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CASE REPORT

Bone Transport Osteogenesis and Minimally Invasive Plate Osteosynthesis for a Segmental Radius Defect in a Dog

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A B S T R A C T

A female dog presented with non-weight bearing lameness with an open fracture of the right forelimb. The fracture site had a 40 mm-long defect. A segmental bone defect (SBD) was treated with bone transport osteogenesis (BTO) by using a dynamic circular external skeletal fixator (CESF). After 63 days of BTO, a minimally invasive plate osteosynthesis (MIPO) was applied because of non-union at the docking site. BTO using the dynamic CESF method can be used successfully to restore a bone defect. The MIPO technique during the consolidation period is an alternative method to decrease complications and increase patient quality of life.

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INTRODUCTION

Segmental bone defects (SBDs) may be caused by high impact trauma, debridement of osteomyelitis, or tumor resection in human and veterinary medicine (Ting *et al.*, 2010; Oh *et al.*, 2013). It is clinically challenging to treat if SBD due to high impact trauma in a limb because soft tissue reconstruction and infection control is required (Rahal *et al.*, 2003). Traditional grafting techniques can be used for post-traumatic SBD (Rahal *et al.*, 2003). However, they have significant disadvantages. Autogenous bone grafts cannot provide an adequate amount of tissue for a large SBD. Furthermore, an allogenic bone graft should not be used in a SBD with contamination (Mankin *et al.*, 2005).

Bone transport osteogenesis (BTO) via dynamic circular external skeletal fixator (CESF) has been used as a standard method to replace a large SBD in human medicine (Oh *et al.*, 2013). In veterinary medicine, BTO has successfully been employed for SBD after open fracture treatment, debridement of osteomyelitis, and tumor resection (Rahal *et al.*, 2003; Ting *et al.*, 2010). However, this technique requires a long consolidation phase after distraction osteogenesis. The long duration of consolidation results in a delay of CESF removal and can result in morbidity, pin tract infection, and joint stiffness (Ilizarov, 1990; Rahal *et al.*, 2003). Furthermore, some reports state that docking site does not achieve union after BTO (Liu *et al.*, 2011).

Minimally invasive plate osteosynthesis (MIPO) has been recently applied to veterinary medicine (Peirone *et al.*, 2012). MIPO has many biological advantages compared to the conventional bone plating. Recently, clinical studies have shown high success and low complication rates with MIPO (Guiot *et al.*, 2011; Peirone *et al.*, 2012).

The purpose of this case report is to describe the clinical management and surgical outcome of BTO with CESF followed by the application of MIPO to treat segmental radius defect due to a type ⅢB open fracture in a dog.

History and clinical findings: A 3-year-old, 16 kg healthy mixed-breed female hunting dog with non-weight bearing lameness was referred for treatment of an open fracture. The open fracture occurred during a wild boar hunt. Physical and orthopedic examinations did not reveal any abnormalities, aside from an open radius fracture with extensive soft tissue loss. The patient was confirmed that there was a laceration of the flexor and extensor muscles located at the medial side of right distal radius and carpal joint (Figs. 1A and 1B). The results of laboratory blood tests were within normal range. Radiologic examination revealed a right distal diaphyseal comminuted fracture with bone loss of the radius approximately 3cm in length and an ulnar short oblique fracture (Figs. 1C and 1B).

§The first two authors contributed equally to this work.

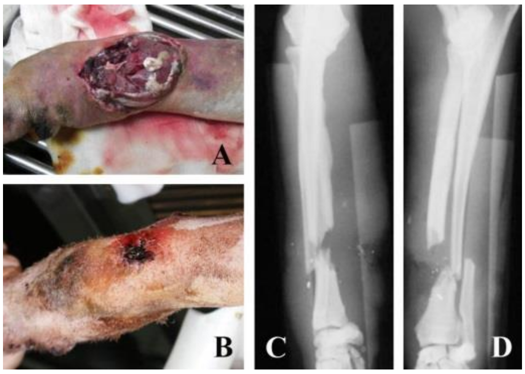

Fig 1: Preoperative photographs and radiographs of the dog showing a large skin defect on the medial side (A), a perforation wound on the lateral side (B) of the right forelimb, a comminuted fracture of the radius with a 3cm segmental bone defect of the radius, and a short oblique fracture of the ulna (C, D)

Based on examination results, we diagnosed a type IIIB open fracture of the right radius and ulna.

Prior to surgery for fracture repair, open wound management was performed with the use of wet-to-dry contact dressings as well as daily debridement and lavage for five days. There was a skin defect after debridement that could not be closed. Five days later, we performed bone transport osteogenesis with CESF (IMEX veterinary Inc., Texas, USA).

Patient preparation and anesthesia: The dog was pre-medicated with atropine sulfate (0.02 mg/kg SC, Atropine Sulfate Daewon®; Dae Won Pharm) and butorphanol (0.4 mg/kg IM, Butophan Inj®; Myung Moon Pharm, Korea). Anesthesia was induced with propofol (6 mg/kg IV, Anepol IN®; Ha Na Pharm). After intubation, general anesthesia was maintained with isoflurane (2-3%) in oxygen (1.5 L /min). A brachial plexus nerve block was performed by administration of 2% lidocaine (3 mg/kg, Lidocaine HCl Dalhan Inj®; Dai Han Pharm).

Surgical procedure: The right forelimb was prepared by aseptic technique. The patient was placed in a dorsal recumbent position. After bone debridement of the injured area, a CESF frame with three 118mm full rings was used. Once the appropriate position and alignment were obtained, the frame was secured to the bone with two 1.6mm transosseous smooth fixation wires on each proximal and distal ring. An osteotomy was made 4cm proximal from the end of the proximal radial segment to create an intercalary bone transport segment. The intercalary radial segment was transfixed with two fixation wires with an olive wire that was secured to the centrally positioned transport ring. Routine closure of the surgical site was performed. Postoperative radiographs showed a 4cm bone defect resulting from the bone debridement (Figs. 2A and B). A latency period of five

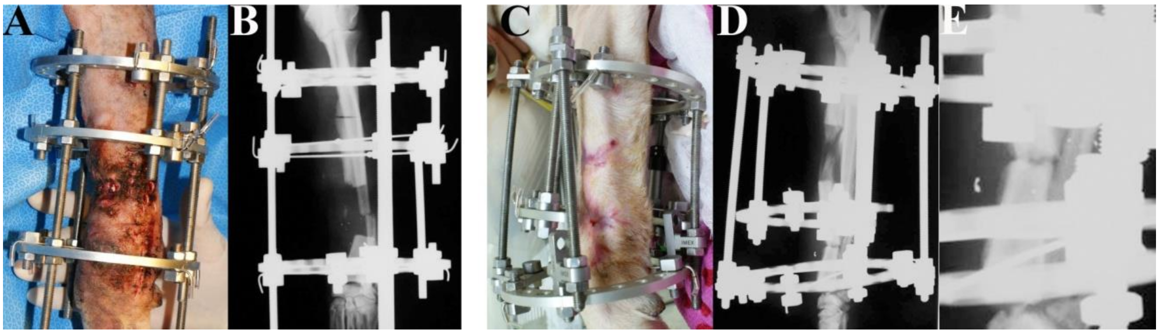

Fig 2: Postoperative photographs and radiographs of the dog showing a type IIIB open fracture of the right radius with a soft tissue defect (A),a 4-cm segmental radius defect (B), complete healing of the skin lesion (C), docking of transport bone to distal bone 36 days postoperatively (D), nonunion at the docking site 60 days postoperatively (E).

Fig 3: Photographs (A), craniocaudal (B) and lateral (C) radiographs after minimally invasive plate osteosynthesis with a locking plate. Lateral radiograph of the right forelimb 4 months (D), 6 months (E), and 12 months (F) postoperatively.

days was allowed prior to beginning distraction of the bone segment. The distraction rate was 1.5mm/day at an interval of two times. On postoperative day 36, the transport segment had docked at the distal bone fragment and bone regeneration bone continued to fill in the distraction gap (Figs. 2C and 2D). However, on postoperative day 60, nonunion at the docking site were present (Fig 2E).

After 63 days of BTO, MIPO was applied using a locking compression plate over the distraction callus with autogenous cancellous bone graft at the docking site after removal of CESF frame (Figs. 3A, 3B, 3C and 3D). Four months postoperatively, bony union was present and bone regeneration was progressing satisfactorily (Fig. 3E). Sixteen months postoperatively, although the patient exhibited a decrease in range of motion of the carpal joint of the affected limb, she had good limb function without lameness (Fig. 3F).

DISCUSSION

The patient was achieved satisfactory results with BTO and MIPO for post-traumatic SBD in our patient. CESF allows axial micro-motion of bone segments without compromising the stability of the fixation. This controlled axial micro-motion of bone segments appears to stimulate callus formation at the fracture site or distraction gap (Ilizarov, 1990; Ting *et al.,* 2010). New bone formation resulting from BTO is highly resistant to infection because it contains regenerated vascular tissue (Ilizarov, 1990; Liu *et al.,* 2011). Clinical studies have shown that bone infection does not occur after BTO for SBD in dogs (Rahal *et al.*, 2003; Ting *et al.,* 2010). Our patient had a SBD and a large skin defect with contamination after trauma. BTO with CESF can provide simple wound management and stabilization of the SBD without infection.

Although BTO with CESF has been reported to have a high success rate in in human and veterinary medicine, this technique has the complication of patient discomfort due to factors such as pin tract infections, pin breakages, pin loosening, and joint contractures because a long period of time is required before the removal of the CESF. BTO has two distinct treatment phases: distraction and consolidation (Ilizarov, 1990). Although time for consolidation varies dependent upon the size of the SBD and patient characteristics, the consolidation period is twice that of the distraction phase (Rahal *et al.,* 2003; Ting *et al.,* 2010; Oh *et al.,* 2013). The bone transport over the bone plate or an intramedullary nail can be used to remove external skeletal fixation before the distraction callus has consolidated (Oh *et al.,* 2008; Oh *et al.,* 2013). However, it is difficult to apply an intramedullary nail to the canine radius, as in our case. The conventional bone plating technique requires an open reduction for internal fixation, whereas the MIPO technique preserves the perforating arteries and nutrient artery; thus, it improves periosteal and endosteal perfusion (Guiot *et al.,* 2011; Peirone *et al.,* 2012). Garofolo *et al.,* reported on the development of the extraosseous blood supply after MIPO and conventional bone plating of the canine radius. The periosteum plays a critical role in intramembranous ossification during the consolidation phase in BTO. It can decrease the external skeletal fixation time with application of a bone plate by the MIPO technique during the consolidation period.

BTO using the dynamic CESF method can be used successfully to restore an open fracture with a bone defect. Moreover, the application of a bone plate by the MIPO technique during the consolidation period is an alternative method to decrease complications of external fixators and to increase patient quality of life.

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