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Clinical and radiographic evaluation of minimally invasive plate osteosynthesis (MIPO) in dogs with tibial fractures

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Abstract: The aim of this study was a clinical and radiographic evaluation of the minimally invasive plate osteosynthesis (MIPO) method for treatment in dogs with tibial fractures. Ten dogs of different breeds, ages, and sex with tibial fractures were used as the subjects. A medial approach to the tibia was used in all the cases. The tibial tuberosity was palpated proximally and a short incision was made along the midline. After reduction of the fracture, proximal and distal insertion incisions were made to approach the tibia. The mean times for the MIPO operations were 21 minutes. The patients were able to stand and walk postoperatively on the first day and recovery was rapid for all of the dogs. The fracture healing was completed on day 45 based on the radiographic evaluations of these cases. Dogs with tibia fractures treated by MIPO healed rapidly without any complications (90%). Correct fracture selection is important for the use of MIPO to be successful. Further studies with a larger group of dogs should be considered to compare the efficacy of MIPO and other fixation techniques and for the long-term evaluation of the repaired tibial fractures.

Keywords: callus evaluation; lameness scoring; pain scoring

Increasing road congestion is causing a significant number of animal injuries, with orthopaedic and surgical intervention required in 63.5% of cases (Arican 2020). Osteosynthesis methods, such as external fixation, intra-medullar pinning and plate and screw fixation, have been used for fracture treatment (Johnson 2013). One of the newest techniques for the internal fixation termed MIPO, for minimally invasive plate osteosynthesis, has been developed as an alternative to standard plate osteosynthesis (Farouk et al. 1999; Krettek et al. 2001; Williams and Schenk 2008; Istim and Arican 2020). This technique avoids the need for an extensive surgical approach to access the fracture site. The bone segments are reduced using indirect reduction techniques (Perren 2002). It allows for the protection of bone vascularisation, improved consolidation and decreased infection rates to avoid recurrent fractures or the need for bone grafting. This technique involves using a small skin incision made at the proximal and distal aspects of a long bone to be applied to the fracture line. The two incisions are combined with a soft tissue tunnel between the periosteal surface and fascial muscle above it and the plate is shifted along the bone surface through the created soft tissue tunnel (Schmokel et al. 2003; Peyser et al. 2007; Laflamme et al. 2008; Pozzi 2009). For clinical use, a compression plate is used as a locking internal fixator in both the bridging plate and in the MIPO technique, where it is recommended that two or three screws are used on both sides of the fracture line

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for femoral and tibial fractures, which are mostly applied in compression (Stoffel et al. 2003). Small incisions away from the fracture line means that the fracture haematoma will not be touched (Williams and Schenk 2008).

The aim of this study was a clinical and radiographic evaluation of the MIPO method in treating dogs with tibial fractures.

MATERIAL AND METHODS

Ten dogs of different breeds, ages, and sex with non-dislocated tibial fractures were used as the subjects (Table 1). A complete clinical and physical orthopaedic examination was performed on each dog. After the patient history was recorded, the CBC (complete blood count) and blood gas indicators of all the patients were evaluated. Mediolateral and cranio-caudal radiographic projections of the affected tibiae were taken for diagnosis (Figure 1). The study design followed the published guidelines and was approved by the institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine (2019/53).

Surgical approach

The dogs were fasted for 12 h before anaesthesia. For sedation, medetomidine hydrochloride (Domitor®; Zoetis, Espoo, Finland) was used at 0.025 mg/kg and butorphanol (Butomidor 10 mg/ml i.m.; Richter-Pharma, Wels, Austria) was used for the preoperative analgesia at 0.1 mg/kg. Propofol (Propofol-Lipuro 1%; B Braun, Melsungen, Germany) at 1.5–3 mg/kg was administered intravenously for induction and anaesthesia was maintained on isoflurane (Isoflurane; ADEKA İlaç®, Pennsylvania, USA) after intubation starting at 4%, then reducing to 2% once the dogs were clinically stable. An intraoperative analgesia was given intravenously as 500 ml saline containing 60 mg of ketamine (Ketasol 10%, 100 mg/ml; Richer Pharma, Wels, Austria), 24 mg of butorphanol, 0.2 ml of medetomidine hydrochloride (Domitor®; Zoetis, Espoo, Finland) given at a rate of 5 ml per kg body weight per hour.

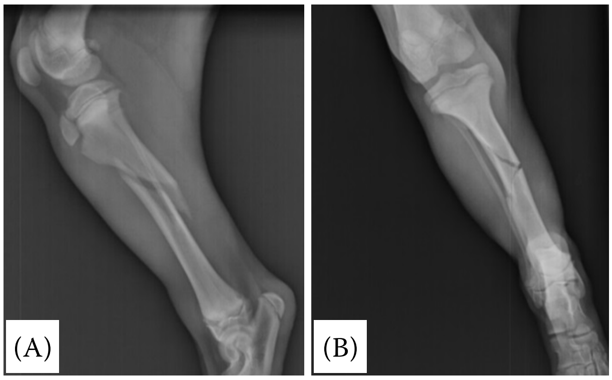

Figure 1. Preoperative cranio-caudal (A) and mediolateral (B) radiological images

A medial approach to the tibia was used in all the patients. A short incision was made proximally along the midline of the tibial tuberosity and the distal incision site was proximal to the medial malleolus. After reduction of the fracture, proximal and distal insertion incisions were made to approach

Table 1. Details of the dogs with the tibia fractures

Case No.	Age (months)	Weight (kg)	Fracture pattern	Plate type/size
1	60	18.5	proximal, partial	3.5 mm 12 hole LCP
2	4	6.2	diaphyseal, oblique	3.5 mm 6 hole LCP
3	7	13	diaphysis, partial	3.5 mm 10 hole LCP
4	2.5	7	proximal, partial	2.7 mm 6 hole LCP
5	10	20.4	diaphyseal, oblique	3.5 mm 10 hole LCP
6	3	7.7	diaphyseal, oblique	2.7 mm 10 hole LCP
7	3	5.5	proximal, transversal	2.7 mm 8 hole LCP
8	6	12.2	diaphyseal, transversal	3.5 mm 8 hole LCP
9	5	9	diaphyseal, transversal	2.7 mm 10 hole LCP
10	3	6.2	proximal, transversal	2.7 mm 8 hole LCP

LCP = locking compression plate

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Figure 2. The plate was shifted from the distal approach site along the medial surface until it appeared at the level of the proximal incision

the tibia. An epiperiosteal tunnel was prepared by Metzenbaum scissors to preserve the periosteum. The plate was moved from the distal approach site along the medial surface until it appeared at the level of the proximal incision (Figure 2). The first screw was fixed on the proximal end and then distally and an X-ray was taken after the first screw was fixed if required to check the correct position. The plate contouring and plate position were adjusted before fixing the plate with screws. When using locking compression plates (LCPs), non-locking screws are used first to reduce the distance between the plate and the bone. Either 6-, 8-, 10- or 12-hole (using either 2.7 mm or 3.5 mm diameter screws) LCPs (Travmavet, Safir, Antalya, Turkey) were applied. After reassessing the limb alignment, the locking screws were placed through the insertion incisions (Figure 3). The proximal and the distal incision sites were closed with USP 2-0 polyglycolic acid sutures (Katsan Catgut San. ve Tic. Izmir/Turkey) (Figure 4).

Postoperative care

Orthogonal radiographs of the tibia were obtained preoperatively, postoperatively, and at each scheduled re-examination for days zero, 15 and 45 of the recovery in all the cases. Ceftriaxone, (Unacefin 1 g, i.m.; Avis İlaç San. Tic. Aş., Tuzla/İstanbul,Turkey) was given for prophylactic antibiotic treatment one day before the operation and continued for 7 days after the operation. Passive range-of-motion exercises for 2 weeks after the operation were recommended to the clients. The dogs were allowed to walk on a leash for 10–15 min in duration several times a day for the first four weeks after the operation and the duration of the walk increased to 20–30 min after first examination, with no running allowed. Clinical examinations were performed on the 1st post-surgery in all the cases.

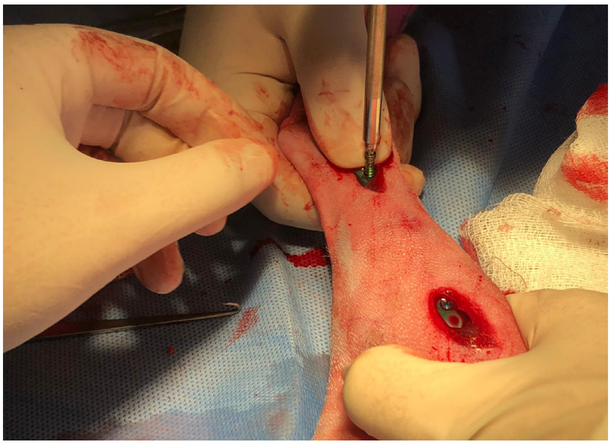

Figure 3. Locking screws were placed through the insertion incisions

Figure 4. The proximal and the distal incision sites was closed

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Table 2. Scoring system used for assessment of lameness in dogs undergoing fracture repair

Score	Variable
0	stands and walks normally
1	stands normally, slight lameness when walking
2	stands normally, obvious lameness when walking
3	stands abnormally, slight to obvious lameness when walking
4	non weight bearing lameness

Lameness scoring

The clinical lameness evaluation was undertaken on day 45 post-op according to a four-grade scoring system ranging from no lameness to severe lameness (Bergmann et al. 2007) (Table 2).

Pain scoring

The clinical pain evaluation scores was undertaken on day 45 post-op according to a four-grade scoring system from no pain to severe pain (Cross et al. 1997) (Table 3).

Callus evaluation

The callus evaluation was undertaken by taking X-rays preoperatively on day 0 of the surgery and postoperatively on day 15 and 45 and scored using Lane and Sandhu's radiological scoring system (Lane and Sandhu 1987) as seen in Table 4.

Table 4. Radiographic scoring

	Score
Callus formation	
No callus formation	0
Filling 25% of the defect	1
Filling 50% of the defect	2
Filling 75% of the defect	3
Filling 100% of the defect	4
Union	
No union	0
Beginning of bone union	1
Full bone union	2

Table 3. Pain score used in the subjective clinical evaluations

Score	Evaluation
1	none
2	slight lameness
3	moderate lameness
4	severe lameness

Statistical analysis

The results are expressed as a percentage. In addition, the mean values of the scores were calculated (Microsoft Office Professional Plus 2016, Microsoft Co., USA).

RESULTS

Each fracture was evaluated for alignment, reduction of fragments, and stage of healing by X-rays. The mean times for the MIPO operations were 21 min with the middle diaphyseal fracture repair taking a shorter time. None of the patients developed complications. The patients were able to stand and walk postoperatively on the first day and recovery was rapid in all the cases.

Lameness scoring

Based on the lameness scoring system, 90% of the patients stood and walked normally and 10% stood normally, but had slight lameness when walking.

Pain scoring

According to the pain assessment, 90% of the patients were pain-free and 10% were slightly lame.

Callus evaluation

On day 15, five patients had calluses filling 50% of the defect and the other five patients had 75% filling. At day 45, seven patients were completely healed, two patients had a 75% deficit filling and one had 25% filling, as seen in Table 5.

On day 15 of the union scores, 10% of the patients had no union and 90% of the patients showed the

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Table 5. Radiological evaluation of the cases

Case	Radiological evaluation			
	callus formation		union	
	15th day	45th day	15th day	45th day
1	3	4	1	2
2	3	4	1	2
3	3	4	1	2
4	2	4	1	2
5	2	3	1	2
6	3	4	1	2
7	2	4	1	2
8	2	1	0	0
9	2	3	1	2
10	3	4	1	2

beginning of bone union (Table 5). On day 45, 10% of the patients had no union and 90% of the patients scored a full bone union (Figure 5, 6).

DISCUSSION

This study showed that MIPO offers several advantages for tibial fracture repair. It caused less soft tissue damage compared to the more invasive osteosynthesis methods, improving the wound healing time. As smaller incisions were used, the approach to the bone and the soft tissue closure process was quicker, reducing the risk of infection and improving anaesthetic safety (Schmokel et al. 2007). A bandage application was not required since the soft tissue damage was reduced and rotation and torsion of the bone was prevented by using plates (Pozzi 2009; Istim and Arican 2020).

The use of MIPO, as a technique, protects the biological environment that facilitates rapid bone healing by minimising soft tissue damage and avoiding the fracture site haematoma. The fracture haematoma is critical in the healing process of the fracture and its formation is one of the important stages in the healing process (Mundy 1993). Within a few days, an increase in the capillaries begins to turn into haematoma granulation tissue,

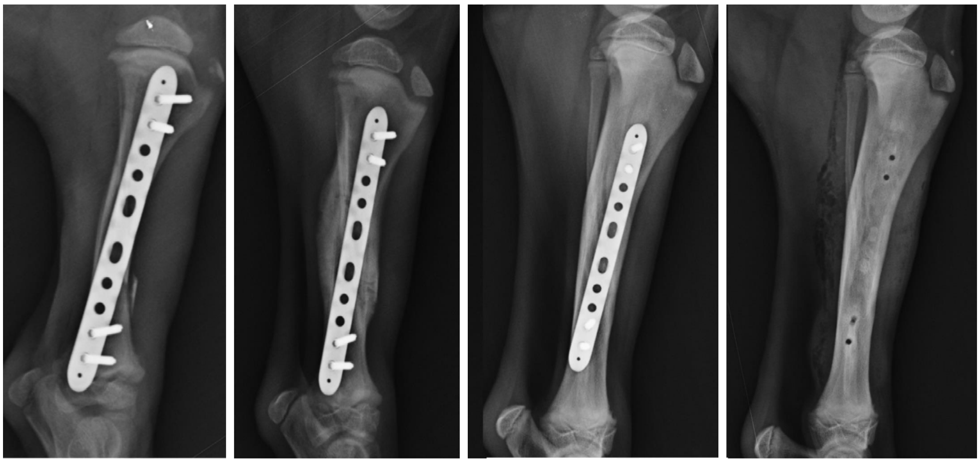

Figure 5. Medio-lateral radiological view of days 0, 15, 45 and after the plate removal

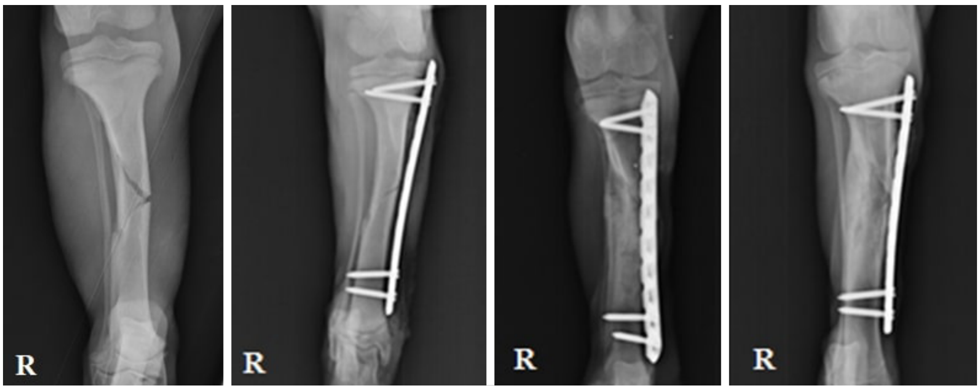

Figure 6. Cranio-caudal radiological view of days 0, 15, 45, and after the plate removal

with mononuclear cells and fibroblasts, filling the fracture gap (Johnson 2013). Cartilage and bone tissue formation develops with chondroblast and osteoblast proliferation. Osteoblasts are transformed into osteocytes as intramembranous healing or bone continuity is achieved by endochondral ossification (Johnson 2013).

Although MIPO can also be used in fragmented fractures of long bones, the technique is best suited to simple diaphyseal and metaphyseal fractures (Hudson et al. 2009). The MIPO technique has advantages over invasive methods for partial fractures (Cheng et al. 2011). This study was applied to simple tibial fractures and the success rates were similar to previous studies. Pozzi and Lewis (2009) showed that the MIPO technique could have a higher risk of saphenous vein and saphenous nerve injury. However, the same researchers, in another study, concluded that MIPO could be used safely for the stabilisation of humeral, femoral and tibial fractures in dogs with cadaveric dissections. All the plates were placed without any major damage to the major regional neurovascular structures and no clinical neurovascular complications have been reported in clinical cases where researchers used this technique (Pozzi and Lewis 2009). In the presented study, the plate was placed without any neurovascular damage or any other complication in all the cases.

The tibiae fracture assessment score is given on a scale of 1 to 10, defined as high (8–10), medium (4–7) and low (1–3) (Arican 2020). The mechanical assessment of fractures predicts the strength of the implants and the biological evaluation of the fractures determines the time that the implants should be functional. If the fracture assessment scores are low, the recovery period should be extended. In the present study, no difficulty was experienced in the reduction of bone fragments even with dislocated mid-diaphyseal fractures. If MIPO is to be applied, the criteria for fracture assessment must be made correctly (Johnson 2013) and double radiological positions of the proximal and distal joints of the fracture site are required to evaluate the type of fracture and the shape of the site. Johnson found that MIPO was not preferred for fracture dislocation (Johnson 2013), but a normograde intramedullary pin can be first applied to achieve reduction of fragments. While this technique can be used for many bones, if the reduction cannot be achieved, an open reduction technique can be used (Horstman et al. 2004; Pozzi 2009; Istim and Arican 2020). When the intramedullary pin is inserted under fluoroscopy, the size of the applied pin in the medulla should be 40% to 50% of the diameter of the bone (Johnson 2013). In this study, there was no need to put an intramedullary pin in any of the subjects. The fractures were easily reduced due to this fact.

The implant selection and use is important in the MIPO method. Locking plates have been reported to have mechanical and biological advantages (Koch 2005); locking plates were used in all the cases during this study, which were selected to suit the size and body weight of the patients (Pozzi 2009). The preoperative adjustment of the lengths of the plates is particularly important to reduce surgery times. Long plates reduce the stress on each screw, so fewer screws are required for fracture stabilisation (Rozbruch et al. 1998). Locking plates increase the callus formation and prevent cortical necrosis formation since the plate does not fully compress the bone periosteal blood support (Koch 2005), thus preserving the capillary network of the periosteum under the plate (Johnson 2013). It is noted that locking plates should be considered an excellent implant option for MIPO (Pozzi 2009).

Dogs with tibia fractures treated by MIPO in this study healed rapidly without any complications, but the correct fracture selection is important for success. More accurate results will be obtained in larger trials by applying MIPO to different anatomical regions of the tibia. Despite the advantages of MIPO, there is still a lack of studies comparing MIPO with other internal fixation techniques. Further studies with a larger group of dogs should be considered to compare the efficacy of MIPO and other fixation techniques and provide a long-term evaluation for tibial fractures.

Conflict of interest

The authors declare no conflict of interest.

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