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Sugical Management of Long Bone Fracture by String of Pearl Locking Plate

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Abstract:- The research was carried out on six dogs that were admitted to with fractures of long bones. The fracture was diagnosed pre-operatively through radiographic and orthopaedic examination. In order to stabilize the fractures of all six canines, open reduction and internal fixation with 3.5mm string of pearl plates and cortical screws were utilized. As a consequence, the fracture was effectively immobilized and fixed. Radiographic analysis identified the development of periosteal and endosteal calluses beginning in the second week following the operation. In the sixth week following the operation, obliteration of the fracture line and radiographic union of fracture fragments were observed. Stable fixation resulted in the observation of complete radiographic union of fractured bone and minimal callus formation by the eighth postoperative week in every case. Fractures of long bones in canines were effectively treated with SOP plates, allowing for early, pain-free ambulation.

Keywords:- *Dogs, Long Bone Fracture, String of Pearls Plate.*

I. INRTODUCTION

Bone is a specialized type of connective tissue that consists cells, fibers and ground substance. This osseous tissue dominates on microscopic and chemical levels. Its extracellular components are mineralized which gives substantial strength and rigidity after which the bone ideally suited to provide the mechanical support to the animal. It can be broken down into multiple levels.

Among differently classified bones, one of its type is the long bone that usually have proximal and distal ends and the main middle shaft. The ends are identified as epiphysis that comprised cancellous bone and the middle majority of the shaft called diaphysis that comprised of cortical bone. Fractures in bones are more commonly occurs due to an acute non-physiological forces that exceeds ultimate tensile strength over bone (Burns, 2010).

Femur fractures were the most frequently observed in canines, constituting 45% of all long bone fractures (Harasen, 2003). The femoral diaphyseal fractures most frequently observed were mid shaft diaphyseal fractures, with distal and proximal diaphysis fractures following suit (Aithal *et al*., 1999).

There are six degrees of freedom in which the SOP locking plate can be deformed: cranial to caudal bending, medial to lateral bending, and torsion (Kraus and Ness, 2007).Long bone fractures are a prevalent phenomenon within the field of small animal orthopedics (Julie et al., 2007).

In distal femoral fractures, conventional bone plating, which necessitates the use of three or more plate fasteners on either side of the fracture, is unsuitable due to its inability to accommodate a sufficient number of screws in the distal fragment and the potential obstruction of the stifle joint capsule closure by the distal end of the plate. A disruption may occur in the operation of the distal portion of the quadriceps patellar mechanism. On the management of distal femur fractures in canines, the literature is scant (Lidbetter and Glyde, 2000).

Moreover, as Mathai (2015) and Mathai et al. (2016) assert, it restores the structural integrity of the bone. Internal reduction and open fixation (ORIF) ensures appropriate reduction and immobilization of fracture fragments, in addition to establishing rigid fixation that facilitates the timely retrieval of an ambulance without inducing distress in the patient. The development of the string of pearls (SOP) plate system has occurred. Designed specifically for use in the veterinary field, with a contoured appearance. The plate's function is to ensure adequate stability and improved alignment when it is appropriately fastened (Ness, 2018). This Particularly concerning were claims that the method provided specific benefits, including flexible, consistent contouring across multiple planes of curvature, which could potentially enhance plate reduction and bone reduction (Karus and Ness, 2014). Screw openings (nodes) that possessed an area moment of inertia greater than that of empty screw hole internodes are no longer considered vulnerable locations along the length of the plate (Malenfant and Sod, 2014). Therefore, it is postulated that the string of pearls gilding technique serves as a viable remedy to address the deficiencies of alternative plating systems, including plate fracture and fastener loosening, both of which have the potential to result in osteonecrosis. The corpus of scholarly

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work pertaining to the clinical assessment of string pearl plating as a therapeutic intervention for fractures occurring in long bones of canines. Consequently, the current investigation examines the functional, clinical, and radiographic results associated with the utilization of a string of pearl plating in the management of long bone fractures.The objective of this article is to document the outcome of a surgical procedure involving SOP plates for the repair of long bone fractures in six canines.

II. METHODS AND MATERIALS

In six cases involving canines ranging in body weight from 12 to 25 kg and aged 10 to 22 months, long bone fractures were stabilized using a String of Pearls (SOP) locking plate (Uma surgicals ,Mumbai) in conjunction with standard cortical and cancellous screws.

For fracture stabilization, imported String of Pearls (SOP) locking plates (Uma surgicals, Mumbai) were utilized. Specifically, a 2.7 mm SOP plate was paired with 2.7 mm cortical and cancellous screws, while a 3.5 mm SOP plate was accompanied by 3.5 mm cortical and cancellous screws.

Dogs weighing less than 12 kg were chosen for the 2.7mm plate system of the SOP, while those weighing more than 12 kg were chosen for the 3.5mm plate system. In all animals, food and water were withheld for 12 hours prior to treatment. Prior to surgery, the canines were premedicated subcutaneously with Atropine sulphate at a rate of 0.04 mg per kg body weight, and subsequently sedated intramuscularly with Xylazine hydrochloride at a rate of 1 mg per kg body weight. Intravenous administration of Ketamine hydrochloride at a rate of 10 mg per kg body weight and Diazepam at a rate of 0.25 mg per kg body weight were utilized to induce general anesthesia. Inhalant isoflurane (1.5–2%) was utilized to maintain anesthesia in conjunction with 100% oxygen. The surgical site was prepared in accordance with aseptic surgery protocols. When an external wound occurred, it was appropriately attended to by removing the dirt with Povidone-iodine and suturing the epidermis. The animals were placed in lateral recumbency with the afflicted limb elevated prior to the fracture repair. When repairing a femoral fracture, various factors were taken into account, including the anatomical structure, direction, and positioning of the String of Pearls (SOP) bone plate, as well as the local nerve innervations. Stabilization was achieved subsequent to fracture reduction using precontoured 3.5mm or 2.7mm SOP plates in conjunction with chosen cortical fasteners. SOP plate was subsequently inserted into the bending irons on adjacent pearls, prior to bending and twisting. This step was taken to safeguard the locking properties of the screw holes by loading the holes in SOP with SOP bending tees. The contour was reviewed after the SOP was inserted into the soft tissue tunnel following contouring. Torsion was applied in the supracondylar region and the distal end of the plate was bent caudally in order to obstruct the patellar motion.Constantly, the fasteners were oriented perpendicular to the spherical SOP component. The insert is extracted from the SOP at the proximal or distal first screw location. Following the formation of the cavity with the drill guide, the depth was determined using a depth gauge. First, screws were inserted into the distal and proximal apertures of the SOP plate.

Self-tapping fasteners were employed to provide stability. By tightening the screw, the screw head became securely inserted into the spherical component of the SOP. Surgical wounds were dressed with Povidone Iodine solution as an antiseptic. Two times daily for seven days, 20 mg/kg body weight of Ceftriaxone was administered intramuscularly; for three days, 0.30 mg/kg body weight of Meloxicam was administered intramuscularly. The proprietors were instructed to limit the animal's activities for the initial ten days. The canines were subsequently permitted limited physical activity on a regular basis. It was recommended that an Elizabethan collar be worn in order to prevent the incision from being self-mutilated. The bandage was replaced at intervals of one day. The skin sutures were extracted during the tenth to twelfth day following the operation.

The surgical site was prepared according to protocol, and the suspended limb technique was utilized to achieve traction and countertraction for a duration of 15 minutes. In accordance with conventional AO principles, open reduction and internal fixation were performed utilizing 3.5 mm SOP plates and 3.5 mm cortical screws ranging in length from 14 mm to 30 mm. Once the fracture site had been exposed, the fracture fragments were reduced and the structure was stabilized using a pre-contoured SOP plate system. In contouring, the fracture line and bone anatomy were considered. The pate was applied to the stabilized bone fragments subsequent to contouring, and perforations were created using a 2.7mm drill bit. Using a depth gauge, the depth of the holes was determined, and 3.5mm self-tapping cortical screws of suitable length were inserted into the distal openings of the SOP plate after the proximal ones. The voids that extended across the fracture line remained unoccupied. By tightening the fasteners, the screw head was firmly embedded into the spherical component of the SOP plate. In a straightforward continuous suture pattern, polyglactin 910 (size-0) sutures were used to secure the muscle and fascia, while nylon was employed to secure the skin in a horizontal mattress suture pattern.

The surgical incision was dressed with an antiseptic solution containing 5% povidone iodine. Subsequently, the affected limb was immobilized using a plaster of Paris cast for a duration of two weeks. Seven consecutive days of antibiotic therapy were administered orally containing cefixime at a dose rate of 20 mg/kg body weight twice daily, while carprofen was taken orally once daily at a dose rate of 4.0 mg/kg body weight for three days. It was recommended that proprietors limit the canine's mobility for a duration of two weeks. The skin sutures were extracted on the fourteenth day following the operation. The clinical, orthopaedic, and radiographic assessments were documented prior to the operation, on the day of the procedure following

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anesthesia recovery, and evident on radiographs taken at 0th, 7th, 14th, 28th and 45th day.

III. RESULTS AND DISCUSSION

In present study, total six clinical cases of the dogs with fracture of long bone fracture presented at Veterinary clinical complex, Nagpur veterinary college Nagpur from march 2022 to July 2023. The healing of the fracture boneswas assessed by evaluating the different parameters at different time intervals. Pre operative medio lateral (ML) and anterio-posterior (AP) radiographs of long bone of affected limb were taken.

This study revealed that Non descript dogs (n-4) had higher prevalence followed by rottweiler (n-1) and German shepherd (n-1) breeds. The total of 4 female dog and 2 male dog between age groups of 1-4 years were recorded. Etiologicalfactors responsible for fracture of lone bone fracture in dog (n-5) were due to automobile accidents with four wheelers / two wheelers and dog fights (n-1)were found in veterinary clinical complex Nagpur between March 2022 to July 2023.

These canines were secured with SOP locking plates (Table 1). Dogs that weighed less than 12 kg were chosen to utilize the SOP system with 2.7mm plates, while those that weighed more than 12 kg were chosen to utilize the 3.5mm plate system. There were no technical complications observed during the implementation of the SOP locking plate on the chosen animal cases. The utilization of SOP plates to treat long bone fracture fractures was facilitated by their medial-to-lateral and cranial-to-caudal bending capabilities.

Table 1 Size of the String of Pearl Locking Plate (SOP) and Locking Head Screws

Case no.	String of Pearl Locking Plate (holes)	Locking head screws	
		Diameter (mm)	Length (mm)
1	8 Holes	3.5	10 to 28
2	10 Holes	3.5	10 to 28
3	8 Holes	3.5	10 to 28
4	8 Holes	3.5	10 to 28
5	8 Holes	3.5	10 to 28
6	8 Holes	3.5	10 to 28

Table 2 Details of Cases when SOP Bone Plating was Performed.

Case no.	Breed	Gender (M/F)	Age (yrs)	Etiology	Location	Type of fracture	Left/ Right Limb
1	ND	M	1 year	Automobile accident	Proximal 1/3rd	Transverse	Left
2	Rottweiler	F	2 year	Accident	Midshaft	Transverse	Right
3	ND	F	1.5 year	Accident	Distal 1/3rd	Short oblique	Right
4	German shefferd	F	4 year	Dog fight	Proximal 1/3rd	Short oblique	Left
5	ND	F	2 year	Automobile accident	Midshaft	Transverse	Right
6	ND	F	1.5 year	Automobile accident	Midshaft	Short oblique	Left

A. Lameness

Weight-bearing lameness recorded for each of the six animals. All instances were observed carrying the limb while standing observed in one cases on 4th day , one cases on 5th day and four cases on 6th day. During walking partially touching toe was recorded in one cases on 5thday and three cases was observed on 6th day while two cases on 7th day. During Running, frequent touching toe in one case, partially touching toe in two cases and touching toe in three cases were observed on 10th day.

Table 3 Details of Weight Bearing in Group II

Case . no	Standing	Walking	Running
1	Carrying limb on 4th days	Partially touching toe 6th day	Frequent touching on 10th day
2	Carrying limb on 4th days	Partially touching toe 6th day	Touching toe on 10th day
3	Carrying limb on 5th days	Partially touching toe 7th day	Partially touching toe on 10th day
4	Carrying limb on 4th days	Partially touching toe 6th day	Touching toe on 10th day
5	Carrying limb on 5th days	Partially touching toe 7th day	Partially touching toe on 10th day
6	Carrying limb on 3rd days	Partially touching toe 5th day	Touching toe on 10th day

B. Radiographical Evaluation

Radiograph taken immediately after surgery provided fracture reduction, alignment and fixation of bone. In this study, the placement of String of pearl plate was satisfactory in all animals. Good apposition of fracture fragment throughout the study site indicate sufficient stability at fracture site. Radiograph taken on 7th day revealed that good apposition of fracture fragment and proper position of plate and screw.

Radiograph taken on 14th day revealed that intiation of periosteal reaction and callus formation. In five cases observed that intiation of periosteal proliferation and fracture line visible while in one cases no evident of periosteal proliferation. Radiograph taken on 28th day revealed that periosteal bridging callus. In five cases observed that periostel bridging callus and proper position of plate and screw while in one cases lossening of plate.

Radiograph taken on 45th day revealed that perfect alignment of bone, periosteal bridging callus and callus appeared densified. In five cases observed that the primary callus formation between the periosteal space and fracture line was partially visible.

C. Clinical Evaluation of Weight Bearing and Lameness

Fig 1 On the Day of Presentation

Fig 2 Weight Bearing on Day 45th Day after Postoperatively

D. Complications, if any

Complication due to implant failure was observed in one case observed that loosening of implant on 28th day post operatively which were used String of pearl locking plate in dog.

SOP locking devices were found to be effective in stabilizing long fractures for early limb ambulance and to promote rapid healing.

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The cylindrical internode design between the screw openings of the SOP locking plate, which is more malleable than conventional plates, enables the plate to be bent in accordance with fracture ends. This permits the insertion of at least one or two additional screws into the distal fragment. The SOP locking plate's spherical component is compatible with conventional cortical bone screws. The spherical component contains a segment featuring conventional threads, as well as a segment into which the head of a standard screw recedes. A ridge makes contact with the screw head as it retracts into the spherical component, causing the screw to force fit into the pearl. By implementing this press fitting, which effectively impeded screw loosening under the cyclic loading of weight bearing, an exceptionally rigid screw/plate construct was produced (Kraus and Ness, 2007). Utilizing SOP benders and SOP bending tees, the contouring was achieved in order to match the topography of the lateral aspect of the femoral diaphysis and to ensure that the plate was properly aligned and positioned to suit the caudal bow on the bone.

E. SOP Plate and Screw after Application

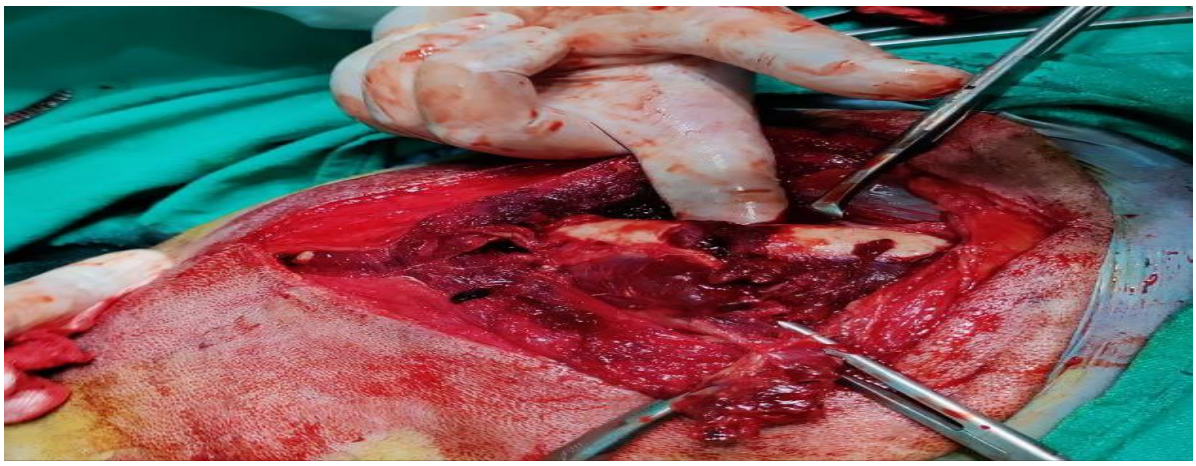

Fig 3 Surgical Exposure of Fractured Fragment

Fig 4 Reduction of Fractured Fragments by String of Pearl Plate Along with Screw

Fig 5 Close Apposition of Muscles after Suturing

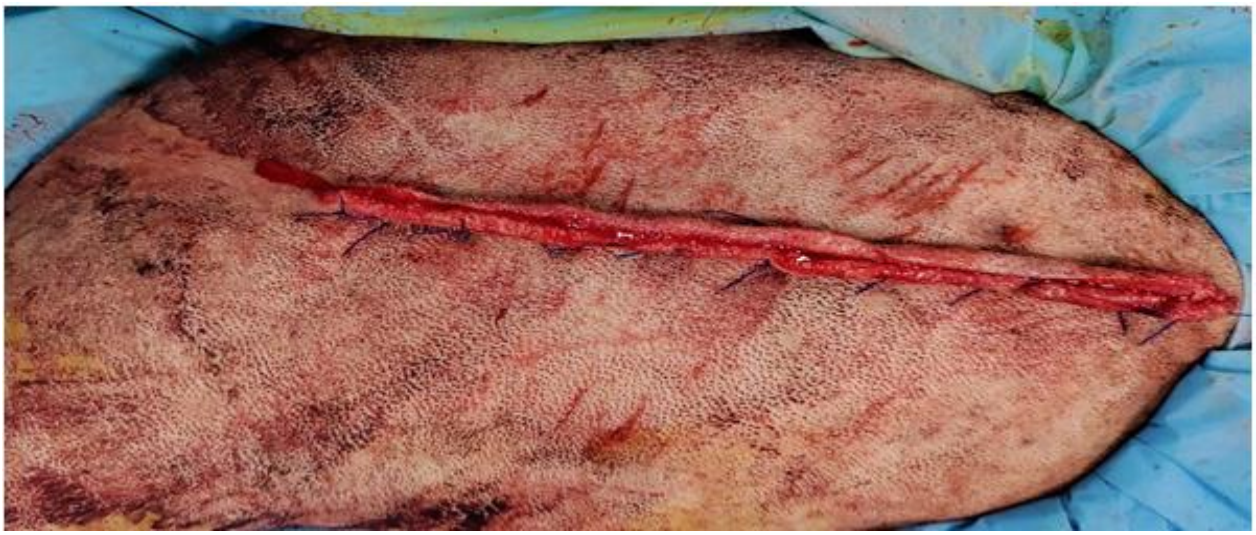

Fig 6 Skin Sutured using Non Absorbable Suture Material with Horizontal Mattress

Fig 7 Removal of Suturing after Complete Healing of Sutures

The experimental investigations carried out by DeTora and Kraus (2008), Ness (2009), and Cabassu et al. (2011) regarding the design and biomechanical properties of SOP proved to be beneficial in this study. The design of the SOP locking plate permits minimal contact with the periosteum, which in all cases promotes osteogenesis and bone regeneration. In a similar vein, the SOP plate's design resulted in an intrinsically higher AMI at the screw hole compared to a conventional plate or LC-DCP of equivalent dimensions, rendering it a viable option for buttress fixation [DeTora and Kraus, 2008]. Presently, the manufacturer advises that in order to reduce the likelihood of fastener failure, each segment should be fastened with a minimum of four screws (Ness, 2010). The absence of fracture lines and the formation of endosteal and bridging callus indicated radiographic healing. Ness (2009), Scrimgeour and Worth (2011), Fitzpatrick et al. (2012), Kim and Lewis (2014), and Hespel et al. (2013) all documented comparable results. There was no evidence of excessive callus formation, periosteal reaction, osteomyelitis, or soft tissue alterations in any of the animals.

F. Radiographic Evaluation

Fig 8 Fracture of Femur Radiographs Showing Lateral View of Overriding Fracture Ends of Femur

Fig 9 Radiographs Showing Ventrodorsal View Shows the Status of Callus on 7th Day


Fig 10 Radiographs Showing Ventrodorsal View on 14th Day Postoperatively


Fig 11 Radiographs Showing Ventrodorsal View on 28th Day Postoperatively


Fig 12 Radiographs Showing Ventrodorsal View on 45th Day Postoperatively with Complete Healing of Bone

IV. CONCLUSION

On the basis of observation recorded during present study, following conclusions are drawn : Incidence of fractures was more common in non-descript dogs compared to other breeds of dogs. Femoral fracture were the highest incidence shows in 0-6 months of age which were automobile accident is the major cause of fracture. Fracture fixation using string of pearl plate provided good healing of fracture supported by dense periosteal bridging callus but delayed in mean time to attain full mobility.

None of cases exhibited any reaction to implant used during study. Hematobiochemical variations did not altered the fracture healing process. String of pearl plates were found suited for fixation of fracture of long bone in dogs with least complication. String of pearl plates exhibit more uniformity but do not behave similarity in all bending direction.

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- *Conflict of Interest:* None

REFERENCES

[1]. Aithal, H.P., Singh, G.R. and Bisht, G.S. (1999) Fractures in dogs: A survey of 402 cases. Indian Journal of Veterinary Surgery 20: 15.
[2]. Burns, C. G. (2010) Influence of Locking Bolt Location on the Mechanical Properties of an Interlocking Nail in the Canine Femur. Master's Thesis, Graduate School of The Ohio State University, USA

[3]. Carr, B.J. and Dycus DL. 2016. Canine gait analysis. Recovery and Rehab. 1. 93-100.
[4]. Clark, D. M. 1986. Treatment of open comminuted intraarticular fractures of the proximal ulna in dogs. J. Am. Anim. Hosp. Assoc. 23: 331-336.
[5]. Demianiuk, R. M., Benamou, J., Rutherford, S., Ness, M. G. and Dejardin, L. M. 2015. Effect of screw type and distribution on the torsional stability of 3.5 mm String of Pearls locking plate constructs. Vet. Surg. 44: 119-125.
[6]. Fitzpatrick, N., Nikolaou, C., Yeadon, R. and Hamilton, M., 2012(a). String-of-pearls locking plate and cerclage wire stabilization of periprosthetic femoral fractures after total hip replacement in six dogs. Vet. Surg. 41:180-188.
[7]. Grand, J. G. 2016. Use of string-of-pearls locking implants for the stabilisation of acetabular and supraacatebular fractures in three dogs. Revue Vétérinaire Clinique. 51:35-41.
[8]. Julie, B., Syam, K.V., Rajankutty, K., Venugopalan, K. and Amma, T.S. 2007. Acrylic external skeletal fixation for the treatment of long bone fracture in dogs. Indian J. Vet. Surg. 28: 6-10
[9]. Kim, S. E. and Lewis, D. D. 2014. Corrective osteotomy for procurvatum deformity caused by distal femoral physeal fracture malunion stabilised with S tring-of-P earls locking plates: results in two dogs and a review of the literature. Aust. Vet. J. 92: 75-80.
[10]. Kraus, K.H. and Ness, M.G. 2014. The SOP locking plate system. In current technique in small animal surgery, Bojrab M J, V Ed, Willams and Wilkins, Baltimore. 792-796.
[11]. Kumar, K., Mogha, I.V., Aithal, H.P., Kinjavdekar, P., Amarpal, Singh, G.R., Pawde, A.M. and Kushwaha, R.B. 2007. Occurrence and pattern of long bone fractures in growing dogs with normal and osteopenic bones. J. Vet. Med. 54: 484-490.
[12]. Kumar, K.M., Prasad, V.D., Lakshmi, N.D. and Raju, N.K.B. 2018. Management of distal femoral diaphyseal fractures with string of pearls locking plate in dogs. Indian J. Anim. Res. 52: 1757-1761.
[13]. Langley-Hobbs, S. 2003. Biology and radiological assessment of fracture healing. In Pract. 25: 26-35.
[14]. Lidbetter, D.A. and Glyde, M.R. (2000) Supracondylar femoral fractures in adult animals. Compendium on Contiinuing Education for the Practising Veterinaria 22 (11): 1041-1055
[15]. Malenfant, R.C. and Sod, G.A. 2014. In vitro biomechanical comparison of 3.5 string of pearl plate fixation to 3.5 locking compression plate fixation in a canine fracture gap model. Vet. Surg. 43:465-470.
[16]. Mathai, V.S. 2015. Comparative evaluation of closed and open static intramedullary interlocking nail fixation in dogs. PhD thesis, Kerala Veterinary and Animal Sciences University, Pookode, 146p.
[17]. Mathai, V.S., Venugopal, S.K., Devanand, C.B., Narayan, M.K., Ashok, N and Nair, N.D. 2016. Minimaly invasive interlocking nail fixation inj a Labrador dog with oblique tibial fracture. Indian J. canine Pract.8: 52-54.
[18]. Ness, M.G. 2009. Repair of YT humeral fractures in the dog using paired 'String of Pearls' locking plates. Vet. Comp. Orthopaedics and Traumatology. 22: 492-497.
[19]. Ness, M.G. 2018. The String of Pearls (SOP) System. Locking Plates in Vet. Orthopedics. 1:91-95.
[20]. Niveditha, M. 2019. Clinical study on the use of string of pearls locking plate for stabilization of radius-ulna fractures in dogs. M.V.Sc thesis, P.V. Narsimha Rao Telangana Veterinary University, Hyderabad, 105p.
[21]. Prabhukumar, M.D., Dileepkumar, K.M., Devanand, C.B., Syam K. Venugopal, Indu, V. Raj, Anoop, S., Sudheesh S. Nair. and laiju M. Philip. 2020. Elastic stable intramedullary nailing for fixation of distal diaphyseal fracture of radius in two dogs. Indian J. Vet. Surg. 41:134-136.
[22]. Reddy, A. K. G. V. 2018. Use of String of Pearls locking plate system for stabilization of femoral fractures in canines. M.V.Sc. Thesis, P. V. Narasimha Rao Telangana Veterinary University, Rajendranagar.
[23]. Scrimgeour, A. B. and Worth, A. J. 2011. The use of the string of pearls locking plate system in the stabilisation of a comminuted calcaneal fracture in a giant breed dog. Case Report in Veterinary Medicine. 2011: 1-4.
[24]. Sumner – Smith, G. 1993. Gait analysis and orthopedic condition. In: Slatter,D.(ed.), Text Book of Small Animal Surgery (2nd Ed.), Saunders company, Philadelphia, 1577-1586p.
[25]. Suresh, D., Syam, K.V., Chgandy,G., Sooryadas, S. and Deepa, P.M. 2017. Radiographic evaluation of bioceramic substituted for critical size bone defect in a goat. Cinical study. J. Vet. Anim. Sci. 48: 40-42.