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A clinical study on the use of string of pearls plate system in stabilization of long bone fractures in dogs

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Abstract
The clinical study on eight dogs under 18 months age with long bone fractures were stabilized with 2.7 mm and 3.5 mm String of Pearls Locking Plates (SOP). Five were male and three were female. Follow-up radiographs on 15th, 30th, 60th and 90th post-operative days revealed secondary bone healing with periosteal callus formation. In one dog, plate breakage on 15th post-operative day and plate bending was on 30th post-operative day in another dog. Grade V lameness improved to grade I lameness and two dogs progressed to grade II lameness by the end of 45th post- operative day.

Keywords: String of pearls plate, dogs, internal fixation, long bone fractures, canines

Introduction
The SOP plate is a novel orthopaedic plate system designed for Veterinary and Human orthopaedic use. As with all locking plate systems, the SOP can be thought of mechanically as an internal- external fixator. The SOP locking plate consists of a series of cylindrical sections (internodes) and spherical components (pearls). The cylindrical component, or internode, has an area moment of inertia greater than the corresponding DCP's. The SOP differs from other locking plate systems; that the SOP can be contoured in six degrees of freedom; medial to lateral bending, cranial to caudal bending and torsion using specially designed bending irons without compromising the locking function The SOP plate achieves locking by having a thread at the base of the hole that matches the screw head, and the screw head is compressed into the wider superficial part of the hole [1]. String of Pearls (SOP) locking plates were good for stabilization of distal femoral shaft fractures for early limb ambulance and excellent healing. The application of SOP plates was found effective with advantages like ability of contouring to any shape of the bone, high bending strength, its central design to use standard cortical screws as locking screws, maintenance of limited contact with periosteum and cost similar or less than those of conventional orthopaedic plating systems. All these attributes allow SOP plate to be used for stabilization of distal shaft fractures of other long bones [2]. The primary utility of the SOP plate is for communited fractures of femur, humerus, tibia and radius-ulna. Although the SOP can be used in conventional 'open approach' fracture surgery, it is especially valuable with so called biologic fixation methods and minimally invasive techniques. A second SOP can be applied on the contralateral or orthogonal side of bone, or two SOP's can be nested side by side [1].

Materials and Methods
Anamensis
The age of the eight dogs ranged from of 4-18months with a mean of 9.75±2.11months. Out of these eight dogs, five were males and three were female. Among them two dogs belonged to Pomeranian breed, two dogs belonged to Labrador and rest of the dogs were Mongrels. The body weight of the dogs ranged from 4.5 to 12 kg with a mean body weight of 7.16 ± 0.91kg.
The cause of fractures in this group was automobile accident in 4 dogs, jump from an height in 3 dogs and trauma in 1 dog. The fractures occurred in 5 male dogs and 3 female dogs. The mean time of gap between the time of fracture and treatment was 5.75± 1.50 days with a range of 1- 12 days. The details were shown in table 1.

Table 1: History and Signalment of the dogs selected for the study in Group

Case No.	Breed	Age (months)	Sex	Body weight (Kg)	Cause	Days since fracture
1	Mongrel	14	Female	12	jump from height	7
2	Mongrel	6	Male	9.2	Automobile accident	12
3	Mongrel	8	Male	8.8	Automobile Accident	5
4	Labrador	4	Female	6	Trauma	4
5	Labrador	5	Female	5	Jump from Height	2
6	Mongrel	18	Male	5.3	Automobile Accident	12
7	Pomeranian	5	Male	4.5	Fall from height	3
8	Pomeranian	18	Male	6.5	Automobile accident	1
Mean ± SE		9.75 ±2.11		7.16 ± 0.91		5.75± 1.50

Pre-Operative Observations

Pre-operative Clinical Observations

The dogs presented with long bone fractures involving radius and ulna, humerus and tibia were first examined routinely for soft tissue injuries, if any, were attended to. The dogs were then clinically examined for loss of function, abnormal mobility, deformity or change in angulation of the affected limb, pain and crepitation at the fracture site. Clinical signs such as local swelling, infection, exudates from the fracture site, soft tissue and neurological status of the dogs were assessed.

Pre-operative Radiographic Observations

Two plain orthogonal views of mediolateral and craniocaudal radiographs of the affected limbs including the proximal and distal joints confirmed fractures. Out of eight dogs, radiographs revealed transverse fractures in five dogs and oblique fractures in three dogs. Pre-operative radiographs of the dogs with long bone fractures are presented in (Fig.1). The details regarding the fractures encountered in all the dogs are presented in Table 2.

Table 2: Pre-operative Radiological Observations (SOP)

S. No	Side	Location of fracture	Type of fracture
1	Right radius and ulna	Distal-diaphyseal	Closed complete transverse fracture
2	Right radius and ulna	Distal-diaphyseal	Closed complete oblique fracture
3	Left radius and ulna	Mid-diaphyseal	Closed complete transverse fracture
4	Right tibia	Mid-diaphyseal	Closed complete oblique fracture
5	Right tibia	Distal-diaphyseal	Closed complete transverse fracture
6	Left tibia	Proximal-diaphyseal	Closed complete oblique fracture
7	Right humerus	Mid-diaphyseal	Closed complete transverse fracture
8	Right humerus	Mid-diaphyseal	Closed complete transverse fracture

Fig 1: Pre-operative radiographs of dogs with Humerus, Radius and Ulna fractures and Tibia (Medio lateral view)

Patient preparation

The dogs with fracture of radius-ulna were positioned in lateral recumbency with the fractured limb down and the contra lateral limb secured out of the way. The dogs with fracture of humerus was positioned in lateral recumbency with the fractured limb up and whereas dogs with fractures of tibia were positioned in lateral recumbency with the fractured limb down and the contralateral limb secured out of the way.

Covering the distal extremity of the limb with sterile gauze bandage facilitated manipulation of the limb during surgery without compromising asepsis. The operative site was shaved and scrubbed using povidone-iodine surgical scrub, followed by the application of surgical spirit and the draping was considered satisfactory since infection was not encountered in any of the eight dogs post-operatively.

Anaesthesia

Atropine sulphate at the rate of 0.04 mg/kg body weight was administered subcutaneously as pre-anesthetic medication followed 10-15 minutes later by xylazine hydrochloride at the rate of 1 mg/kg body weight intramuscularly [9]. Ten minutes later, general anaesthesia was induced with intramuscular injection of ketamine hydrochloride at the rate of 10 mg/kg body weight [10]. Following induction, the dogs were intubated with endotracheal tubes of suitable size. Anaesthesia was maintained with intravenous injection of propofol at the rate of 4 mg/kg body weight. Additional doses of propofol were also administered whenever necessary during surgical procedure through the intravenous line.

Materials Used

Orthopaedic Instruments

A general surgical instrument set and orthopaedic instruments as needed for a particular procedure were used. Orthopaedic instruments including Gelpi retractors, Bone holding forceps, Hohmann's retractors, Senn retractors, Orthopaedic hexagonal screw drivers, 2.0 mm and 2.5 mm Drill bits, Depth gauge and power drill were used for performing string of pearls (SOP)Plating.

The general surgical and orthopaedic instruments including the implants were sterilized in an autoclave prior to surgery while hexagonal head screw driver and low speed high torque drill were sterilized in the formaldehyde sterilizer.

SOP plate benders, Orthopaedic hexagonal screw drivers, drill bits, Power drill, and a K-wire to act as template for plate contouring were used in the present study.

Implants

The String of Pearls Locking plates (SOP) [6] and Bicortical self tapping screws were used for stabilization of fractures *viz*., 3.5 mm SOP plate with 3.5 mm cortical screws and 2.7 mm SOP plate with 2.7 mm cortical screws(Fig 2).The SOP locking plate system is the only locking plate system that locks with conventional cortical screws. The SOP plate achieves locking by having a thread at the base of the hole that matches the screw head, and the screw head is compressed into the wider superficial part of the hole [2].

The choice of plate was determined on the basis of weight of the dog and the diameter of the bone as measured from the pre-operative radiographs. The 2.7 mm SOP plate was used in dogs weighing less than 8 kg and 3.5 mm SOP plate was used in dogs weighing more than 8kg. Due to implant failure observed in one dog weighing more than 10 kg, 3.5 mm SOP plates were used in nested configuration in one dog weighing 12 kg. (Fig. 3). The design of study is given in table.3

Fig 2: 2.7 mm SOP Locking plate with 2.7 mm Bicortical screws

Fig 3: Immediate post operative radiographs of SOP plate nesting in a dog

Table 3: Clinical details of dogs (SoP Plating Technique)

Case no.	Breed of dog	Sex	Age (m)	Etiology of fracture	Side	Location of fracture	Type of fracture	Details of implant used
1	Mongrel	Female	14	jump from height	Right radius and ulna	Distal-diaphyseal	Closed complete transverse fracture	3.5 mm
2	Mongrel	Male	6	Automobile accident	Right radius and ulna	Distal-diaphyseal	Closed complete oblique fracture	3.5 mm
3	Mongrel	Male	8	Automobile Accident	Left radius and ulna	Mid-diaphyseal	Closed complete transverse fracture	3.5 mm
4	Labrador	Female	4	Trauma	Right tibia	Mid-diaphyseal	Closed complete oblique fracture	2.7 mm
5	Labrador	Female	5	Jump from height	Right tibia	Distal diaphyseal	Closed complete transverse fracture	3.5 mm
6	Mongrel	Male	18	Automobile Accident	Left tibia	Proximal-diaphyseal	Closed complete oblique fracture	3.5 mm
7	Pomeranian	Male	5	Fall from height	Right humerus	Mid-diaphyseal	Closed complete transverse fracture	2.7 mm
8	Pomeranian	Male	18	Automobile accident	Right humerus	Mid-diaphyseal	Closed complete transverse fracture	2.7mm
			9.75 ±2.11					

Surgical Procedure

Surgical Approach to the Humerus

A craniolateral skin incision was made from the greater tubercle of the humerus proximally to the lateral epicondyle distally, following the cranio-lateral boarder of the humerus (Fig.4.A). Subcutaneous fat and fascia were incised and retracted with the skin. Brachial fascia incised along the lateral boarder of the brachiocephalicus muscle and distally over the cephalic vein. Care was taken to avoid cutting the cephalic vein. An incision was made in the cranio-medial fascia of the brachialis muscle and in the insertion of the lateral head of the triceps brachii on the humerus. An incision was made in the periosteal insertion of the superficial pectoral and brachiocephalicus muscles on the humerus shaft. The radial nurve overlying the brachialis muscle identified and protected. Muscles were retracted through muscle retractors. The fracture site was thus exposed.

Surgical Approach to the Radius

A cranio-medial skin incision of the desired length was made directly over the radius (Fig. 4 B). The subcutaneous tissues were then incised to expose the radial diaphysis to the described extent. Care was taken to avoid cutting the cephalic vein. The extensor tendons were elevated to expose the cranial surface of the distal metaphysis of the radius. The fracture site was thus exposed.

Surgical Approach to the Tibial Diaphysis

In order to avoid skin incision directly over a bone plate a curved incision was made. The skin incision commenced near the medial tibial condyle, curved cranially to follow the tibial crest, then again curved caudally towards the medial malleolus (Fig. 4 C). Subcutaneous fascia was dissected in the same line as skin incision and care was taken to protect the saphenous vessels and saphenous nerve crossing the middle to distal third of the tibial diaphysis. The saphenous nerve and blood vessels were freed and retracted in the appropriate direction either proximally or distally depending on the area of the bone it was necessary. The deep crural fascia on the medial shaft of the tibia was incised and the fractured bone was exposed.

Fig 4: Surgical approach to the long bones

A. Skin incision along the crani lateral border of the arm
B. Cranio- medial skin incision made directly over Radius shaft
C. Cranio-medial incision made directly over Tibial shaft

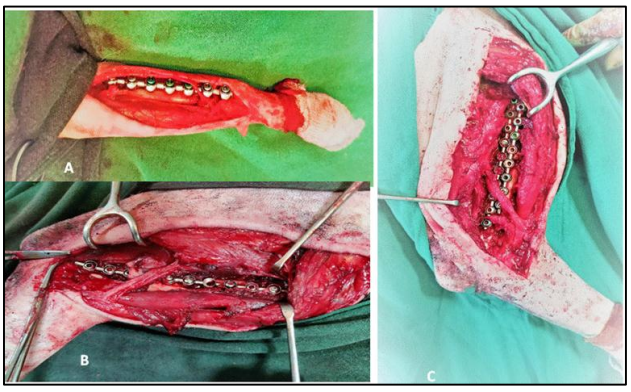

Fig 5 A,B &C: Boneplateing completed in radius and humerus

The fractures were reduced by manipulation and the fracture fragments were aligned and held in position using bone reduction forceps with speed lock. After reduction, the fracture fragments were stabilized with pre contoured 3.5 mm or 2.7 mm SOP plate with locking screws of corresponding size.

After contouring, the SOP plate was placed on the bone and the contour was reviewed. The screws were directed perpendicular to the spherical component of SOP. A hole was drilled using either 2mm (for 2.7 mm SOP plate) or 2.7mm (for 3.5 mm SOP plate) drill bit across the bone diaphysis using a power drill until the drill bit passed through both the near and far cortices. Screws were first placed at the proximal and distal holes of the SOP plate (Fig.3.12). The length of the screws was determined by measuring the thickness of bone from the pre- operative radiographs and was confirmed during the surgical procedure by using a depth gauge. A screw of suitable length was then placed at the drilled hole and tightened using a hexagonal orthopedic screw driver until the taper end of screw exited the far cortex to secure the SOP plate to the bone. String of Pearls bone plating was accomplished by insertion of screws in both proximal and distal fracture fragments (Fig. 5 A,B).

In one dog weighing 12 kg, SOP plate nesting was performed; the surgical approach followed was as described earlier. Instead of one plate, two 3.5 mm SOP plates were contoured to match the topography of lateral aspect of bone and were nested side by side (Fig.5C).

Closure of the incision

The incision made for exposure of humerus and plating was closed with a row of simple continuous sutures of 2-0 polyglactin 910. Subcuticular sutures were applied with 2-0 polyglactin 910. The skin incision was closed in a row of cruciate mattress sutures of 2-0 polypropylene.

In the case of tibia, subcutaneous fascia was closed with continuous sutures of 2-0 polyglactin 910. The skin incision was closed in a row of cruciate mattress sutures of 2-0 polypropylene.

The subcutaneous tissue incision made for exposure of radius -ulna was closed with a row of simple continuous subcutaneous sutures using 2-0 polyglactin 910. The skin incision was closed in a row of cruciate mattress sutures of 2-0 polyamide.

Post-Operative Care and Management

The suture line was covered with a thin layer of sterile gauze bandage dipped in 5% povidone iodine solution. Over this, a thick layer of cotton pad was wrapped. It was then covered

with gauze bandage and finally, a layer of surgical paper tape was applied (Fig.6.A,B,C). Schroeder-thomas splint was applied to dogs with tibial fractures. Schroeder Thomas splint was constructed from Aluminium splint rod and was applied at the end of the cast with the purpose of elevating toes from the ground and preventing contact during weight bearing. The dressing was replaced on every alternate day until the sutures were removed on the 12th post-operative day. Injection ceftriaxone sodium was administered at the rate of 25 mg/kg body weight as intramuscular injection for 7 days post-operatively. Injection meloxicam was administered once a day at the rate of 0.3 mg/kg body weight by intramuscular injection for 3 days post-operatively. Owners were advised to restrict the movement of the animal for the first 2 weeks of surgery and then to allow leash walking for the next few weeks

Fig 6 A, B& C: Humeral, Radius Ulna & tibial fracture stabilized with Robert jones bandage

Results

Clinical evaluation was carried out every alternate day to check for the presence of swelling, exudation and weight bearing in all the dogs. The appearance of suture line was also examined every alternate day until the sutures were removed. The post-operative day on which the dog started bearing weight was recorded and graded. After suture removal, the dogs were examined once in a week for the limb stability until fracture healing was considered satisfactory.

Post-Operative Clinical Observations

Dressing the surgical wound with 5% povidone iodine pads was found to be effective in keeping the site clean in all the dogs. Application of Robert-Jones bandage provided satisfactory immobilization of the limb. The use of injection ceftriaxone sodium effectively prevented post-operative infection. The skin sutures were removed between 10th to 12th post-operative day in all the dogs. None of the dogs developed post-operative swelling and suture dehiscence and the surgical wounds healed well in all the dogs without any complications.

Lameness grading

All the eight dogs in the present study showed partial weight bearing from the 1st post- operative day. Two dogs achieved complete weight bearing by 7th post-operative day, four dogs by 15th post-operative day and one dog by 30th post-operative day. Six dogs progressed to Grade I lameness by 30th post-operative day. Weight bearing on different post-operative days in dogs is depicted in (Figs.7). The details of lameness grading are presented in Table. 4

Fig 7: Progressive weight bearing on different post-operative days in long bone fractures dogs

Table 4: Post-operative details of lameness grading

Case No	SOP	Pre - operative	Post-operative lameness grades					
			Day 1	Day 7	Day 15	Day 30	Day 45	Day 60
1	3.5 mm	V	III	I	I	I	I	I
2	3.5 mm	V	III	II	I	I	I	I
3	3.5 mm	V	IV	III	II	I	I	I
4	2.7 mm	V	IV	III	IV	I	I	I

5	3.5 mm	V	III	II	I	II	II	IV
6	3.5 mm	V	IV	III	II	I	I	I
7	2.7 mm	V	III	II	II	II	II	IV
8	2.7mm	V	III	II	I	I	I	I
Mean ± SE			3.37±0.18	2.25±0.25	1.75±0.36	1.25±0.16	1.25±0.16	1.75±0.49

Grade I- Normal weight bearing on all limbs at rest and while walking.
Grade II- Normal weight bearing at rest, favors affected limb while walking.
Grade III- Partial weight bearing at rest and while walking.
Grade IV- Partial weight bearing at rest; does not bear weight on affected limb while walking.
Grade V- Does not bear weight on limb at rest or while walking.

Post-Operative Radiographic Observations

Immediate post-operative radiographic evaluation confirmed proper placement of the plate and screws, apposition and alignment of the fracture fragments in all the eight cases. Immobilization was considered satisfactory in all the cases. Length of the plate and screws, their size and position were appropriate in all cases. Sequential post-operative radiographs showed progressive bone healing. Postoperatively plate breakage or bending was observed in two cases.

Follow-up radiographs obtained on 15th post-operative day depicted proper position and alignment of the fracture fragments in seven cases but in one dog plate breakage was noticed in humerus due to subsequent fall from height by 15th post-operative day. The radiographs revealed good callus formation, bridging the fracture site in seven the dogs.

Follow-up radiographs obtained on 30th post-operative day revealed bridging callus considerably reduced in size. The callus was smoother and more opaque and the radiolucent fracture line was faintly visible in six dogs however in one dog with radius and ulna fracture, complication was noticed. Plate bending in radius and ulna was noticed by 30th post-operative day due to subsequent fall from height.

Follow-up radiographs obtained on 60th post-operative day, the fracture line disappeared and restitution of cortico-medullary continuity was observed on radiographs.

Radiographs obtained on the 90th post-operative day revealed completed bone healing with distinct cortico-medullary continuity caused by re modelling of excess callus. Post-operative progressive radiographic changes were shown in (Fig.8).

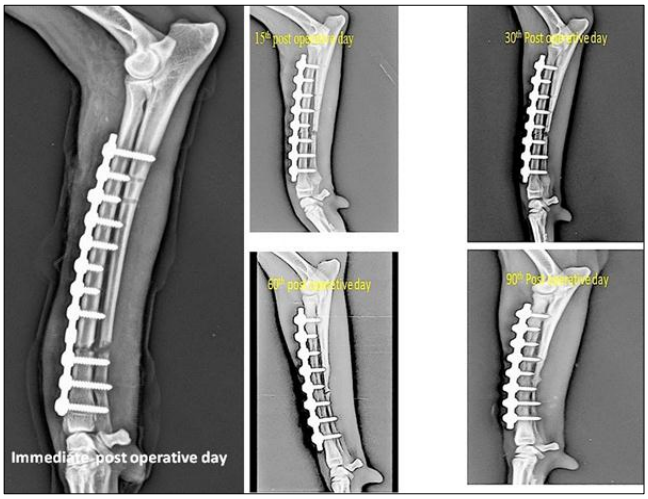

Fig 8: Progressive Radiographic changes in dog with radius and ulna fracture with SOP

Discussion

Post-operatively, lameness grade showed gradual improvement to normal weight bearing over the period of study. The lameness grade was carried out in accordance with protocol [3]. Lameness grading based on weight bearing was recorded in all animals pre-operatively showed grade V lameness before surgical stabilization of the fracture. Post-operatively, six dogs progressed to grade I lameness and two dogs progressed to grade IV lameness by the end of 60th post-operative day.

In the present study, use of the String of Pearls locking plate (SOP) with cortical screws showed remarkable improvement with normal limb function and maintaining good implant stability throughout the treatment period without any complications in six out of eight dogs. Similar findings were observed by [2, 4, 5, 6, 7, 8]. However, in one dog plate breakage was observed adjacent to fracture line by 15th post-operative day with failure occurring through the internode between two screw holes and plate bending was observed adjacent to fracture line by 30th post-operative day. The plate breakage adjacent to fracture line in one dog which was stabilized with SOP Locking plate [9]. The plate breakage was observed in one dog by 30th post operative day [10] and plate breakage was observed in two dogs by 30th post operative day [11].

Immediate post-operative radiographic evaluation confirmed proper placement of the plate and screws, apposition and alignment of the fracture fragments in all the eight cases. Immobilization was considered satisfactory in all the cases. Length of the plate and screws, their size and position were appropriate in all cases. Sequential post-operative radiographs showed progressive bone healing [12, 13]. Postoperatively plate breakage or bending was observed in two cases [11].

Follow-up radiographs obtained on 15th post-operative day depicted proper position and alignment of the fracture fragments in seven cases but in one dog plate breakage was noticed in humerus due to subsequent fall from height by 15th post-operative day. Follow-up radiographs obtained on 30th post-operative day revealed bridging callus considerably reduced in size. The callus was smoother and more opaque and the radiolucent fracture line was faintly visible in six dogs however in one dog with radius and ulna fracture, complication was noticed. Plate bending in radius and ulna was noticed by 30th post-operative day due to subsequent fall from height. Follow-up radiographs obtained on 60th post-operative day, the fracture line disappeared and restitution of cortico-medullary continuity was observed on radiographs. Radiographs obtained on the 90th post-operative day revealed completed bone healing with distinct cortico-medullary continuity caused by re modelling of excess callus. These findings are in agreement with [5, 14, 9, 2, 11, 12, 13].

Conclusion

Based on present study, it was concluded that String of Pearls Locking plates (SOP) was successful in the treatment of long bone fractures and offered good recompense and remarkable improvement in limb function in six out of eight dogs. Although plate breakage was observed adjacent to fracture

line by 15th post- operative day in one dog and plate bending was observed in one dog on 30thPost operative day. Re-surgery was performed in one dog and another dog showed intermittent weight bearing by the end of 45th post-operative day.

It was concluded from the results of the present study that SOP plates were found to be effective in treatment of long bone fractures since they are replete with features like their ability to lend themselves to contouring to any shape of bone, high bending strength and maintaining limited contact with bone. The implant used in this technique was light weight, versatile and economical making it amenable for use in dogs weighing less than 10kg.

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References

1. Kraus KH, Ness MG. The SOP Locking Plate System. In Current Techniques in Small Animal Surgery, Bojrab M J, V Ed., Williams and Wilkins, Baltimore. 2014;Pp:792-796.
2. Kumar KM, Prasad VD, Lakshmi ND, Raju NKB. Management of distal femoral diaphyseal fractures with string of pearls locking plate in dogs. Indian Journal of Animal Research. 2018;52(12):1757-1761.
3. Vasseur PB, Johnson AL, Buderberg SC, Linwln JB, Toombs JP, Whitebain JG. Randomized, controlled trials of the efficacy of carprofen, a non-steroidal anti-inflammatory drug in the treatment of osteoarthritis in dogs. Journal of American Veterinary Medical Association. 1995;206:807-81
4. Ness MG. Repair of Y-T humeral fractures in the dogs using paired 'strings of pearls' locking plates. Veterinary and Comparative Orthopedics and Traumatology. 2009b;22:492-497.
5. Scrimgeour AB, Worth AJ. The use of the string of pearls locking plate system in the stabilization of a comminuted calcaneal fracture in a giant breed dog. Case Report inVeterinary Medicine. 2011, 1-4.
6. Kim SE, Lewis DD. Corrective osteotomy for procurvatum deformity caused by distal physeal fracture malunion stabilized with string-of-pearls locking plates: results in two dogs and a review of literature. Australian Veterinary Journal. 2014;92(3):75-80.
7. Sadan MA, Fischer A, Bokemeyer J, Kramer M. Surgical repair of ilial fractures in dogs and cats using String of Pearls (SOP) – plate. Indian Journal of Veterinary Surgery. 2015;36(1):41-45.
8. Grand JG. Use of string of pearls locking implants for the stabilisation of acetabular and supra-acetabular fractures in three dogs. Clinical Veterinary Journal. 2016;51:35-41.
9. Fitzpatrick N, Nikolaou C, Yeadon R, Hamilton M. String-of-Pearls Locking Plate and cerclage wire stabilization of periprosthetic femoral fractures after Total Hip Replacement in Six Dogs. Veterinary Surgery. 2012a;41:180-188.
10. Latha C. Clinical study on the use of string of pearls locking plate for Stabilization of radius-ulna fractures in dogs (Doctoral dissertation, PVNR TVU). 2019.
11. Reddy GV, Raghavendera K, Pramod D. Use of String of Pearls Locking Plate System for Stabilization of Femoral Fractures in Canines. International Journal of Livestock Research. 2020;10(10):92-98.
12. Jagan Mohan Reddy K, Dilip Kumar D, Chandra Sekhar EL, Srikanth Kulkarni, Vijay Kumar M, Dr. Dhoolappa M. Clinical study on the use of Titanium Dynamic Compression Plate (Ti-DCP) for repair of femur fractures in dogs The Pharma Innovation Journal. 2020;SP-9(12):08-18.
13. Jagan Mohan Reddy K, Dilip Kumar D. Evaluation of titanium locking compression plates for surgical repair of diaphyseal femoral fractures in dogs. Indian J Vet. Surg. 2021;42(1):16-19.
14. Boucher C, Zeiler G. Femur fracture repair of a tiger cub suffering from nutritional secondary hyperparathyroidism and osteopenia. Veterinary Record Case Reports. 2015;3(1):3.