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Use of Minimally Invasive Plate Osteosynthesis for Tibial Diaphyseal Fracture in Three Dogs

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Abstract : Three dogs were presented with diaphyseal fracture of the tibia following separate motor vehicle accidents. On physical and orthopedic examinations, the dogs were noted to have soft-tissue swelling and a closed fracture in these tibia sites. Radiographs revealed a simple, short oblique fracture (case 1), a comminuted, spiral fracture (case 2), and a simple, spiral fracture (case 3) in tibia. Minimally invasive percutaneous plate osteosynthesis (MIPO) using a veterinary cuttable plate or locking plate was applied for the treatment of these fractures. The surgery was successful, and the fractures healed without any complications by 7 weeks (case 1), 10 weeks (case 2) and 8 weeks (case 3) after surgery. Our patients showed fast bone healing times and early weight-bearing during the treatment of their tibia fractures. Therefore, MIPO was a useful procedure for diaphyseal fracture of the tibia in veterinary orthopedics.

***Key words* :** minimally invasive percutaneous plate osteosynthesis, diaphysis, tibia fracture, dog.

Introduction

Tibia fractures are common long bone fractures seen in veterinary orthopedics (2,17). A variety of treatment methods have been applied for tibial diaphyseal fracture. Of these, open reduction for internal fixation (ORIF) with bone plating is often used to treat tibia fractures in small animal practices (2,7,18). Conventional bone plating of long bone fractures generally focuses on anatomical reduction of the fracture. However, anatomical reduction requires surgical exposure all the way to the bone, as well as direct manipulation of the fracture (8,9,13). This reduction technique has the potential to increase the risk of delayed healing and to increase infection and complication rates (4,13).

Minimally invasive percutaneous plate osteosynthesis (MIPO) is a popular treatment of bone fracture in human orthopedics and traumatology (12,13,18). This technique is carried out through small incisions with as limited dissection as possible to minimize periosteal damage. MIPO has many biological advantages compared to the conventional bone plating technique (6,8,13). Recently, clinical studies have shown high success and low complication rates with the MIPO technique in tibia fractures (6,15,16).

We describe a technique and the results of MIPO in diaphyseal fracture of the tibia in three dogs using a veterinary cuttable plate (VCP) or a universal locking plate (ULP).

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Case

Case 1

A five-year-old, 4.5 kg, male Shih Tzu was referred to Chonbuk Animal Medical Center of Chonbuk National University for repair of a right tibial fracture sustained after motor vehicular trauma. The physical and orthopedic examinations did not find any abnormality, excluding a closed tibial fracture with mild swelling. The results of laboratory blood tests were within normal limits. Radiographs showed a simple, short oblique fracture of the right mid tibial diaphysis with distal, lateral displacement (Fig 1A).

Prior to surgery, the patient was premedicated with atropine (0.02 mg/kg SC, Atropine Sulfate Daewon®; Dae Won Pharm, Korea) and butorphanol (0.3 mg/kg IM, Butophan

Fig 1. Radiographs (A, E, F), intraoperative view (B), and fluoroscopy images (C, D) of case 1. Preoperative radiograph (A), percutaneous placement of the plate (B), fluoroscopy images showing the correct alignment and the plate position (C, D). An immediate postoperative radiograph (E), postoperative radiographs at 7 weeks showing union of the fracture with good alignment (F).

Inj®; Myung Moon Pharm, Korea). General anesthesia was induced using propofol (6 mg/kg IV, Anepol IN®; Ha Na Pharm, Seoul, Korea) and was maintained with isoflurane (Forane soln®, JW pharmaceutical, Korea) delivered in oxygen. Cephalexin (22 mg/kg IV q 2 hours, Methilexin Inj®, Union Korea Pharm, Korea) was also given at the time of induction. 2% lidocaine (1 ml/4.5 kg, Lidocaine Hcl Dalhan Inj®, Dai Han Pharm, Korea) was administered lumbosacral space for epidural anesthesia.

Preoperatively, a 2.0 mm VCP (APISTM, ANYPIA, Korea) was cut and contoured based on contralateral radiographs of the tibia. The limb was prepared for aseptic surgery. The patient was positioned dorsally on a radiolucent table. Intraoperative fluoroscopy was used throughout the MIPO procedure. The first skin incision was made approximately 2 mm in length on the medial side of the proximal tibia. The proximal bone was exposed under caudal retraction of the sartorius, gracilis and semitendinosus muscles. The second skin incision, centered over the distal tibia and approximately 2 mm long, was made while taking care to protect the medial saphenous artery and vein. Point-point bone reduction forceps were percutaneously applied for indirect closed reduction (Fig 2A, B). After reduction, an extraperiosteal tunnel was created with a periosteal elevator using blunt dissection (Fig 2C). The precontoured plate was passed along the tunnel from the distal and proximal directions (Fig 1B, 2D). Following insertion, the correct position was confirmed with fluoroscopy using two views. Three 2.0-mm cortical screws were placed in the proximal holes of the plate. Fluoroscopy was used to check the alignment and position of the plate. Final fixation was achieved with three screws at the distal holes of the plate. Final position was confirmed radiographically (Fig 1C, D). The surgical incision was routinely closed in layers. Postoperative radiographs documented acceptable alignment and plate location (Fig 1E). A Robert-Jones splinting bandage was applied to protect postoperative swelling. Three weeks postoperatively, callus formation was noted in the fracture site. At four weeks, the patient was able to use the limb without any support. Seven weeks follow-up radiographs showed formation and union of the fracture line (Fig 1F). The patient was reported to exhibit no repair complications.

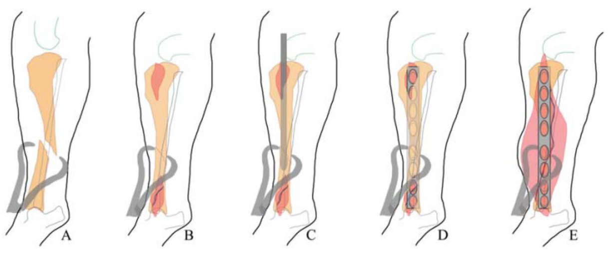

Fig 2. Schematic illustrations of the minimally invasive plate osteosynthesis (MIPO) and the conventional bone plating (ORIF). The fracture is reduced by using pointed forceps (A) and a small incision for the MIPO (B). A subcutaneous tunnel is created with a periosteal elevator (C), and the minimally invasive plate osteosynthesis has limited distal and proximal incisions, whereas conventional bone plating requires a large incision (D and E).

Case 2

A 10-year-old, 3.2 kg, female mixed-breed dog was presented for evaluation of weight-bearing lameness of the left hindlimb. The lameness had occurred for three days previously as a result of a motor vehicle accident. On physical examination, the dog was noted to have soft-tissue swelling and a closed fracture in the tibia site. Radiographs documented a comminuted, spiral fracture of the right mid tibial diaphysis (Fig 3A, B).

The animal's anesthesia, perioperative and operative processes were almost identical to case 1. The surgery was performed in the dorsal position on a radiolucent table. A 2.0 mm VCP (APISTM, ANYPIA, Korea) was selected and precontoured using contralateral radiographs of the tibia. Two 2 cm incisions were made both distal and proximal and medial tibia, and a subcutaneous tunnel was created with the help of a periosteal elevator. The fracture was reduced under fluoroscopy with point-point bone reduction forceps percutaneously. A stab incision was made, and two positional screws were inserted into the fractured fragment to reduce the tibia fracture. The plate was inserted subfascially from a distal to a proximal direction. The two proximal and distal holes of the plate were filled with 2.0 mm cortical screws. The alignment and position of the plate were confirmed radiographically with fluoroscopy. Finally, the surgical site was lavaged and closed in a routine manner. After postoperative radiographs (Fig 3C), a modified Robert-Jones bandage was applied for two days. Radiographs taken at three weeks postoperatively showed a small amount of callus around the fracture site. At 10 weeks follow-up, radiographs suggested that the gaps of the fracture site had been filled with calcified tissue (Fig 3D). Upon recheck at 18 weeks postoperatively, the patient was using the hindlimb normally and was not reportedly experiencing any complications associated with the surgery.

Case 3

A 7-year-old, 6.7 kg, female Shih Tzu dog was admitted to Chonbuk Animal Medical Center of Chonbuk National Uni-

Fig 3. Radiographs of case 2. A lateral (A) and cranio-caudal (B) preoperative radiograph of a mid-tibia diaphyseal fracture. An immediate postoperative radiograph (C). Postoperative radiograph at 10 weeks showing good bone healing without any implant failure (D).

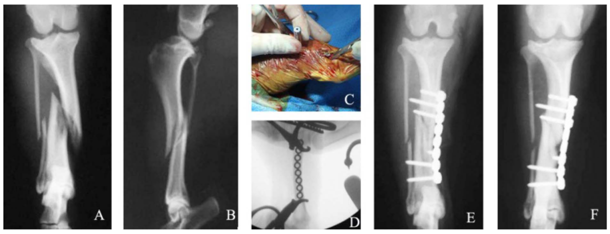

Fig 4. Radiographs (A, B, E, F), intraoperative view (C), and fluoroscopy images (D) of case 3. Preoperative radiograph (A, B), fluoroscopy images showing the accurate plate position (D). An immediate postoperative radiograph (E), postoperative radiographs at 8 weeks showing a bony bridge of the fracture with good alignment (F).

versity after involvement in an automobile accident. On physical examination, the dog was nonambulatory in the left hindlimb. Radiographs of the left tibia revealed a closed, spiral fracture of the mid tibial diaphysis with proximal, medial displacement (Fig 4A, B).

The patient's anesthesia and perioperative protocol were identical to case 1. The patient was positioned in dorsal recumbency on a radiolucent table. A 1-2 cm skin incision is made the medial aspect of the distal tibia. Intraoperative fluoroscopy was used throughout the MIPO procedure. A subcutaneous tunnel was created with long scissor. A 2.0 mm precontoured ULP (Universal locking plate, COREM, Korea) for the tibia is then passed through the tunnel. The locking drill guide was attached to the proximal end of ULP through a skin incision (Fig 4C). One proximal and one distal screw were inserted. Additional screws were then applied using the same technique. The position of the plate was confirmed with fluoroscopy in two orthogonal views (Fig 4D). The surgical site was lavaged. All surgical incisions were closed in a routine manner.

After postoperative radiographs (Fig 4E), a modified Robert-Jones bandage was applied for two days. Postoperative radiographs showed callus formation at three weeks. At an eight weeks follow-up, radiographs suggested the establishment of a bony bridge (Fig 4F). There was not any complication associated with surgery. The patient was able to walk and run, had returned to normal activities.

At each case observed complete bone union, angle of tibia bone alignment (3) and length in postoperative radiography (case 1, 2, and 3) were measured by use of goniometry. Angles and lengths in fractured tibias were compared with radiography of the contralateral tibia (Table 1).

Discussion

Biological fixation using MIPO, which is used to repair diaphyseal fractures of the tibia, has produced good clinical results (6,15,16). The principles of biological fixation of MIPO include reducing iatrogenic soft tissue injury, using indirect reduction techniques and promoting early return to limb function (8,13).

These principles of MIPO produce good results in comparison to ORIF. Previous studies using MIPO reported faster healing times, short operative times and low complication rates. Guiot *et al*. (2011) reported the clinical outcome of MIPO for nonarticular tibial fractures in dogs and cats. The mean time to clinical union was 36 ± 11.6 days. This time was shorter than that reported using ORIF (87-121 days). The rate of major complications was 2.8% lower than that for bone plating (18%) (1,4,6). In other clinical studies using this procedure, the mean surgery time for MIPO to treat tibia fractures was 59 minutes shorter than that reported for comminuted femoral fractures using ORIF (116 minutes) (10,15). Although we only reported on three cases, which is a limitation, we had no reported complications after treatment with MIPO. The amount of time to clinical union in these cases was six weeks (case 1), ten weeks (case 2) and eight weeks (case 3).

The procedure of MIPO involves small skin incisions remote the fracture site. A plate is inserted through small skin incision, and then bone fragment is reduced. These situations may lead to increase in risk of malaligment because of difficult manipulation of bone fragment. Therefore, correct length and alignment of the bone should be conformed on surgery when MIPO procedure is used for repair of bone fracture. In our cases, there were no differences between fracture and contralateral tibia of tibia bone alignment angle or length using radiographic measurement of proximal and distal mechanical joint angles of the tibia (3).

MIPO also allows surgeons to perform bridge plating without requiring extensive surgical exposure of the bone and surrounding soft tissues (Fig 2D, E) (4,8,9,14). The bridge-plates technique aims to protect the soft tissue around the

Table 1. Angle of bone alignment and length of tibias

	mMPTA*		mMDTA*		Length	
	Contralateral limb	Fractured limb	Contralateral limb	Fractured limb	Contralateral limb	Fractured limb
Case 1	95°	95°	94°	96°	75 mm	75 mm
Case 2	100°	96°	101°	100°	79 mm	80 mm
Case 3	98°	98°	98°	98°	69 mm	69 mm

*Normal range: mMPTA (89.74-96.86°), mMDTA (90.59-101.39°).
mMPTA, mechanical medial proximal tibial angle; mMDTA, mechanical medial distal tibial angle.

fracture site and to use flexible fixation to promote secondary bone healing (8,13). Because MIPO preserves any fracture hematomas, this method has favorable effects on bone healing. In a rat model, Mizuno *et al*. found that fracture hematomas have inherent osteogenetic potential (10). In addition, the VCP in our cases (case 1 and 2) had elastic properties in comparison with locking and dynamic compression plates that are used in other methods. Therefore, using MIPO to treat tibia fractures showed a good clinical result in this study with the use of VCPs, which is in agreement with that of another study that reported a good result in most cases (64%) (4). In case 3 by use of ULP showed a good outcome. MIPO have been improved in recent years by the introduction of locking plates. The locking plate systems have the biomechanical and biological advantages in compared with conventional plates. The locking plate make the stability increase between bone and plate due to a screw lock in the plate holes. Moreover, the periosteal blood supply is preserved due to the absence of the contact between the bone and the fixator (5,13)

MIPO offers several advantages compared to ORIF. However, MIPO does not allow direct observation of fracture fragments. Intraoperative fluoroscopy is often used in human medicine. Although it is not required for all cases using MIPO in small animal practice, fluoroscopy increases additional radiation exposure during application of the plate to the bone and screw fixation to both the surgery team and the patient (6,8). Therefore, the benefits need to be weighed against the risks when deciding whether or not to use fluoroscopy intraoperatively.

In our cases, MIPO using a VCP or ULP was applied for the treatment of diaphyseal fracture of the tibia in three dogs. Our patients showed fast bone healing times and no surgical complications during the treatment of their tibia fractures. Therefore, MIPO was a useful procedure for diaphyseal fracture of the tibia in veterinary orthopedics.

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경골 골간 골절에서의 최소 침습적 금속판 고정술의 이용 3례

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요 약 : 교통사고를 원인으로 3마리의 개가 경골 골간 골절로 내원하였다. 신체검사와 정형외과 검사상 이들 골절은 경골주위에 연조직 손상을 동반한 폐쇄성 골절을 보여 주었다. 방사선검사상 단순 경사골절 (증례1), 복잡 나선형골절 (증례 2), 단순 나선형골절 (증례 3)로 진단되었다. 이들 골절은 수의 절단성 금속판이나 잠김 금속판을 이용하여 최소 침습적 금속판 고정술을 적용하였다. 수술은 성공적으로 이루어지고 7주 (증례 1), 10주 (증례 2) 그리고 8주 (증례3) 후 부작용 없이 골절 치유를 확인할 수 있었다. 수술 후 모든 환자들은 빠른 골치유와 체중 지지를 관찰할 수 있었다. 최소 침습적 금속판 고정술은 수의정형외과영역에서 경골 골간 골절의 유용한 수술법으로 생각된다.

주요어 : 최소 침습적 금속판 고정술, 골간, 경골골절, 개