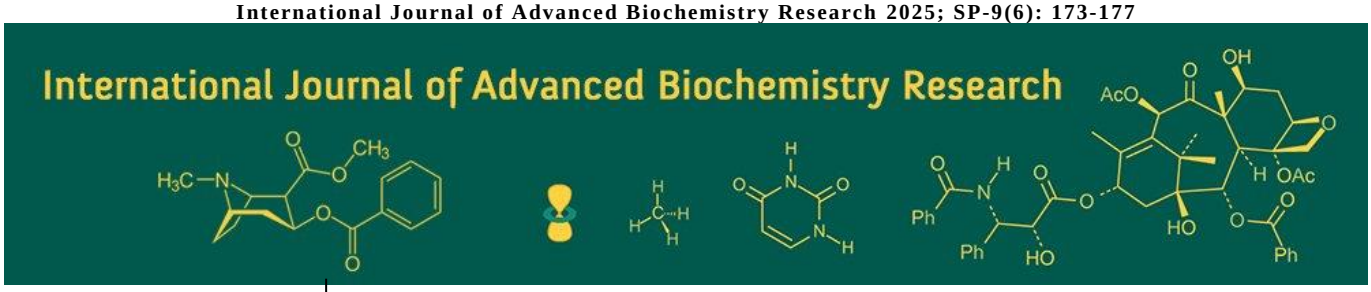

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Evaluation of string of pearls plate for the repair of femur fracture in six dogs

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Abstract
The present clinical study was conducted on six dogs presented to department of Veterinary Clinical Complex, Veterinary College, Hassan, with history of femoral fracture and non-weight bearing lameness. Among six animals five were male and one female having different age groups (all above 6 months). Clinical examination revealed pain and crepitus in all animals. The hemato-biochemical parameters were within the range. Plain radiography of the affected limb was performed in medio-lateral and cranio-caudal view for confirmatory diagnosis, implant selection. Open reduction and internal fixation (ORIF) were performed in all the animal. The surgical site was aseptically prepared and cranio-lateral approach was used to expose the fracture fragments. All the animals were pre-anaesthetised using atropine sulphate, xylazine HCl and Butorphanol tartarate combination and induction was done using propofol and maintainance was done using Isoflurane. String of Pearls plate was used to stabilize the femur fracture. Upon lameness grading majority of the animal started to bear weight from 3rd day and upon radiogrphice evaluation by 60thday complete bone homogenous structure with absence of fracture line was observed in two cases and apparent bridging of callus with barely discernible fracture line was observed in remaining four cases. All the animals recovered uneventfully and SOP proved to be better option for the management of femur fracture in dogs.

Keywords: Dogs, femur, string of pearls plate, lameness, radiography

Introduction
Fractures remain still one of the major clinical cases in the field of orthopedics in veterinary. Femoral fractures are the most common among the long bone fracture, which accounts for 37 percent followed by radius-ulna (28.7%), tibia-fibula (20.4%) and humerus (7.9%) respectively (Kallianpur *et al.*, 2019) [3]. The healing of fractures and ambulance depends on accurate diagnosis and the application of treatment strategies. The String of Pearls (SOP) plate is a novel orthopedic plate system designed for both veterinary and human orthopedic use. The SOP locking plate consists of a series of cylindrical sections (internodes) and spherical components (pearls). The SOP differ from other locking plate systems in its ability to be contoured in six degrees of freedom; medial to lateral bending, cranial to caudal bending and torsion. This contouring is achieved using specially designed bending irons without compromising the plate's locking function (Kraus and Ness, 2014) [4].

Materials and Methods
The study was carried out on the clinical cases of six dogs with femoral fracture, presented to Department of Veterinary Surgery and Radiology, Hassan. The cases were selected based on physiological, clinical, radiographic and haemato-biochemical examination (table no 1 and 2). The study was meant to clinically evaluate the efficacy of SOP plate for the management of femoral fracture in six dogs for a period of 60 days with lameness grading and radiographic evaluation. Roberts-jones bandaging was applied to prevent soft tissue damage, to immobilize the fracture fragment, reduce swelling and to provide comfort until surgery. Patients were prepared for surgery by withholding food for 12 hours and water for 6 hours prior to surgery.
The surgical site was aseptically prepared and Inj. Ceftriaxone @ 25 mg/kg b.wt intravenously, Inj. Meloxicam @ 0.2 mg/kg b.wt i/v was administered as pre-operative

antibiotics and analgesics respectively. The dogs were administered with Inj.Atropine sulphate @ 0.04 mg/kg b.wt subcutaneously, Inj.Butorphanol tartarate @ 0.2 mg/kg b.wt i/v and Inj. Xylazine Hcl @ 1 mg/kg b.wt intramuscularly as pre-anaesthetics. Induction was done using inj propofol @ 4mg/kg b.wt intravenously and maintenance with 1-2% isoflurane with closed circuit and precision vaporizer.

The skin incision was made on the craniolateral aspect of the femur from greater trochanter to stifle joint. The incision was extened through the subcutaneous tissue. Tensor fascia lata was dissected and biceps femoris muscle retracted caudally and vastus lateralis muscle retracted cranially to expose the fracture fragment.

Stabilization of fracture

The reduced fracture fragments were stabilized by using SOP with self-tapping locking head screws. The plate was pre-contoured according to the shape of bone using plate benders, the plate was fixed to the bone using self-centering bone holding forceps. The plate holes were drilled using drill bit of size 2.2 mm for 2.7 mm plate and 2.7 mm for 3.5mm plate. Size of the screws were measured using depth gauze and appropriate screws were fixed to the plate using hexagonal screw driver.

Wound Closure

After fracture fixation, the surgical site was lavaged with sterile 0.9% normal saline to clear debris and clots. The implant was covered by suturing tensor fascia lata in simple interrupted fashion using polyglactin 910 and simple continuous pattern for subcutaneous tissue closure. The skin incision was closed with cross mattress sutures pattern using monofilament polyamide.

Post-operative care and management

The operated limb was supported externally with Robert-Jones bandage for a period of 15 days with alternate day wound dressing. The dogs were provided with Tab. Cefpodoxime Proxetil @ 10 mg/kg b.wt once daily for seven days and tab. Carprofen @ 4 mg/kg b.wt once daily for 3 days as post-operative antibiotic and analgesic respectively. They were also provided with Tab. Trypsin twice daily for 5 days and Calcium syrup b.i.d for 20 days. The owners were advised to restrict the activities, with short leash walks for a period of three weeks. Skin sutures were removed on 10thday post-operatively.

Results

The soft tissue damage was mild in four cases, mild callus formation observed in one case and mild soft tissue damage was observed in the another one case. Physical traction and counter traction, reduction forceps helped in bringing fragments to normal anatomical alignment easy in all cases of except one case difficulty was observed due to callus formation.

The application of SOP was easier in terms of its narrower structure and this property is very much useful while applying in narrower width bone. One more advantage of SOP is due to its six degrees of freedom it can be bent with the help of SOP plate benders and bending tees according to the need such that bending should not exceed 20 degree per internode and this was especially useful for distal femoral fracture management as done in S4 case.

Figure format

Table 1: Case Details

S1	Non-Descript	48	Male	19.5	Left	Automobile Accident
S2	Non-Descript	11	Male	16	Left	Automobile Accident
S3	Siberian Husky	7	Female	10.5	Right	Fallen From Height
S4	Non-Descript	24	Male	22	Left	Dog Bite
S5	Non-Descript	18	Male	16.5	Left	Automobile Accident
S6	Non-Descript	30	Male	20.5	Left	Automobile Accident

Table 2: Fracture type and AO Classification

S1	Transverse	Proximal diaphyseal	31A3
S2	Oblique	Distal diaphyseal	33A2
S3	Transverse	Distal diaphyseal	33A3
S4	Impacted Transverse	Mid diaphyseal	32C2
S5	Transverse	Proximal diaphyseal	31A3
S6	Oblique	Distal diaphyseal	33A2

Table 3: Lameness grading in both Group A and Group B

Grade 1	Normal weight bearing on all the limbs during stance and while walking
Grade 2	Normal weight bearing at stance but favors affected limb when walking
Grade 3	Partial weight bearing while standing and walking
Grade 4	Partial weight bearing at stance but non-weight bearing while walking
Grade 5	Non-weight bearing while standing and walking

S1	5	5	1	1	1
S2	5	5	1	1	1
S3	5	5	2	1	1
S4	5	5	3	3	2
S5	5	5	3	1	1
S6	5	5	1	1	1

Table 4: Radiographic evaluation

S1	5	3	2	2
S2	5	2	2	1
S3	5	3	2	1
S4	5	4	3	2
S5	5	3	2	2
S6	5	3	3	2

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

Lameness Grading In Case S1 (Plate 1-4)

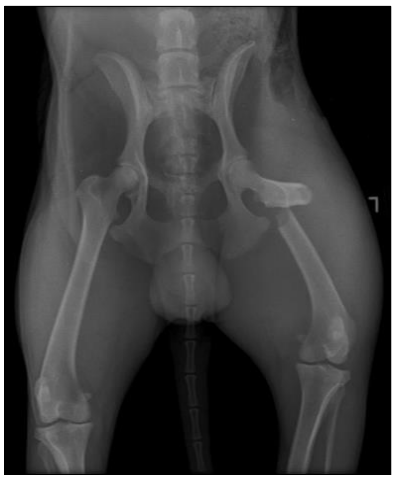
Showing grade 5 lameness on preoperative day

Showing grade 2 lameness on 15th day

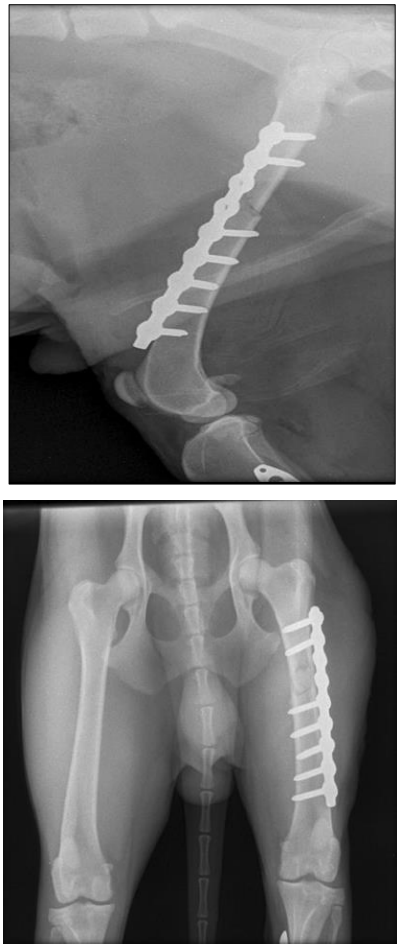
Showing grade 1 lameness on 30th day

Showing grade 1 lameness on 60th day

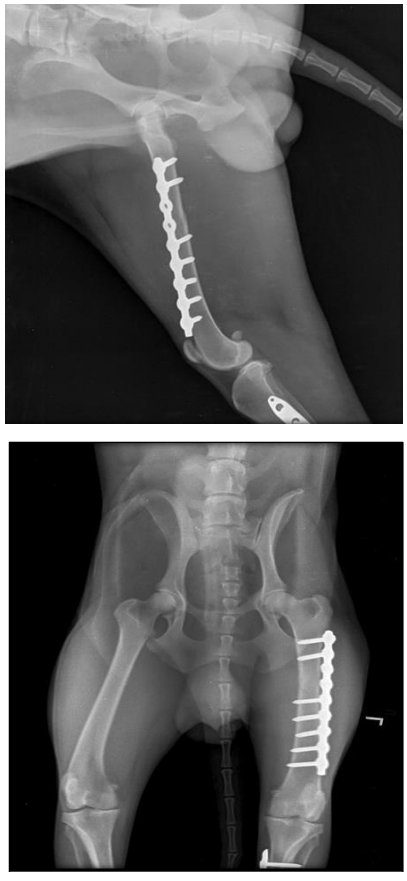
Radiographic Evaluation of S1 (Plate 5-8)



Preoperative radiography revealed proximal diaphyseal fracture of left femur



On 15th radiograph revealed correct placement of screw and plate and fracture line is visible



On 60th day radiography revealed restoration of corticomedullary junction and absence of fracture line

Discussion

The lameness grading was performed pre and post-operatively on scheduled intervals i.e., pre-operatively, on 1st, 15th. 30th and 60th day post-surgery (table no 3). The dogs showed grade 5 lameness in all cases on pre-operative day and immediate post-operative day.

On 15th day three dogs (S, S2 and S6) showed grade 1 lameness, One dog (S3) showed grade 2 lameness and remaining two (S4 and S5) cases showed grade 3 lameness and by 30th day five cases (S1, S2, S3, S5 and S6) showed grade 1 lameness and one case (S4) had grade 3 lameness and by 60th day all cases had grade 1 lameness except one case (S4) which had grade 2 lameness (plate 1-4).

Bhoomaiah *et al.* (2022) [1] and Joshi *et al.* (2022) [2] used SOP for stabilization of long bone fracture and observed that all the dogs showed partial weight bearing from immediate postoperative day and majority of dogs progressed to grade 1 lameness with normal walking and stance pattern was observed by 30th postoperative period.

Radiographic evaluation

Through immediate post-operative radiograph fracture reduction to normal anatomical alignment, length of the plate, screw size, position and placement of plate were optimum in all the cases (plate 5-8). These observation were in correlation with Joshi *et al.* (2022) [2].

Apparent bridging of the callus with discernible fracture was observed by 15th post-operative day in four cases (S1, S3, S5 and S6). By 30th post-operative day apparent bridging of the callus with discernible fracture was observed in two cases (S4 and S6) and three cases (S1, S2, S3 and S5) showed massive bone trabeculae crossing the fracture line with fracture barely discernible was observed.

By 60thday complete bone homogenous structure with absence of fracture line was observed in two cases and apparent bridging of callus with barely discernible fracture line was observed in remaining four cases. (Radiographic evaluation was given n table no.4)

Ness (2009b) [6], Kumar *et al.*(2018b) [5], Joshi *et al.*(2022) [2] all revealed that fracture healing pattern in long bone fracture management by SOP took 7-11 week with restoration of corticomedullary junction with bone union.

Conclusion

In conclusion clinical outcome after SOP application had excellent results both radiographically and in regards to lameness grading also. SOP seems to be good option in restoration of corticomedulary junction and absence of fracture line can be observed earlier. SOP can be contoured in any conformation according to the bone conformation this property of SOP helped in distal femoral fracture repair and application wise it proved to easier in terms of application.

Acknowledgments

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