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Management of distal femoral diaphyseal fractures with string of pearls locking plate in dogs

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ABSTRACT

Distal femoral diaphyseal fractures in 6 dogs about 10–22 months old with body weight ranging from 12–25 kg were stabilized using String of Pearls (SOP) locking plates along with standard cortical and cancellous screws following standard AO/ASIF principles. Selection of appropriate size of plate and screws was according to body weight and type of fracture (2.7 mm plate for dogs below 12 kg body weight and 3.5 mm plate for dogs above 12 kg body weight) which provided good fracture stability. The outcome of fracture stabilization and healing was evaluated with lameness grading and radiography. Postoperatively, all the animals showed weight bearing with early functional limb usage of grade I lameness and good joint mobility in an average of 7 weeks. Functional outcome was good in four cases and excellent in two cases. The healing time in all the cases was 7–11 weeks. The fractures showed radiographically excellent postoperative healing with cortical union, absence of fracture lines and bridging callus. Based on present study, it was concluded that, String of Pearls (SOP) locking plates provided good stabilization of distal femoral diaphyseal fractures resulting in early limb ambulance and healing.

Key words: Distal femoral diaphyseal fractures, Dogs, String of pearls locking plate (SOP)

Fracture of femur is most often encountered in dog, accounting for 45% of all long bone fractures (Harasen 2003). Mid shaft diaphyseal fractures are the most common femoral diaphyseal fractures, followed by fractures of the distal and proximal diaphysis (Aithal *et al.* 1999). The distal femur has anatomical peculiarities such as caudal bowing, soft cancellous bone in condylar region and presence of short segment of distal metaphyseal bone. A distal fracture produces a short distal fragment from the critical stifle joint and predisposes to significant bending forces, which are magnified in the chondrodystrophoid and large breeds (Harasen 2002). Conventional bone plating which requires three or more plate screws on either side of a fracture is not suitable in distal femoral fractures as it will not permit enough screws to be placed in distal fragment and the distal end of plate may interfere with proper closure of stifle joint capsule. The function of the distal part of the quadriceps patellar mechanism can be affected. There is paucity of literature on the management of distal fractures of femur in dogs (Lidbetter and Glyde 2000). Only few case reports are available in literature especially regarding the use of the bone plates particularly locking plates, for use in the repair of distal diaphyseal femur fractures.

The string of pearls (SOP) implant is a relatively new orthopaedic locking plate system that was designed for Veterinary orthopaedic use. The SOP locking plate consists of a series of cylindrical sections ('internodes') and spherical components ('pearls'). The spherical component of the SOP accepts a standard cortical bone screw. The SOP locking plate can be contoured in six degrees of freedom; medial to lateral bending, cranial to caudal bending, and torsion (Kraus and Ness 2007). Mechanical testing using ASTM (American Society for Testing and Materials) standards demonstrated that a 3.5 mm SOP was approximately 50% stiffer, and had a bending strength (load at which the plate bends) 16–30% greater than that of the 3.5 mm LCP, DCP, or LC-DCP (De Tora and Kraus 2008 and Ness 2009). An SOP pate bent through 40 degrees remains almost (96%) as stiff as an untouched 3.5 mm DCP. The purpose of this paper is to describe the repair of distal femoral diaphyseal fractures using SOP plate via lateral surgical approach, and to report the outcome in 6 dogs.

MATERIALS AND METHODS

Distal femoral shaft fractures in six selected cases of dogs (10–22 months old with body weight ranging from 12–25 kg) were stabilized with String of Pearls (SOP) (Orthomed, UK) locking plate along with standard cortical and cancellous screws (Table 1). The imported String of

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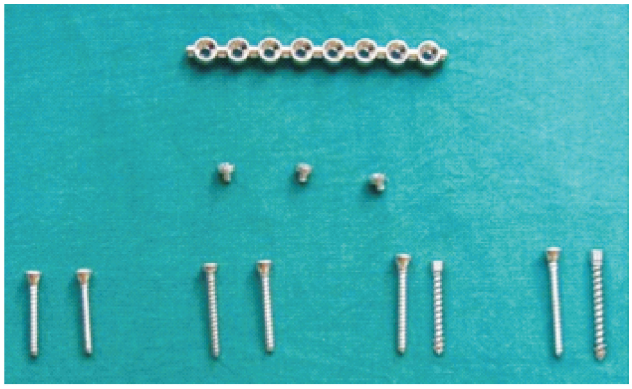

Fig. 1. SOP plate compatible with cortical and cancellous screws and SOP bending tees.

Pearls (SOP) locking plates (Orthomed, UK) used for stabilization of fractures included 3.5 mm SOP plate with 3.5 mm cortical and cancellous screws, and 2.7 mm SOP plate with 2.7 mm cortical and cancellous screws (Fig.1). Dogs weighing less than 12 kg were selected for using SOP system of 2.7 mm plates and those weighing above 12 kg were selected for a 3.5 mm plate system.

Food and water were withheld for 12 h before treatment in all animals. The dogs were premedicated with atropine sulphate subcutaneously @ 0.04 mg/kg body weight followed by sedation with xylazine hydrochloride @ 1 mg/kg body weight intramuscularly before surgery. General anaesthesia was induced using Ketamine hydrochloride @ 10 mg/kg body weight intravenously and Diazepam @ 0.25 mg/kg body weight intravenously. Anaesthesia was maintained with Isoflurane. The surgical site was prepared in a standard manner for aseptic surgery. In case of any external wound, it was treated suitably and was cleaned with povidone iodine and skin was sutured. Prior to the fracture repair, the animals were positioned in lateral recumbency with the affected limb uppermost.

An incision was made along the craniolateral border of the thigh. After incising skin and subcutis along the cranial border of biceps femoris muscle, fascialata was incised. After retracting of biceps femoris caudally, vastus lateralis was reflected from the surface of femur to expose the femoral diaphysis (Piermattei and Greeley 1993). After reduction of fracture, stabilization was done with precontoured selected 3.5 mm or 2.7 mm SOP plate along with selected cortical screws. Prior to bending and twisting, the holes in SOP were loaded with a SOP bending tees which was meant to protect the locking properties of screw hole and then SOP plate was loaded in the bending irons on adjacent pearls. After contouring, the SOP was placed in the soft tissue tunnel, and contour was reviewed. The distal end of plate was bent caudally and torqued in the supracondylar region to prevent interference with the patellar motion. It was well ensured that, the most distal screws did not enter the patellofemoral or femorotibial joints. Then, the drill guide was placed into a screw hole on one end of the bone and the remaining screw holes were positioned properly. The screws were always directed perpendicular to the spherical component of the SOP. The insert was removed from the SOP at the first screw location, either proximal or distal. The drill hole was made using the drill guide, and then the depth was measured with help of depth gauze. Screws were first placed at the proximal and distal holes of SOP plate. Self tapping screws were used for stabilization. The screw was tightened so that, the screw head seated firmly into the spherical component of the SOP.

Antiseptic dressing of surgical wound was done with povidone iodine solution. Ceftriaxone @ 20 mg/kg body weight intramuscularly was administered twice daily for 7 days and meloxicam @ 0.30 mg/kg body weight was administered intramuscularly for three days. The owners were advised to restrict the activities of the animal for first ten days. Subsequently, the dogs were allowed limited

Table 1. Details of cases and fixation techniques adopted

Dog No.	Breed	Age (months)	Sex	Body weight (kg)	Type of fracture	Fixation technique
1	Non descript	19	F	15	Transverse	Closed reduction with 9 holed, 3.5 mm SOP locking plate with 3.5 mm cortical and cancellous screws
2	Rottweiler	12	M	25	Long oblique	Closed reduction with 9 holed, 3.5 mm SOP locking plate with 3.5 mm cortical and cancellous screws
3	German Shepherd	18	M	23	Transverse	Closed reduction with 8 holed, 3.5 mm SOP locking plate with 3.5 mm cortical screws
4	Spitz	22	F	10	Short oblique	Closed reduction with 8 holed, 2.7 mm SOP locking plate with 2.7 mm cortical screws and cancellous screws
5	Non descript	20	M	18	Short oblique	Closed reduction with 8 holed, 3.5 mm SOP locking plate with 3.5 mm cortical screws and cancellous screws
6	Non descript	10	F	12	Transverse	Closed reduction with 8 holed, 2.7 mm SOP locking plate with 2.7 mm cortical screws and cancellous screws

physical activities regularly. Elizabethan collar was advised to prevent self mutilation of the wound. The bandage was changed on alternate days. Skin sutures were removed between 10th to 12th postoperative days.

RESULTS AND DISCUSSION

No technical difficulties encountered while application of SOP locking plate in the selected cases of animals. The application of SOP plate was found easy for distal femoral diaphyseal fractures as the SOP plate had bending ability in medial to lateral bending and cranial to caudal bending.

Lameness grading: Lameness grading based on weight bearing for all the 6 animals was tabulated. All the animals preoperatively showed grade V lameness before surgical stabilization of the fracture. Postoperatively, all the animals showed weight bearing with grade II lameness after 14 days. Stitch abscess at the incision site was noticed in case No. 5, in which wound dehiscence was observed which healed after antiseptic dressing and antibiotic therapy. All the cases showed grade I lameness with good joint mobility in an average of 7 weeks (Table 2) (Fig. 2). Functional limb outcome was good in four cases and excellent in two cases.

Table 2. Lameness grading in 6 dogs in pre and postoperative days

Case No.	1st day	7th day	14th day	28th day	45th day	60th day
1	V	III	II	I	I	I
2	V	III	II	I	I	I
3	V	III	II	I	I	I
4	V	III	II	I	I	I
5	V	III	II	II	I	I
6	V	III	II	I	I	I

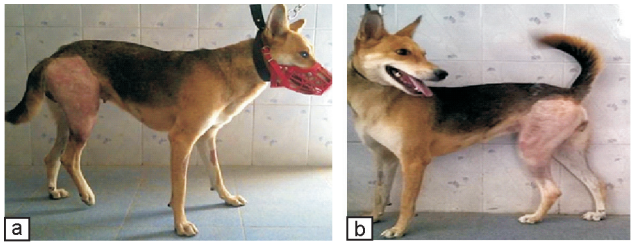

Fig. 2. a. Preoperative nonweight bearing. b. Weight bearing on 4th postoperative day

Radiographical evaluation: The results of radiographic evaluation of fracture site for implant position, fragment alignment and callus formation at immediate postoperative stage, after 3 weeks, 7 weeks and 9 weeks in 6 dogs were recorded (Fig. 3). The overall average healing time in all the dogs was 7–11 weeks. Postoperatively, no screw loosening was observed in any cases. Excellent healing was noticed radiographically with absence of fracture lines with endosteal callus or bridging callus in all cases.

Complications: No major intraoperative complications were observed. No major post operative complications were

Fig. 3. Radiographical evaluation (Case No: 1). a. Preoperative and immediate postoperative fracture stabilized with 9 holed, 3.5 mm SOP plate. b. Post operative 3 weeks. c. Post operative 7 weeks. d. Post operative 9 weeks—The distal diaphyseal fracture healed with bridging callus and good cortical union was observed.

observed except in case No. 5, in which stitch abscess at the incision site with wound dehiscence was observed.

Plates were removed after 18 weeks in two cases while in the rest of the dogs implants coud not be removed due to non-compliance from the clients.

The SOP locking plate which is more malleable than conventional plates has a cylindrical internode design between the screw holes, so that the plate can be bent according to distal extremity of the femur which allows to place at least 1 or 2 more screws in the distal fragment. The spherical component of the SOP locking plate accepts a standard cortical bone screw. There is a section of standard threads within the spherical component, and a section into which the head of a standard screw recedes. As the screw head recedes into the spherical component, it comes into contact with a ridge causing the screw to press fit into the pearl. This press fitting prevents loosening of the screw during the cyclic loading of weight bearing, and results in a very rigid screw/plate construct (Kraus and Ness 2007). The contouring was done with help of SOP benders and SOP bending tees to match the topography of lateral aspect of femoral diaphysis and to ensure proper alignment and positioning of the plate to fit to the caudal bow on the bone. SOP locking plate design itself allows maintenance of limited contact with periosteum thus promoting osteogenesis and bone healing in all the cases. Similarly,

the design of the SOP plate achieves an inherently greater AMI at the screw hole than an equivalent-sized conventional plate or LC-DCP making it a suitable choice for buttress fixation (DeTora and Kraus 2008). Current recommendations from the manufacturer suggest that a minimum of 4 screws should be engaged in each segment to decrease the risk of screw failure (Ness 2010). However, in the present study, 2–3 screws were employed in the distal segment according to length of fragment which showed sufficient stability with good healing and complete weight bearing. Use of SOP plates has been reported for the repair of Y-T humeral fractures (Ness 2009a), stabilisation of vertebral bodies in thoracolumbar disc protrusions (Mc kee and Down 2008), and as a transilial plate stabilisation of a sacral fracture (Mills 2009). Lameness grading based on weight bearing of all the animals under study was carried out using the one recommended by Vasseur *et al.* (1995). Radiographic healing was noticed with development of endosteal and bridging callus with absence of fracture lines. Similar findings were also reported by Ness (2009), Scrimgeour and Worth (2011), Fitzpatrick *et al.* (2012), Kim and Lewis (2014) and Hespel *et al*. (2013). None of animals showed excessive callus formation, periosteal reaction, osteomyelitis or soft tissue changes.

In conclusion, String of Pearls (SOP) locking plates are good for stabilization of distal femoral shaft fractures for early limb ambulance and excellent healing.

REFERENCES

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.

DeTora M and Kraus K. 2008. Mechanical testing of 3.5 mm locking and non-locking bone plates. *Veterinary and Comparitive Orthopaedics and Traumatology* **21**(4): 318–22.

Fitzpatrick N, Nikolaou C, Yeadon R and Hamilton M. 2012. String-of-Pearls locking plate and cerclage wire stabilization of periprosthetic femoral fractures after total hip replacement in six dogs. *Veterinary Surgery* **41**: 180–88.

Harasen G. 2002. Fractures involving the distal extremity of the femur: part 2-The mature patient. *Canadian Veterinary Journal* **43**: 131–32.

Harasen G. 2003. Common long bone fractures in small animal practice – part 2. *Canadian Veterinary Journal* **44**: 503–04.

Hespel A M, Bernard F, Davies N J, Huuskonen V, Skelly C and David F. 2013. Surgical repair of a tibial fracture in a two-week-old grey seal (*Halichoerus grypus*). *Veterinary and Comparitive Orthopaedics and Traumatology* **26**(1): 82–87.

Kim S E and Lewis D D. 2014. 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* **92**(3): 75–80.

Kraus K H and Ness M G. 2007. SOP Interlocking Plate System. Standard Operating Procedure (Company Product Information). Version 1.4. Orthomed (UK) Ltd. pp 1–20.

Lidbetter D A and Glyde M R. 2000. Supracondylar femoral fractures in adult animals. *Compendium on Continuing Education for the Practicing Veterinaria* **22**(11): 1041–55.

Mc Kee W M and Downes C J. 2008. Vertebral stabilization and selective decompression for the management of triple thoracolumbar disc protrusions. *Journal of Small Animal Practice* **49**(10): 536–39.

Mills J. 2009. Transilial interlocking plate stabilization of a sacral fracture and an ilial fracture in a dog. *Veterinary and Comparative Orthopaedics and Traumatology* **22**(1): 70–73.

Ness M G. 2009. The effect of bending and twisting on the stiffness and strength of 3.5 mm SOP implant. *Veterinary and Comparative Orthopaedics and Traumatology* **22**(2): 132–35.

Ness M G. 2009a. Repair of Y-T humeral fractures in the dogs using paired 'strings of pearls' locking plates. *Veterinary and Comparative Orthopaedics and Traumatology* **22**: 492–97.

Ness M G. 2010. Locking pates: SOP. Proceedings of the 3rd World Veterinary Orthopaedic Congress, ESVOT-VOS, 15th ESVOT Congress, Balgona, Italy, p 149.

Piermattei D L and Greeley R G. 1993. The hind limb in an atlas of surgical approaches to the bones and joints of the dog and cat, 3rd edn. WB Saunders, Philadelphia, pp 264.

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 Reports in Veterinary Medicine*, pp 1–4.

Vasseur P B, Johnson A L, Buder berg S C, Linwln J B, Toombs J P, Whitebain J G and Lentz E L. 1995. Randomized, controlled trials of the efficiency of carprofin, a non steroidal anti- inflammatory drug in treatment of osteoarthritis in dog. *Journal of American Veterinary Medical Association* **206**: 807–11.