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Management of tibia fracture by open reduction internal fixation and minimal invasive plate osteosynthesis in dogs

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ABSTRACT

In the present study, tibia fracture in dogs were repaired by using two different fixation techniques, open reduction internal fixation (ORIF, Group 1, n=11) and minimal invasive plate osteosynthesis (MIPO, Group 2, n=8). Various factors such as age, bodyweight, fracture type, soft tissue trauma, severity, post-operative care and fixation technique governs fracture healing. Majority of the factors were kept similar other than fixation technique, for an unbiased comparison between the two treatment groups, i.e. ORIF and MIPO. The mean duration of surgery was significantly more in group 1 (ORIF, 107.7±6.61) whereas it was nearly half of the time in group 2 (MIPO, 31.8±4.12). No significant difference between the fracture gap, plate length, plate bridging ratio and plate span ratio was noticed in the two groups. The working length of plates applied in the MIPO group (45.7±2.4) was longer than in the ORIF group (23.2±4.96) and there was statistically significant difference in the screw density between both the groups. Fractured tibia was 4.8% shorter than contralateral limb in MIPO group whereas in ORIF group fractured limb was 3.2% shorter than the contralateral limb. The MIPO group showed an early ambulation, i.e. 5.24±0.63 days in comparison to ORIF group (11.60±2.8 days). The radiographic time to union (days) was shorter in group 2 (MIPO, 38.1±12.5) as compare to group 1 (ORIF, 76.2±10.34).

Keywords: Dog, Fracture repair, Minimal invasive plate osteosynthesis (MIPO), Open reduction internal fixation (ORIF), Tibia

The loss of continuity in the bone or cartilage is referred to as a fracture. There are variety of options available when operative treatment for tibia fractures is required, of which, open reduction internal fixation is the most commonly applied method with the advantage of anatomical reduction. Open reduction and internal fixation technique involves extensive soft tissue damage and muscle retraction for adequate exposure, leading to further damage to vascular supply of fractured fragments and disruption of periosteal blood supply to the bone. As a consequence of this, risks of delayed union, non-union and infection increases.

Minimal invasive plate osteosynthesis is a comparatively new concept in veterinary fracture management which minimizes dissection of broken fragments, preserves vascularity and soft tissue, reduce surgical trauma and increase healing process. Certainly, numerous factors can impact the rate at which a fracture heals, including age, gender, overall health, the type of fracture, the severity of soft tissue trauma, the surgeon's skill, the alignment of fracture edges, the technique used for fracture fixation and the quality of post-operative care.

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MATERIALS AND METHODS

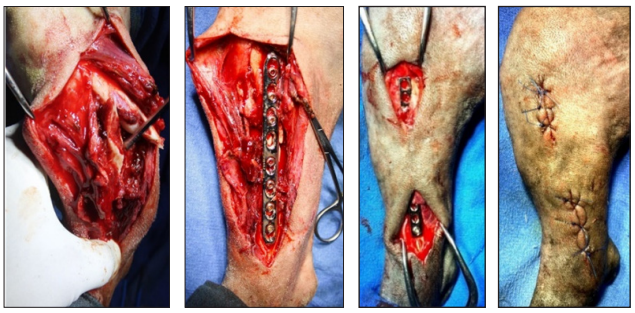
The study was carried out on 19 days suffering from tibial fracture and presented at Department of Surgery and Radiology, Dr G C Negi College of Veterinary and Animal Sciences, Palampur, Himachal Pradesh. History, clinical examination, orthopaedic examination, haematobiochemical analysis which included inflammation, pain, crepitus and weight-bearing status at the fracture site were recorded for all nineteen cases. Two orthogonal radiographic views were taken to see the location of fracture and fracture type. In the majority of cases, inflammation was observed at the fracture site. So, to reduce swelling at the fracture site, Robert Jones compression bandage was used for at least 1-2 days. There was no inflammation on the surgical site at the day of surgery. On the day of surgery, the dogs were anesthetized using a standard general anaesthetic protocol. Bone length of the unaffected contralateral limb from the radiographs for selecting the bone plate length and cortex to cortex bone width was taken to select the approximate length of the bone plate screws.

Surgical approach: ORIF and MIPO was performed with the dog positioned in the lateral recumbency with

the fractured limb on the lowermost side. The dog was aseptically prepared and draped in a standard fashion. The approach used was as per (Brinker 1957 and Wilson 1974).

In minimally invasive plate osteosynthesis (MIPO) technique, the tibia was approached medially by making proximal and distal surgical incisions. Artery forceps was used to create a soft tissue tunnel immediately adjacent to the periosteal surface of the bone, taking care to minimize the iatrogenic trauma at the fracture site. Post operatively supportive Robert Jones bandaging was also done in all the cases (Piermattei and Johnson 2004).

Intraoperative parameters: The extent of tissue manipulation and soft tissue damage, degree of technical difficulty, status of fracture reduction, status of fracture fixation, extent of overriding (mild, moderate and marked), ease of fracture reduction (mild, moderate and marked), fixation technique, implant size, screw placement and surgery time from the skin incision to skin closure were all noted as intra-operative observations (Fig. 1).



Soft Tissue manipulation during ORIF | Plate application (ORIF) | Plate application (MIPO) | Skin closure (MIPO)

Fig. 1. Intra-operative photographs of ORIF and MIPO group.

Post-operative parameters: Radiographs were taken at various intervals to assess the status of fracture healing, stability of fracture fixation, implant position, bone shortening, radiographic healing time and for any complications, radiographic fracture healing was assessed and graded for fracture healing from 1-5, based on elimination of fracture line, callus formation, stage of union as described by (Whelan *et al*. 2002) (Table 1). Implant related characteristics assessment was done by determining different parameters, namely the plate bridging ratio (ratio between the plate length and the bone length), the plate working length (distance between proximal and distal screw closest to the fracture, reported to the length of the plate) and plate span ratio (the quotient of the plate length over the overall fracture length) (Miller and Goswami 2007) (Fig. 2). Fracture healing and functional outcome

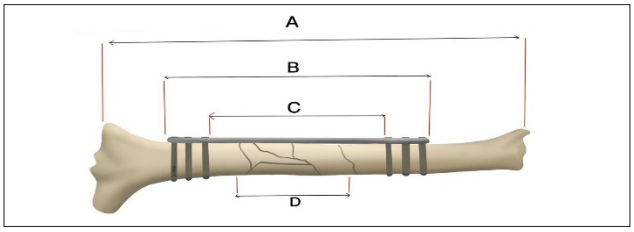


Fig. 2. Implant parameters: Plate span ratio = B/D; Plate-bridging ratio = B/A; Working length = C.

were assessed at 15 days, 30 days post-operative period and then at every 30 days interval or whenever, the cases were presented at the suitable time interval for radiographic and clinical examination till complete healing of the fractured bone. Information was taken from owners about the extent of limb usage with reference to, whether the dog started to touch the surgical limb on ground, the extent of weight bearing while standing, walking and running by telephonic conversation.

Statistical analysis: An unpaired t-test was used to assess difference between the ORIF and MIPO group for all the measurable variables. Significance was calculated at $P<0.05$.

RESULTS AND DISCUSSION

Various factors such as age, bodyweight, fracture type, soft tissue trauma severity, post operative care and fixation technique governs fracture healing (Rahman *et al*. 2017). Thus, majority of the factors were kept similar in both the groups for an unbiased comparison (Table 2). No statistically significant difference was observed in the mean±SE for age of the animals in ORIF group (10.6±2.1) and MIPO (12.6±5.6) group. The mean±SE for body weight in ORIF was (16.7±2.3) and for MIPO was (14.7±3.24) which was again statically non-significant. In both the groups there were an equal number of simple, spiral and oblique fractures and in both the groups one dog fracture was repaired with plate and rod combination. The size of the implant used for fracture fixation was based upon the body weight of the dog and bone size. There was no significant difference between the proximal and distal segment of ORIF and MIPO groups in present study. Most of the fractures were diaphyseal simple oblique fracture (42A2). Similar observations were reported by Zaal and Hazewinkel (1996), i.e. 73% of the fracture was mid diaphyseal oblique type.

The duration of surgery for the ORIF group was 107.7± 6.61 min and for the MIPO group was 31.8±4.12 min (Table 3). Operative time period was in concordance with Rahman *et al.* (2017) for MIPO, i.e. 36.4±3.5 min and

Table 1. Grading of fracture healing (Whelan *et al*. 2002)

Grade	1	2	3	4	5
Callus formation	Homogenous bone structure	Massive bone trabeculae crossing the fracture line	Apparent bridging of the fracture line	No bridging of the fracture line	No callus formation
Fracture line	Obliterated	Barely discernible	Discernible	Distinct	Distinct
Stage of union	Achieved	Achieved	Uncertain	Not achieved	Not achieved

Table 2. Pre-operative observations in both groups

	ORIF group 1				MIPO group 2		
	Age (months)	Body weight (kg)	Fracture pattern	S. No.	Age (months)	Body weight (kg)	Fracture pattern
1.	14	29.9	42A1		3	3	42A3
2.	3	10	42A3		5	5	42A1
3.	11	14	42A1		6	11.3	42A1
4.	24	14	42A2		7	16	42A3
5.	24	10.4	42A1		48	26	42A1
6.	6	9	42A3		5	15	42A1
7.	4.5	15.7	42A1		3	9	42A1
8.	8	21	42A3		24	30	42A1
9.	12	30	42A2				
10.	6	14	42A1	Mea± SE	12.6±5.6	14.7±3.24	42A1
11.	5	24	43A1				
Mean± SE	10.6±2.1	16.7±2.31	42A1				

Table 3. Mean±SE for outcome measures for ORIF and MIPO groups

Outcome measure	ORIF	MIPO	P-value
Time of surgery (min)	107.7±6.61	31.8±4.12	0.0001*
Radiographic time to union (days)	76.2±10.34	38.1±12.5	0.03*
Fracture gap (mm)	7.8±1.4	6.8±1.2	0.40
Plate length (cm)	11.3±1.4	10.4±1.2	0.61
Plate span ratio	3.39±0.70	3.35±0.40	0.95
Plate bridging ratio	0.6±0.03	0.7±0.03	0.06
Screw density	0.71±0.04	0.5±0.04	0.0026*
Working length	23.2±4.96	45.7±2.4	0.0004*
Initial weight bearing (days)	11.60±2.8	5.24±0.63	0.081
Tissue manipulation	2.09±0.21	1.3±0.26	0.0408*
Limb shortening	0.5±0.2	0.7±0.2	0.5

Pozzi *et al.* 2012 for ORIF, i.e.113.5±37.9 minutes. It was significantly more (P<0.0001) in group 1 (ORIF) as compared to group 2 (MIPO). It is due to the fact that the minimally invasive plate osteosynthesis involves minimal dissection of the soft tissue and the broken bone fragments, in contrast to open reduction and internal fixation. The pre-operative and post-operative radiographs are shown in Figs. 3 and 4. At 15 days of surgery, radiographic clinical union was observed in 3 cases of MIPO

whereas, in most of the cases treated with ORIF radiographic clinical union was found after 60 days of surgery. Seven cases out of 8 cases in MIPO group showed radiographic fracture union before 60 days whereas in ORIF group most of the fractures showed radiographic fracture union after 60 days. The mean proximal and distal fragment length of ORIF was not significantly different from MIPO as shown in Table 4. This indicates that fracture pattern was almost same for both the groups. Pozzi *et al*. (2012) reported 16 dogs with radius-ulna fractures and the dogs that underwent MIPO healed in significantly less time than the ones with ORIF (mean±SD: 38±12.6 days and 76.2±10.34 days, respectively). Baroncelli *et al.* (2012) evaluated that the dogs undergone MIPO technique exhibited a healing time that was half as long and displayed significantly greater callus formation compared to dogs treated with ORIF. The healing pattern observed through the utilization of minimally invasive plate osteosynthesis for fracture stabilization may be attributed to the minimal disruption of regional blood supply and the preservation of soft tissue structures (Farouk *et al*. 1999, Palmer 1999, Schmokel *et al*. 2003, Hudson *et al.* 2009, Kowaleski 2012). This approach also avoids direct manipulation of the intermediate fracture fragments, minimizing iatrogenic trauma to the periosteum and fracture hematoma, ultimately leading to accelerated bone healing (Field and Tornkvist 2001).

Table 4. Mean±SE values of lengths of proximal and distal fracture fragments

Group	Proximal fragment (cm)	Distal fragment (cm)
ORIF	6.4±1.21	6.94±1.25
MIPO	6.35±1.21	6.34±0.87

There was no significant (P>0.40) difference between the fracture gap of both the groups (Table 3). But when comparing radiographic time of fracture union, a significant difference between (P<0.05) two groups was observed. In addition, no statistically significant difference was observed in the plate length of the MIPO (10.4±1.2) and ORIF (11.3±1.4) group.

The MIPO group showed an early healing in case of fractures i.e. presence of periosteal callus at about 38.1±12.5 days in comparison to dog treated with ORIF (76.2±10.34 days). Guiot *et al.* (2011) reported bone healing in MIPO at 36±11.6 days, whereas in ORIF, Rahman (2017) *et al.*

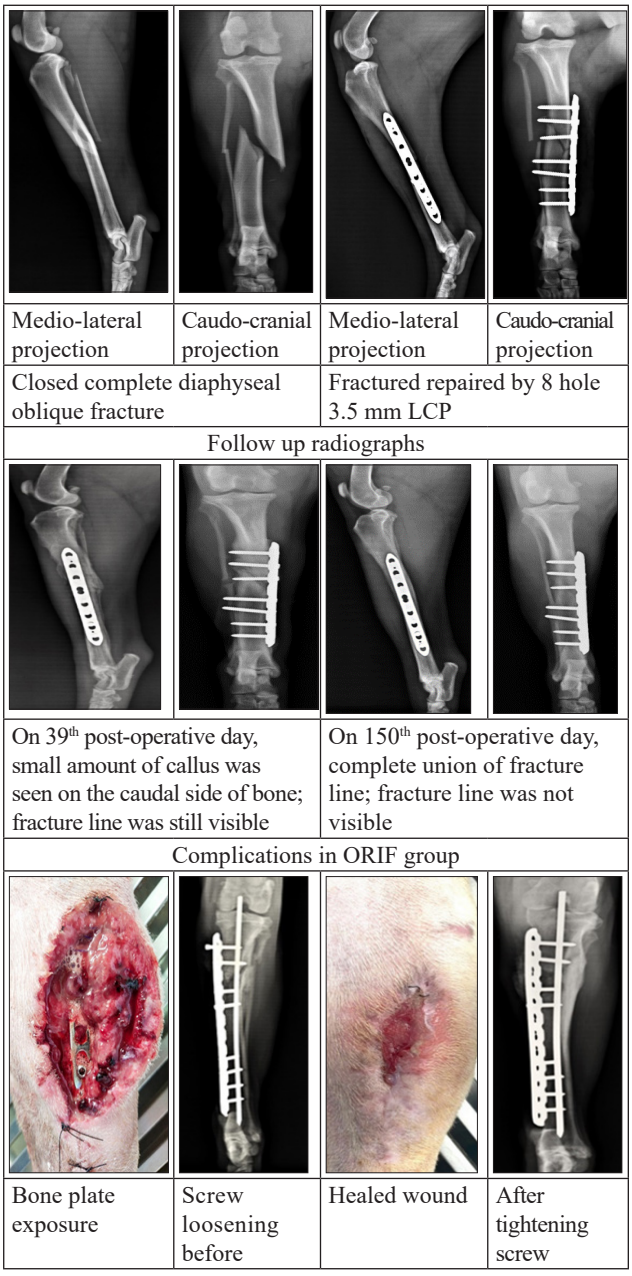


Fig. 3. Pre-operative and immediate post-operative radiographs of fracture case managed by ORIF.

documented at 131.8±18.6 days. Oe *et al*. (2007) also suggested that it is advisable not to remove the hematoma from the fracture site to promote healing. This is because the hematoma contains multi-lineage mesenchymal progenitor cells and plays a crucial role in the process of bone healing.

No significant difference was found between mean plate span ratio and plate bridging ratio in both the groups which indicated that the implants used in both the group were as per the standard operating procedures for fracture management using bone plate for the repair of tibia fracture by ORIF and MIPO. A reduced plate span is associated with increased pull-out strength on the bone (Gautier and Sommer 2003, Sommer *et al*. 2007). There was statistically significant difference in the screw density ($P<0.0026$) in both the groups. Egol *et al*. (2004) reported

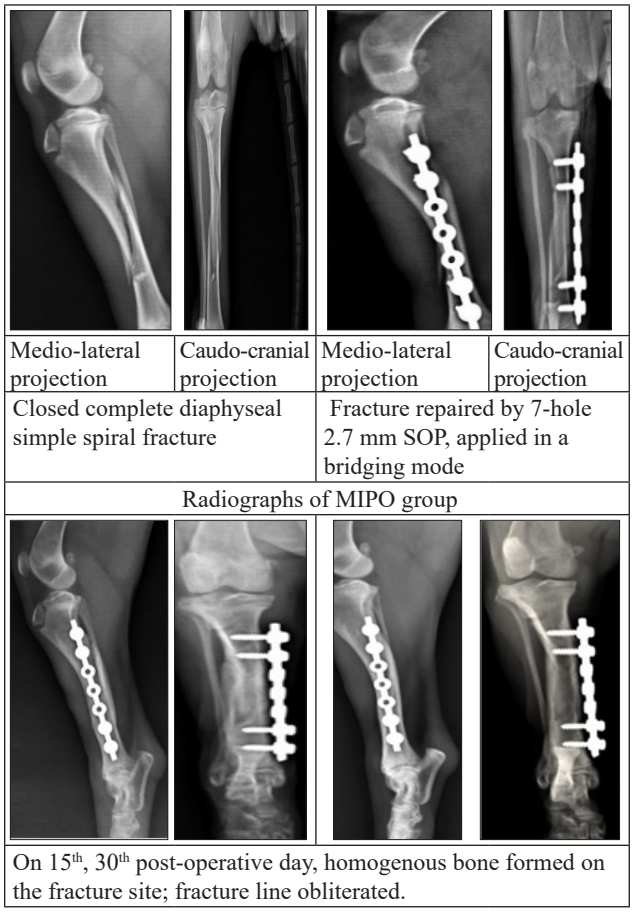


Fig. 4. Pre-operative and immediate post-operative radiographs of fracture case managed by MIPO.

that the insertion of more than three screws in each main fragment did not result in an increase in axial stiffness. Similarly, the use of more than four screws in each main fragment did not enhance torsional rigidity. The working length of plates applied in the MIPO group is longer than in the ORIF group which again made it a more efficient fracture management method for repair of tibia fractures in dogs. Similar findings were also reported by Pozzi *et al.* (2012) that a higher plate working length and lower screw density in dogs treated with MIPO compared to those treated with ORIF. Gautier and Sommer (2003) suggested that an increase in the working length of the plate resulted in reduced screw loading, thereby requiring fewer screws to be inserted. Consequently, this allows for a lower plate screw density to be maintained.

Fractured tibia after repair was 4.8% shorter than contralateral limb in MIPO group, whereas in ORIF group it was 3.2% shorter than the contralateral limb. It was due to the fact that obtaining proper alignment can be technically challenging and demanding during MIPO because the fracture is not exposed and indirect reduction techniques was used. Guiot and Dejardin (2011) also reported in MIPO that repaired tibia was 1% shorter than contralateral limb.

There was a non-significant difference between the means of initial weight bearing days on fractures limb in the cases treated with MIPO or ORIF (Table 3). But,

otherwise still MIPO group showed an early ambulation, i.e. 5.24±0.63 days in comparison to ORIF group (11.60±2.8 days). The mean values were considerably less in MIPO group indicative of its early healing because of less tissue manipulation. Post-operative complications, i.e. screw loosening and plate exposure was found in one animal each in ORIF group whereas there were no post operative complications reported in the MIPO group in the present study. Also, the limb usage score for both groups has been given in Table 5.

Table 5. Limb usage score % in two treatment groups

Group	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
ORIF	9	81.8	1	9	1	9	0	0
MIPO	8	100	0	0	0	0	0	0

No., Number.

It can be concluded that the dogs treated with minimal invasive plate osteosynthesis (MIPO) had earlier normalisation of limb function and radiographic union of the fracture leading to early fracture healing in addition to the advantages that these procedures take less surgical time, less surgical trauma to the fracture site and with least complications post-operatively.

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