International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Management of Fracture of Long Bones Using String of Pearls (SOP) Plating Technique in Dogs

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Abstract: ***The study was conducted in six dogs presented with fracture of long bones to University Veterinary Hospital, Mannuthy and Kokkalai. Pre-operatively fracture was diagnosed by orthopaedic and radiographic examination. Fracture stabilization by open reduction and internal fixation was resorted to in all the six dogs following standard AO principles using 3.5mm string of pearls plates and cortical screws. This resulted in good fracture fixation and immobilization. Radiographic examination revealed periosteal and endosteal callus formation from second post-operative week onwards. Obliteration of fracture line and radiographic union of fracture fragments were evident on sixth post-operative week. Complete radiographic union of fractured bone with minimal callus formation was observed by eighth post operative week in all the cases with stable fixation. The SOP plate application was found to be effective in managing fractures of long bones in dogs with early pain free ambulation.***

Keywords: Dogs, long bone fracture, String of pearls plate

1. Introduction

Fractures of long bone are commonly encountered in small animal orthopaedics (Julie *et al*., 2007). Proper diagnosis and appropriate use of techniques for the treatment influence the fracture healing and early ambulance. The immediate goal of fracture repair is to maintain anatomical reduction and fixation until the healing mechanism of the body restores the structural continuity of the bone (Mathai, 2015 and Mathai *et al.*, 2016). Open reduction and internal fixation (ORIF) provides proper reduction, immobilization of fracture fragments and rigid fixation, so that early and pain free ambulance is attained.

The string of pearls (SOP) plate is a plate system developed specifically for veterinary use and an accurately contoured plate when properly fixed with screws is supposed to impart sufficient stability and better alignment (Ness, 2018). This technique was reported to have certain advantages such as flexible contouring on multiple planes with smooth uniform bends which may facilitate better bone reduction and plate fixation (Karus and Ness, 2014). Since the screw holes (node) which had a greater area moment of inertia than internode, empty screw holes are no longer weak points along the length of the plate (Malenfant and Sod, 2014). Hence, string of pearls plating technique is believed to be the effective technique to overcome the drawback of other plating systems, such as screw loosening, plate breakage, osteonecrosis etc.

There is dearth of literature about clinical evaluation of string of pearls plating for repair of fractures of long bones in dogs. Hence, in the present paper, the clinical, radiographical and functional outcome of treatment of fracture of long bones using string of pearls plating technique have been placed on record.

2. Review of Literature

Fitzpatrick *et al.* (2012) in their study on stabilization of canine femoral fracture with string of pearls plate reported that string of pearls plates were designed in such a way that standard cortical screws were adapted to serve as locking screws. These plates could be contoured and twisted readily and has higher bending stress due to unique cross sectional design. The ability of the plate to twist around its axis was helpful in contouring and screw insertion and the twisting of plate was advised to be restricted to 20 degrees per internode to prevent device weakening.

Ness (2009) used string of pearls locking plates for repair of Y-T humeral fractures through combined medial and lateral incisions in 13 dogs and mentioned that, SOP could be contoured with six degrees of freedom, so that the implant could be shaped and applied in optimum position according to anatomical and biomechanical requirements.

Ness (2018) reported that 3.5mm SOP locking plates were significantly stronger and stiffer than dynamic compression plates and risk of device failure was potentially less and opined that contoured SOP plate remained as stiff and strong as uncontoured DCP plate.

Calcaneal fracture in a Pyrenean mountain dog was stabilized by Scrimgeour and Worth (2011) with string of pearls plate, which had an uneventful recovery.

Kim and Lewis (2014) performed corrective osteotomy and stabilization with string of pearls in two dogs reported excellent surgical outcome and limb function.

Kraus and Ness (2014) mentioned that contouring of string of pearls plate was possible to any shape of the bone easily than conventional bone plates with a maximum of 40 degrees of twisting or bending between nodes and plate could be contoured in total of six degrees of freedom *i.e.* medial, lateral, cranial, caudal torsion and anti torsion.

Demianiuk *et al*. (2015) reported that a minimum of one bicortical screw at each fragment was necessary to increase the torsional stability of 3.5mm SOP construct.

Grand (2016) reported acetabular and supra acetabular fracture in three dogs which were stabilized with SOP locking plate and opined that SOP plating of dorsal acetabulum was challenging and provided excellent fixation and adequate reduction with no post surgery complication.

Kumar *et al*. (2018) summarised that SOP plate provided early ambulance, good fracture stabilization and excellent healing in six dogs, which were treated for distal femoral fracture using SOP locking plate.

Niveditha (2019) studied the clinical efficacy of SOP locking plates for the management of radius and ulna fractures in dogs and concluded that the plating technique provided excellent functional limb outcome.

3. Materials and Methods

The study was conducted in six clinical cases of fracture of long bones in dogs presented to University Veterinary Hospital with the objective of evaluating the efficacy of string of pearls (SOP) plating technique for the management of long bone fractures. All the dogs presented with symptoms like swelling, pain on manipulation, non-weight bearing, abnormal angulation, lameness and crepitation of the affected limb were subjected to detailed clinical and orthopaedic evaluation like grading of lamneness according to Sumner-Smith (1993), grades of weight bearing according to Carr and Dycus (2016), functional outcome according to Clarke (1986) and radiological examination. Six dogs confirmed with fractures of long bones were included in the study. These dogs were subjected to open reduction and internal fixation using string of pearls plating technique.

Pre-operatively all the dogs were administered with tramodol hydrochloride at the dose rate of 2.0 mg/kg body weight intramuscularly and the limb was temporarily immobilised with Robert Jones bandage for a period of three days till the oedema was reduced. Food and water were withheld for 12 hours prior to surgery. Dogs were operated under general anaesthesia with the protocol including atropine at the dose rate of 0.045 mg/kg bodyweight and xylazine at the dose rate of 1.0 mg/kg bodyweight given intramuscularly as pre-anaesthetic medication, induction with ketamine at the dose rate of 5.0 mg/kg bodyweight intramuscularly and midazolam at the dose rate of 0.1 mg/kg bodyweight intramuscularly and anaesthesia was maintained with isoflurane at 2 to 3 per cent in oxygen using Bains coaxial circuit (Prabhukumar *et al*., 2020). Ceftriaxone at the dose rate of 30 mg/kg body weight intravenously was administered 30 mins prior to skin incision.

Surgical site was prepared in routine manner and hanging limb technique was employed for 15 mins to effect traction and counter traction. Open reduction and internal fixation was employed following standard AO principles with 3.5 mm SOP plates and 3.5 mm cortical screws with length varying from 14 mm to 30 mm.

After the exposure of the fracture site, reduction of fracture fragments and stabilisation were done with pre-contoured SOP plate system. Contouring was done based on the bone anatomy and fracture line. After contouring, the pate was placed on the stabilised bone fragments and the holes were drilled with 2.7mm drill bit. Depth of the holes were measured using depth gauge and 3.5mm self tapping cortical screws of appropriate length were placed first in the proximal and then in distal holes of SOP plate. Holes over the fracture line were left empty. The screws were tightened so as to embed the screw head firmly into the spherical component of SOP plate.

The muscle and fascia were apposed with polyglactin 910 (size-0) sutures in simple continuous suture pattern and skin was apposed with nylon in horizontal mattress suture pattern.

Antiseptic dressing of surgical wound was done with 5% povidone iodine solution and the limb was immobilised with plaster of Paris cast for a period of two weeks. Antibiotic therapy with cefixime at the dose rate of 20 mg/kg body weight was given twice daily orally for seven consecutive days and carprofen was given at the dose rate of 4.0 mg/kg body weight once daily orally for three days.

Owners were advised to restrict the movement of the dog for a period of two weeks. Skin sutures were removed on 14th post-operative day. The clinical, orthopaedic and radiographic evaluation were recorded pre-operatively, on day of surgery after recovery from anaesthesia and on second, fourth, sixth and eighth post operative weeks.

4. Results and Discussion

The study was conducted in six clinical cases of fracture of long bones in dogs with the objective of evaluating the efficacy of string of pearls (SOP) plating technique for the management of long bone fractures in dogs.

The age of the animals ranged from six months to 10 years. The weight of the animals ranged from 14 to 32 kilogram. Four of them were male and two were female. The breeds of dogs studied were Labrador retriever (3), non-descript (2), and Boxer (1) (Table. 1).

The exciting causes of fracture were jumping from a height (4) and automobile accident (2). The duration between the

onset of trauma resulting in fracture and presentation for treatment ranged from one to seven days.

Bones involved in the selected cases of fractures were tibia (4), femur (1) and radius and ulna (1), of which four dogs were affected with right hind limb (66.66 per cent) and one dog each with left hind limb (16.67 per cent) and right forelimb (16.67 per cent). Kumar *et al*. (2007) reported that the incidence of fractures of hind limb bones were more in comparison with forelimb (Table. 1).

The symptoms like non-weight bearing lameness, unable to place the foot on the ground, abnormal mobility of the limb, oedema, pain and crepitation on palpation of the affected limb were observed on the day of presentation.

Pre-operative orthogonal radiographs were used for classification of fractures, planning of treatment option and elucidating prognosis. Ness (2009) also mentioned that a minimum of two orthogonal radiographic views, centred on the fracture, were to be obtained to determine the number, size and shape of the fragments.

Langley-Hobbs (2003) opined that the radiograph of contra-lateral limb might be used for the purpose of comparing, as they gave information about shape, size and direction of bone. Orthogonal radiographic views (medio-lateral and cranio-caudal) were preferred for the diagnosis of fracture type and for fracture planning (Suresh *et al*., 2017).

Since the body weight of all the dogs selected for the study were more than 12 kg, 3.5 mm SOP plates were used in all the six dogs for fracture stabilisation. 3.5 mm SOP plate with 3.5 mm self tapping cortical screw provided sufficient stability and apposition of fracture fragments. Kumar *et al.* (2018) also opined that 3.5mm SOP plate for dogs above 12 kg body weight provided sufficient stability throughout the observation period.

The thickness of the bone at different areas, obtained from pre-operative radiographs of affected and contra lateral limb was used to determine the length of the screws and were confirmed by measuring the depth of the screw hole using depth gauge. Post-operative orthogonal radiographs taken immediately after the surgery revealed satisfactory fracture reduction and good alignment in all the six dogs. Follow-up radiographs taken on second, fourth, sixth and eighth post-operative weeks revealed rigid and stable fracture fixation with minimal callus formation.

Lameness evaluation was based on Sumner and Smith (1993). All the dogs on the day of presentation were unable to place the foot on the ground (Score 10). By fourth post operative week, four dogs progressed to mild lameness at slow trot, none while walking (Score 2), one dog progressed to occasional shifting of weight (Score 1) and the other dog was moderately lame but placed the foot on the ground while standing (Score 5). By eighth post-operative week, all the dogs progressed to normal sound gait (Score 0) except one dog which had occasional shifting of weight (Score 1) (Table. 2).

Weight bearing was evaluated based on the grades of weight bearing by Carr and Dycus (2016). All the dogs were unable to bear the weight on the affected limb (Grade VI) before surgical stabilisation. By fourth post-operative week, four dogs were able to bear weight on the affected limb and were sound at walk (Grade I) and two cases progressed to mild weight bearing lameness (grade II). By sixth post operative week all the dogs were able to bear complete weight on the affected limb and were sound at walk (Grade I) (Table.3)

Functional outcome of the limb was evaluated based on Clark (1986). All the dogs on the day of presentation were having persistent lameness and required immediate surgery. All the dogs returned to complete weight bearing by sixth post-operative week without any post-operative complications.

Fracture fixation using string of pearls plates with self tapping cortical screws provided good healing of fracture with minimal callus formation resulting in normal limb function. Throughout the observation period, the implant provided good stability of fracture fragments in all the six dogs without any complications.

5. Conclusion

The strength and stiffness of SOP plate with high bending strength and ability to contour to any shape make them suitable for the fixation of various long bones. It provided sufficient fracture stability and rigidity of fixation throughout the period of observation with limited contact with the bone. Due to the above mentioned qualities, all the dogs under the study exhibited excellent fracture healing and returned to early pain free ambulance. Hence, SOP plates were found suited for stabilisation of fractures of long bone in dogs.

6. Future Prospects

This technique can be extrapolated to different species of animals for the repair of fracture of various bones.

Table 1: Signalment of the selected cases

Case	Breed	Age	Sex	Body Weight (Kg)	Exciting Cause	Fractured Bone	Type of fracture
Dog-I	Labrador retriever	1.5yrs	Female	29	Fall/Jump	Right Tibia	Mid-diaphyseal transverse
Dog-II	Labrador retriever	9m	Male	32	Fall/Jump	Right Tibia	Mid-diaphyseal Oblique
Dog-III	Boxer	10m	Male	24	Fall/Jump	Right Femur	Mid-diaphyseal transverse
Dog-IV	Labrador retriever	8m	Female	25	Road Traffic Accident	Left Tibia	Mid-diaphyseal transverse
Dog-V	Non Descript	5yrs	Male	18	Road Traffic Accident	Right Tibia	Mid-diaphyseal short oblique
Dog-VI	Non Descript	10yrs	Male	17	Fall/Jump	Right Radius And Ulna	Mid-diaphyseal transverse

Table 2: Grading lameness (Sumner and Smith, 1993)

Cases	Pre-operative	Post surgery	Post operative observation (weeks)			
			Second	Fourth	Sixth	Eighth
Dog-I	10	10	3	2	0	0
Dog-II	10	9	4	2	0	0
Dog-III	10	10	5	5	3	1
Dog-IV	10	10	2	1	0	0
Dog-V	10	10	4	3	0	0
Dog-VI	10	10	3	2	0	0

Table 3: Grades of weight bearing (Carr and Dycus, 2016)

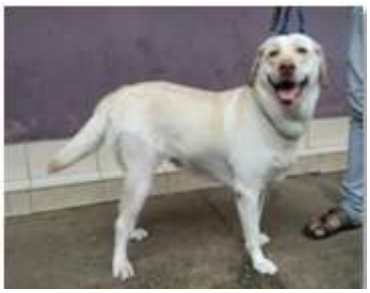
Cases	Pre-operative	Post surgery	Post operative observation (weeks)			
			Second	Fourth	Sixth	Eighth
Dog-I	VI	VI	I	I	I	I
Dog-II	VI	V	II	I	I	I
Dog-III	VI	VI	III	II	I	I
Dog-IV	VI	VI	II	I	I	I
Dog-V	VI	VI	V	II	I	I
Dog-VI	VI	VI	III	I	I	I

Dog I: Clinical evaluation of weight bearing and lameness


On the day of presentation


Second post operative week


Fourth post operative week


Sixth post operative week


Eighth post operative week

SOP plate and screw after application


Exposure of fracture fragments


Reduction of fracture fragments


Insertion of screw and tightening

SOP plate-screw construct after application

Apposition of underling tissue and skin

Dog I: Radiographic evaluation

On the day of presentation

After surgery

Second post-operative week

Fourth post-operative week

Sixth post-operative week

Eighth post-operative week

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