RESEARCH ARTICLE

Evaluation of String of Pearls Locking Plate System for Long Bone Fracture Repair in Dogs

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Abstract

The study was conducted on 18 clinical cases of diaphyseal fractures of long bones in dogs. The dogs were divided into three equal groups with six dogs in each group, affected with fractures of the radius, femur, and tibia, respectively. Fractures were diagnosed by clinical, radiological examination and they were stabilized with 3.5 mm locking String of Pearls plates (7-10 holes) and appropriate locking cortical screws (16-32 mm). All dogs had an uneventful recovery with minimal complications.

Key words: Dogs, Long bone fracture, String-of-pearls plate.

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Introduction

Fracture of long bones is a common orthopedic condition seen in dogs. Among the long bones, the incidence of fractures was highest in the femur, followed by the radius-ulna, tibia-fibula, and humerus in dogs (Kallianpur *et al.,* 2018). The primary goal of any fracture treatment is to restore function to the injured limb as quickly as possible along with preservation of intramedullary and periosteal vascularization, anatomical reduction, and early return to normal motor function (Schwandt and Montavon, 2005). It is important to choose an implant system that is able to adequately neutralize any disturbing forces at the fracture site and allow for rapid healing of the bone. Internal fixation with open reduction has been adopted for the treatment of various types of long bone fractures in dogs. The selection method for fracture fixation depends on the fracture configuration, the size and age of the animal, concomitant soft tissue injuries, and the surgeon's familiarity with the equipment and techniques (Aron, 1998). Fractures of long bones in dogs can be successfully treated with plate fixation, which provides excellent stabilization by neutralizing all forces (axial loading, bending and torsion) acting on a bone. The String-of-Pearls (SOP) plate is a novel, distinctive and adaptable orthopedic locking plate system designed for use in veterinary and human orthopedic applications to address the problems and limitations associated with first generation locking plates. Therefore, the purpose of the current study was to assess the effectiveness of the String-of-Pearls plate as an internal fixation technique for the treatment of canine long bone diaphyseal fracture.

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Materials and Methods

The study was conducted on 18 clinical cases of long bones fractures in dogs presented to the Department of Surgery and Radiology, Veterinary College, KVAFSU, Bidar (India). The dogs were divided into three equal groups with six dogs in each. Group I had dogs with radius fractures, Group II with femur fractures, and Group III with tibia fractures. All the fractured dogs had non-weight bearing lameness (Fig. 1). The fractured canines underwent standard clinical, orthopedic and neurological examinations. Clinical indicators from the fracture site, such as swelling, and crepitation, were noted. Orthogonal radiographs of both the fractured and contralateral intact limb segments were taken pre-operatively to plan the operation (Fig. 2) (Langley-Hobbs, 2003). Details of cases selected for study were recorded in Table 1.

Table 1: Distribution of animals under surgical treatment

Group	Breed	Age (months)	Sex	B.wt. (kg)	Etiology	Type of fracture
Group I (Radius)	Mongrel	24	Male	19.6	Automobile accident	Transverse
	Mongrel	24	Male	15	Automobile accident	Transverse
	Mongrel	12	Male	13.5	Automobile accident	Transverse
	GSD	24	Male	32	Fall from height	Transverse
	Mongrel	24	Male	18	Automobile accident	Short oblique
	Pom cross	18	Male	16	Fall from height	Transverse
Group II (Femur)	Labarador	24	Female	24	Accidental hitting	Transverse
	Pomerian	7	Male	10	Fall from height	Transverse
	Mongrel	24	Male	18	Accidental hit injury	Short oblique
	Labrador	10	Male	12	Accidental hit injury	Transverse
	Mongrel	12	Female	12	Fall from height	Short oblique
	Mongrel	20	Female	16	Accidental hit injury	Transverse
Group III (Tibia)	Mongrel	24	Male	20	Automobile accident	Short oblique
	Mudhol hound	8	Male	25	Accidental hit injury	Transverse
	Labrador	24	Male	16	Automobile accident	Transverse
	Mongrel	8	Female	11	Automobile accident	Short oblique
	Mongrel	24	Male	18	Accidental hit injury	Transverse
	Doberman	12	Male	20	Automobile accident	Transverse

Fig. 1: Non-weight bearing lameness: A. Radius fracture, B. Femur fracture, C. Tibia fracture

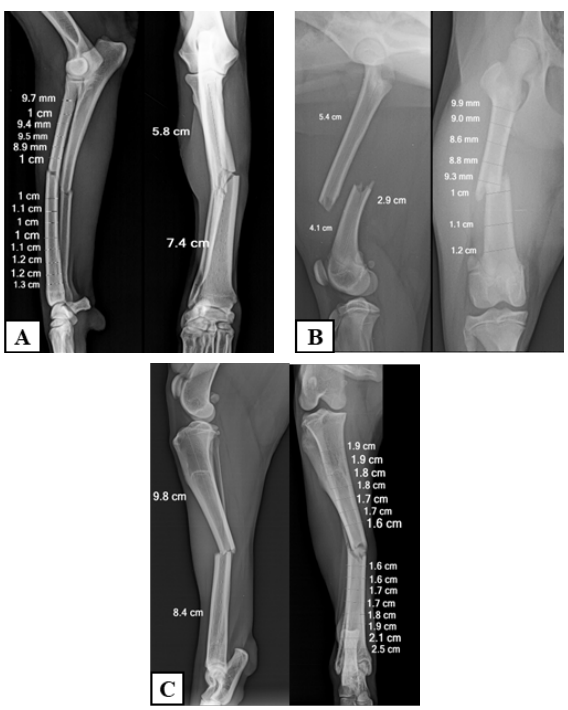

Fig. 2: Pre-operative radiographs: A. Radius and Ulna, B. Femur, C. Tibia and fibula

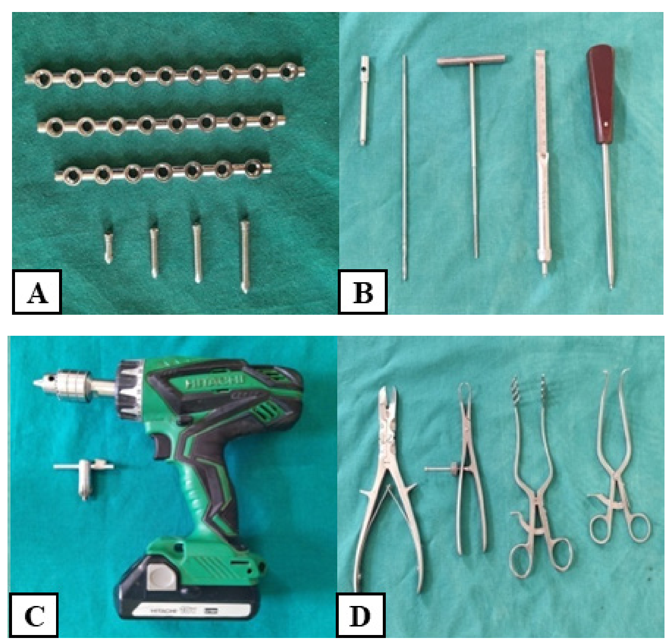

Fig. 3: A. 3.5 mm locking SOP plates of different length with cortical screws. B, C, D. orthopaedic instruments used in the study

Patient Preparation and Anaesthesia

Food was withheld for 12 h and water for 6 h preoperatively in all dogs. The entire limb to be operated was prepared for aseptic surgery. Pre-operatively, inj. Tramadol @ 4 mg/kg was administered intramuscularly for analgesia. Dogs were premedicated with inj. Atropine sulfate @ 0.45 mg/kg, i/m and inj. Xylazine hydrochloride at 1 mg/kg b. wt, i/m. General anesthesia was induced by intravenous inj. Thiopental sodium at 12.5 mg/kg and maintained with Isoflurane at 1-2%.

Instrumentation

3.5 mm locking String-of-Pearls (SOP) plates and 3.5 mm hexagonal headed locking cortical screws were used for stabilization of fractures. The length of the screws varied from 14 mm to 32 mm. A general surgical instrumentation set and an orthopedic set along with the SOP plates and screws (Fig. 3) were sterilized by autoclaving.

Surgical Procedure

The fractured bones were exposed using a standard procedure (Fig. 4) (Fossum *et al*., 2013). All the fractures of the long bones (femur, radius and tibia) were stabilized by an open reduction and internal fixation technique using 3.5 mm locking SOP plate (7-10 holes) and screws (16-32 mm) (Fig. 5).

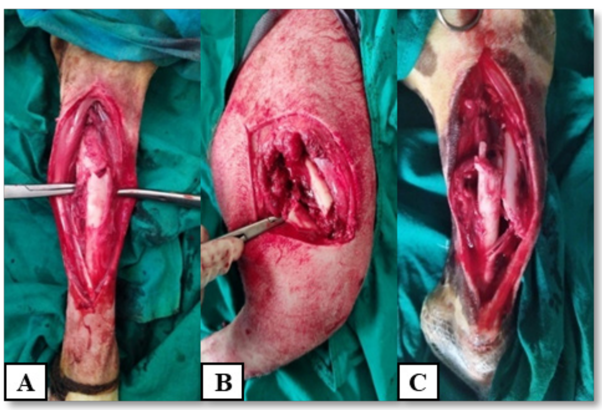

Fig. 4: Exposure of fracture fragment. A. Radius. B. Femur. C. Tibia.

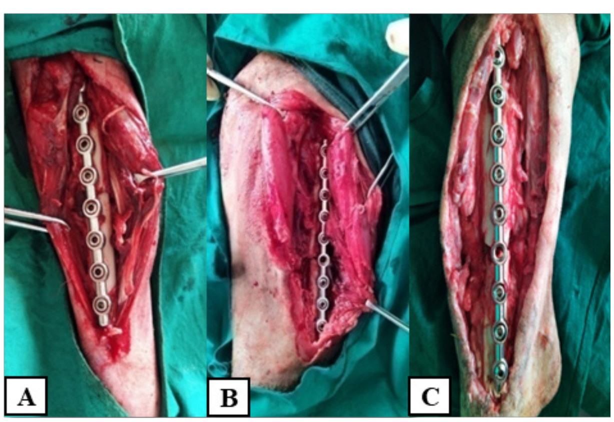

Fig. 5: After complete application of SOP plate. A. Radius, B. Femur, C. Tibia.

Post-operative Care and Follow Up

Following implant fixation, antiseptic dressing and Robert Jones bandaging was done up to two post-operative weeks. Inj. Amoxicillin-cloxacillin @ 10 mg/kg, IV for 7 days and Inj. Tramadol @ 4 mg/kg, IV for 5 days were administered after surgery. An Elizabethan collar was applied to prevent auto-mutilation of the bandage and operated site. Passive exercises of the affected limb was performed twice daily during the convalescent period from second week post-surgery. Skin sutures were removed on 15th post-operative day.

The weight bearing and lameness was recorded on immediate day after surgery, day 15, 30 and 60, and scored I-V as described by Vasseur *et al.* (1995). The follow up radiographs were taken immediately after surgery and on 15th, 30th and 60th post-operative days to evaluate the progress of fracture healing.

Results and Discussion

In this study, 18 clinical cases of dogs with long bone fractures were treated with open reduction and internal fixation using a 3.5 mm String-of-Pearls locking plate. The footprint of the plate was flat, round, and small at the beads (knots) and narrower at the internodes (cord). The plate contacted the bone surface only at the nodes, providing minimal bone-to-plate contact. The flat undercut surface of the plate made the plate easy to handle and attach as it did not move or slip during the SOP plate attachment process. The shape of the SOP plate allowed for easy intraoperative visualization, alignment, and assessment of the fracture fragments. However, the SOP plate was found to be thicker as opined by DeTora and Kraus (2008) and Mills (2009). Maritato (2018) opined that clinically, a reduction in plate footprint and better preservation of bone vascularity should be associated with better healing and reduced risk of refracture after removal. The anaesthesia protocol used in the study was found to be satisfactory. Post-operative edema, inflammatory soft tissue swelling and warmth at the surgical site were noted immediately the day after surgery.

Lameness Grading

Lameness assessment based on the type of weight bearing during standing and walking performed pre-operatively and at various postoperative intervals (Vasseur *et al*., 1995) revealed that all dogs had non-weight bearing lameness pre-operatively (grade V). Immediate postoperative evaluation showed an improvement in weight bearing (grade IV) in 17 of 18 dogs. There was an improvement in lameness score in 17 of 18 dogs by day 15 (Grade III). Full weight bearing was observed on day 30 while standing (at rest) (Grade II), and normal weight bearing at both rest and in motion (walking) (Grade I) was observed on day 60 (Fig. 6-8).

Radiographic Evaluation

Radiographs taken immediately after surgery (Day 0) showed excellent reduction and good alignment of the fractured

Fig. 6: Sequential evaluation of weight bearing and lameness grading in radius fracture. A. Pre-operative, B. Immediate day after surgery, C. Day 15, D. Day 30, E. Day 60.

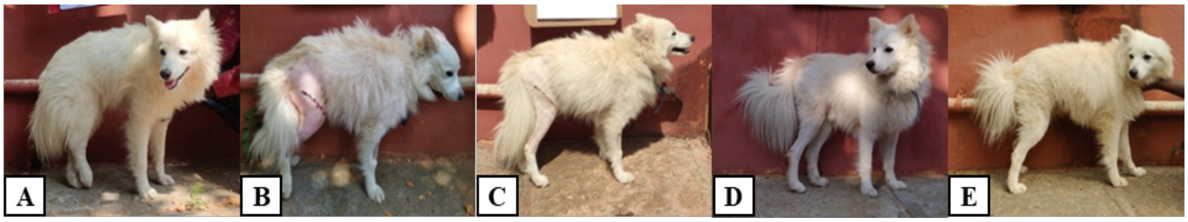

Fig. 7: Sequential evaluation of weight bearing and lameness grading in femur fracture. A. Pre-operative, B. Immediate day after surgery, C. Day 15, D. Day 30, E. Day 60.

Fig. 8: Sequential evaluation of weight bearing and lameness grading in tibial fracture. A. Pre-operative, B. Immediate day after surgery, C. Day 15, D. Day 30, E. Day 60.

fragments, except in one tibia fracture case where a screw was inadvertently placed at the fracture line (Fig. 16A). However, it did not interfere with fracture healing. Follow-up radiographs taken on postoperative day 15 showed that the apposition and orientation of the fracture fragments were stable in all cases, with adequate cortical contact between the fractured fragments. The fracture line was clear with initial evidence of bone resorption in all cases, indicating the onset of callus formation (Fig. 9-11). On the 30th postoperative day, an unstructured bridging of the bone cortex and the radiolucent fracture line was faintly visible. The fracture line had become blurred and faded. More callus formation was found in the far cortex than in the near cortex. On postoperative day 60, observation showed that early cortico-medullary bridging was evident, indicating early clinical healing. The fracture site was obliterated, indicating bridging of the fractured fragments (the callus was radiopaque; completely filled the fracture site and was barely discernible). Complete bone remodeling was observed after one year of postoperative recording (Fig. 9-11). All cases healed by primary healing with minimal callus formation. However, the callus observed in tibia at the fractured site was slightly more when compared to femur and radius. Previously many researchers (Mills, 2009; Sadan *et al*., 2015; Kumar *et al*., 2018; Segal *et al.,* 2018; Niveditha. 2019; Reddy *et al.,* 2020) reported use of String-of-Pearls plate for the repair of long bone fractures with good outcome.

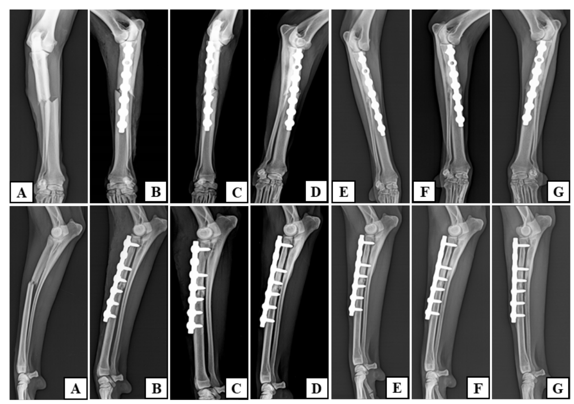

Fig. 9: Sequential cranio-caudal (below) and medio-lateral (above) radiographs showing healing of radius fracture. A. Pre-operative, B. Day 0, C. Day 15, D. Day 30, E. Day 60, F. Day 90, G. Day 120.

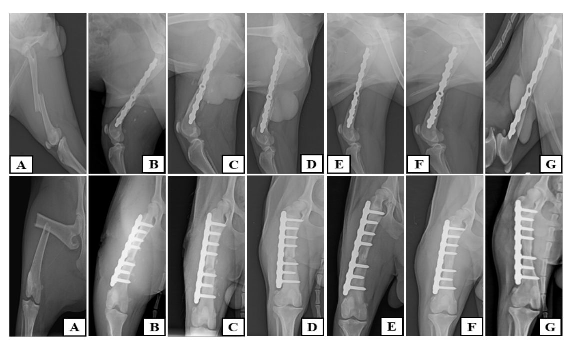

Fig. 10: Sequential cranio-caudal (below) and medio-lateral (above) radiographs showing healing of femur fracture. A. Pre-operative, B. Day 0, C. Day 15, D. Day 30, E. Day 60, F. Day 90, G. One year.

Fig. 11: Sequential cranio-caudal (below) and medio-lateral (above) radiographs showing healing of tibia fracture. A. Pre-operative, B. Day 0, C. Day 15, D. Day 30, E. Day 60, F. Day 90, G**.** One year.

Implant Removal

In very few cases the plates were removed (Fig. 12). Because of the client's non-compliance, in the remaining dogs implants could not be removed. Intra-operative observations revealed that the implant could be removed with ease due to very little callus development and infiltration surrounding the bone plate. There was no incidence of screw breakage; screw loosening or cold welding during implant removal. Radiographs of radius, femur and tibia after plate removal are depicted in Figures 13 to 15.

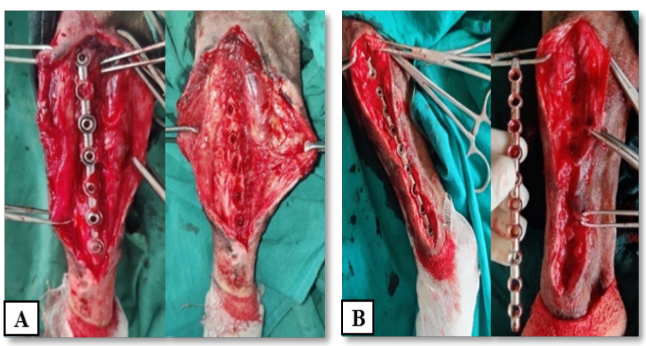

Fig. 12: Plate removal. A. Radius, B. Tibia

Fig. 13: Radiograph of radius after plate removal

Fig. 14: radiograph after plate removal B. Femur. C. Tibia.

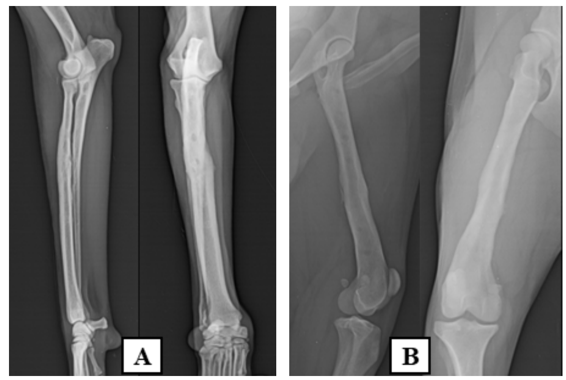

Fig. 15: Complete bone union 3 months after plate removal. A. Radius. B. Femur.

Complications

One dog with a fractured radius and one dog with a fractured tibia both displayed signs of auto-mutilation. In a patient with a tibia fracture, the plate became visible 60 days following surgery (Fig. 17C). String-of-Pearls plates in these dogs had one major drawback: the prominent profile of the implants caused soft tissue irritation in the area of high mobility that had less muscle (Kim and Lewis, 2014).

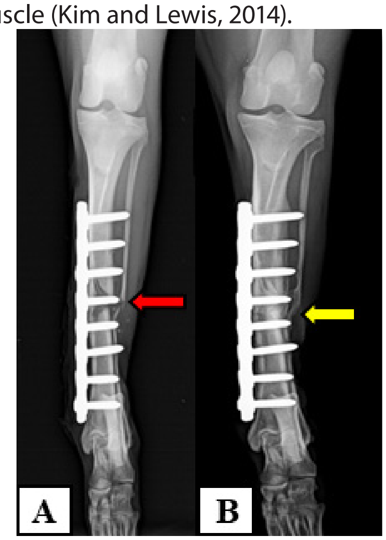

Fig. 16: A. Accidental placement of screw at fracture site. B. Fracture union

Fig. 17: A, B. Self mutilation. **C.** Exposure of plate

Conclusion

According to the findings of the current study, locking String-of-Pearls plates were an effective treatment for long bone fractures in dogs providing good compensation, a noticeable improvement in limb function and good fracture stability till the completion of the bone healing in all dogs. This technique's implant was affordable, making it suitable for application in veterinary practice.

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