographs in cranio-caudal and medio-lateral views were obtained to assess the level of fracture fixation in all the cases. Postoperatively all the dogs received Antibiotics, analgesics and calcium supplements.

The usage of the limb was assessed at regular intervals i.e on 7^{th}, 15^{th}, 30^{th}, 60^{th} and 90^{th} postoperative days by giving clinical lameness scores as per Cook *et al.* (1999)

0 - No observable lameness
1 - Intermittent, mild weight-bearing lameness with little change if any in gait
2 - Consistent, mild weight-bearing lameness with little change in gait
3 - Moderate weight-bearing lameness - obvious lameness with noticeable “head bob” and change in gait
4 - Severe weight-bearing lameness - “toe-touching” only
5 - Non-weight-bearing lameness

Radiographic examination was also performed at the above mentioned periodic intervals to assess the fracture stability, initiation of callus formation, fracture healing and complications related to implant and fracture healing if any. A score (0-6) was given for fracture healing based on the callus formation and/or elimination of the fracture line as per Hayashi et al. (2008).

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

The limb usage at the end of the period of study in dogs of different groups was categorized using classification devised by Fox *et al.* (1995) as followed:
Excellent- weight bearing without lameness
Good- slight lameness
Fair- slight to moderate lameness principally after exercise
Poor-intermittent or consistent non-weight bearing lameness

The results obtained were compared in between the groups and the superiority of the technique is established.

Results

The evaluation of limb usage using clinical lameness scores showed a progressive improvement in both groups over time (table-1). Partial weight bearing with signs of lameness was observed from 5.0 ± 0.82 days and 4.0 ± 0.86 days in groups I and II respectively. Initially, group-I exhibited more severe lameness compared to group-II. By 15th postoperative day, both groups showed noticeable improvement, with a significant reduction ($p<0.05$) in lameness scores. By 30th postoperative day, lameness had substantially decreased, and complete resolution was observed in both groups by 60th postoperative day and persisting through the remainder of the study period (fig-10 and 11). Statistical analysis confirmed a significant reduction ($p<0.05$) in lameness scores over time within each group, though no significant difference was observed in between the two groups at different periodic intervals.

Radiographic assessment revealed a significant ($p<0.05$) progression in fracture healing across different periodic intervals in both groups. In the early postoperative period, minimal signs of healing were observed, with group-II showing slightly better initial healing compared to group-I. By 15th postoperative day, notable callus formation was evident in both the groups, with group-II showing significant ($p<0.05$) dominance over group-I. during the later postoperative assessment periods, both groups exhibited continuous improvement, with callus formation becoming more organized. By the end of the study period, complete fracture healing was observed in all cases (fig12 and 13). A significant negative correlation ($p<0.05$) has been observed between the fracture healing scores and lameness scores in the present study. In one case from group-I, nail locking was unsuccessful in the distal fragment due to screw misplacement; however, no postoperative complications were observed in this case.

At the end of the study, the majority of dogs in both groups achieved an "excellent" functional outcome, while a one dog of group-I was classified as "good." No dogs exhibited "fair" or "poor" limb function.

Both treatment approaches led to effective fracture healing and functional recovery. While group-II showed slightly faster healing and early lameness improvement, the final outcomes were comparable between the groups. These findings suggest that both methods provided satisfactory fracture stabilization, leading to full functional limb recovery by the end of the study period

Fig-1: Photograph showing non weight bearing lameness on left hind leg in case-2 of group-I

Fig-2: Photograph showing non weight bearing lameness on right hind leg in case-4 of group-II

Fig-3: Preoperative radiograph showing complete long oblique diaphyseal fracture of Tibia with displaced fragments in case-2 of group-I

Fig-4: Preoperative radiograph showing complete spiral diaphyseal fracture of Tibia with displaced fragments in case-4 of group-II

Fig-5: Intraoperative photograph showing open reduction of fracture fragments and application of intramedullary interlocking nail in case-2 of group-I

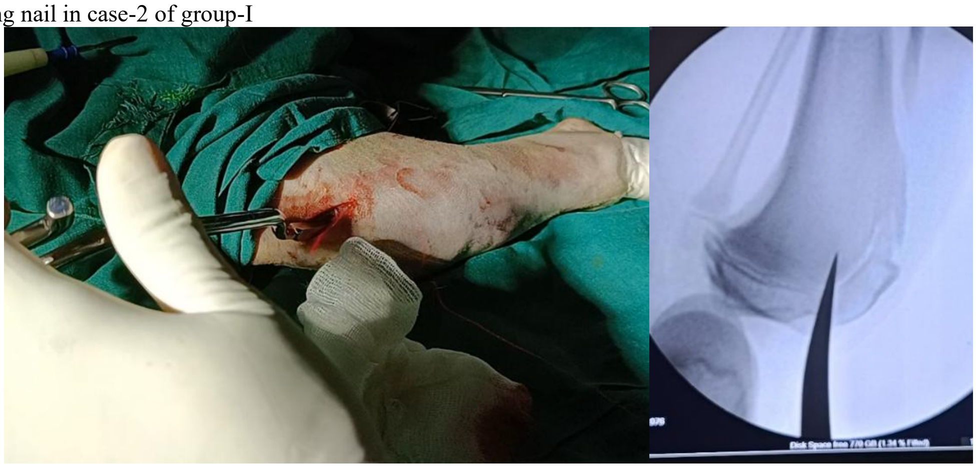

Fig-6: Intraoperative photograph showing preparation of pilot hole for insertion of nail in case-4 of group-2

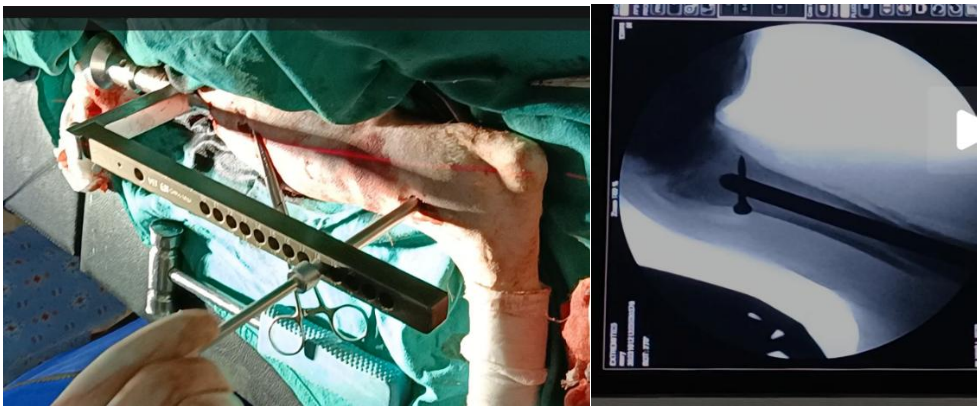

Fig-7: Intraoperative photograph showing closed reduction of fracture fragments and application of intramedullary interlocking nail under the guidance of C-arm in case-4 of group-2

Fig-8: Immediate postoperative radiograph showing the anatomical alignment of fracture fragments and the position of implants in case-2 of group-I

Fig-9: Immediate postoperative radiograph showing the anatomical alignment of fracture fragments and the position of implants in case-4 of group-II

Fig-10: Photograph showing normal weight bearing with absence of lameness on left hind leg on 90th postoperative day in case-2 of group-I

Fig-11: Photograph showing normal weight bearing with absence of lameness on left hind leg on 90th postoperative day in case-4 of group-II

Fig-12: Radiograph showing exuberant callus bridging the fracture gap with absence of radiolucent line at the fracture site on 90th postoperative day in case-2 of group-I

Fig-13: Radiograph showing exuberant callus bridging the fracture gap with absence of radiolucent line at the fracture site on 90th postoperative day in case-4 of group-II

Table-1: Table showing the mean ± SE values of clinical lameness scores at different periodic intervals

	7th P.O.D	15th P.O.D	30th P.O.D	60th P.O.D	90th P.O.D
Group I	$4.33{\pm}0.21^{C}$	$1.83{\pm}0.31^{B}$	$0.50{\pm}0.22^{A}$	$0{\pm}0^{A}$	$0{\pm}0^{A}$
Group II	$3.83{\pm}0.31^{C}$	$1.67{\pm}0.21^{B}$	$0.50{\pm}0.22^{A}$	$0{\pm}0^{A}$	$0{\pm}0^{A}$

P.O.D- Post operative Day, Means bearing different superscripts within a row (A,B..) and within a column (a,b..) differ significantly ($p<0.05$).

Table-2 Table showing the mean ± SE values of fracture healing scores at different periodic intervals

	7th P.O.D	15th* P.O.D	30th P.O.D	60th P.O.D	90th P.O.D
Group I	$0.17{\pm}0.17^{A}$	$2.17{\pm}0.17^{Ba}$	$4.17{\pm}0.40^{C}$	$5.50{\pm}0.21^{D}$	$6.00{\pm}0.00^{D}$
Group II	$0.50{\pm}0.22^{A}$	$3.33{\pm}0.21^{Bb}$	$4.0{\pm}0.0^{C}$	$5.83{\pm}0.17^{D}$	$6.00{\pm}0.00^{D}$

P.O.D- Post operative Day Means bearing different superscripts within a row (A,B) and within a column (a,b) differ significantly ($p<0.05$).

Discussion

Preoperative radiographs aided in nail selection, while immediate postoperative radiographs confirmed reduction, alignment, and implant position, in agreement with Dejardin et al. (2012) and Mathai et al. (2016). Minimally invasive placement of the interlocking nail in group-II was facilitated by C-arm guidance without intraoperative complications, consistent with Manjunatha and Ranganath (2012) and Baderiya et al. (2021), although this technique is technically demanding and carries a steeper learning curve than open approaches (Robinson et al., 2020).

Clinical lameness scores declined progressively in both groups, with group-II achieving comparatively earlier functional recovery, in agreement with reports emphasizing the biomechanical and biological advantages of ILN fixation (Durall et al., 2004, Horstman and Beale, 2002).

Radiographic healing progressed significantly over time in both groups, with group-II demonstrating significantly ($p<0.05$) superior callus formation at the 15th postoperative day, reflecting the biological advantage of minimally invasive nailing in preserving fracture-site vascularity and enhancing callus formation. This finding corroborates Baderia et al. (2021) and Manjunatha and Ranganath (2012), who similarly reported that C-arm guided closed interlocking nailing reduced surgical trauma and favoured faster radiographic healing and earlier weight-bearing compared with the open method, despite a longer initial learning curve and greater fluoroscopic exposure (Patel et al., 2007).

In one case from group-I, nail locking failed due to screw misplacement in the distal fragment, a complication previously attributed to improper jig alignment or instability during screw insertion (Arican et al., 2017); no postoperative sequelae occurred. By the end of the study, all animals achieved excellent or good limb function (Fox et al., 1995), consistent with earlier reports of favourable healing following ILN fixation (Arican et al., 2017).

Conclusion

Overall, the present findings confirm that intramedullary interlocking nail fixation, whether applied via open or minimally invasive technique, is an effective method for stabilizing tibial fractures in dogs. However, the minimally invasive C-arm guided technique demonstrated comparatively better performance than the open technique, with significantly superior radiographic healing at the 15th postoperative day and earlier clinical improvement in lameness, while both techniques ultimately achieved equally excellent long-term fracture healing and functional recovery. These findings support minimally invasive interlocking nailing as the preferable technique for tibial fracture management in dogs, consistent with previous experimental and clinical studies.

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