Clinical Experience of Interlocking Nail Stabilization of Long Bone Fractures in Dogs – A Retrospective Study of 26 Cases

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ABSTRACT

The aim of the study is to report the clinical and radiographic outcome after use of an interlocking nail (ILN) for stabilization of long bone fractures in dogs. Twenty-six dogs were evaluated. There were ten femoral fractures, 12 tibial fractures and four humeral fractures. The equipment was manufactured by Orthovet (Orthovet, Izmir, Turkey). Three ILN lengths with three different diameters (4, 6 and 8 mm) were used. Each ILN had a trocar tip on one end and four screw holes (two distal and two proximal). Ten fractures (four femoral, five tibial, one humeral) were associated with other orthopedic problems. Nine (39.1%) patients had aseptic nonunion and malunion fractures. A static fixation mode was used for nine fractures and a dynamic fixation mode was used in 17 (65.3%). The surgical time recorded was 45-52 minutes. Three dogs had a major complication requiring surgical intervention. At 6 months, the functional outcome was excellent in 15 (57.6%) animals, good in seven (26.9%), fair in three (11.5%), and poor in one (3.8). In conclusion, the use of ILNs to repair diaphyseal fractures of the femur, tibia, and humerus in dogs resulted in a good or excellent functional outcome in most patients.

Keywords: Dogs; Interlocking Nail Stabilization; Long Bone Fractures.

INTRODUCTION

Interlocking nails (ILNs) are a valuable tool for treating tibial, femoral, and humeral fractures in small animals, and especially comminuted fractures in dogs and cats (1, 2, 3, 4). ILNs have been used for more than a decade for the treatment of long-bone fractures in dogs and cats (5, 6, 7, 8, 9, 10, 11), and in birds (12). ILNs provide a viable option for minimally invasive fracture repair and may be an attractive alternative to the use of standard bone plates for the repair of comminuted diaphyseal fractures. However ILNs, like other fracture repair modalities, have associated complications. These include implant failure, including failure of the nail itself and failure of the locking bolt, misdirected locking bolts, joint penetration, delayed union, non-union and infection (13, 14). Nail failure has been reported in dogs (3, 8, 15) but not in cats (11, 15, 16). Screw failure is a less serious complication because bone healing is usually not affected (3, 8, 15). Screw bending has also been reported as a complication (1, 17, 18).

In the current study, the clinical outcomes of femoral, tibial, and humeral diaphyseal fractures repaired by ILN in 26 dogs are reported. Long-term follow-up (> 6 months) was available for all patients.

MATERIALS AND METHODS

Dogs

Twenty-six dogs weighing 15 to 50 kg (mean 28.5 kg) with diaphyseal fractures of the femur, tibia (Fig. 1) or humerus were used in the study. The fracture type (bone, degree of comminution, cause), use of ILN as method of application, complications that occurred during application, surgical time, and clinical outcome, including healing, function and complications, were assessed. Confirmation of the diagnosis was obtained by radiography of the involved bone in mediolateral and craniocaudal views, in order to assess the location and type of fracture. The dogs were followed up for 6 months. The study was performed with approval from and under the guidelines of the Institutional Laboratory Animal Care and use Committee of Selcuk University.

Interlocking Nails

Three generations of ILN and instrumentation were used in this study. The equipment was manufactured by Ortovet (Orto-vet, Izmir, Turkey, www.orto-vet.com). Seven ILN lengths (150, 160, 170, 180, 190, 210 and 230) with three different diameters (4, 6 and 8 mm) were available (Table 1). Each ILN had a trocar tip on one end, a negative thread on the other end to receive the jig used for cortical screw placement, and four screw holes (two distal and two proximal). The ILNs could be inserted with a Jacobs chuck in a retrograde direction (with use of a removable tip), and AO/ASIF cortical bone screws (2.7 mm diameter; 22, 24, 26, 28, 30 and 32 mm length) were used as interlocking screws.

Figure 1: 3 year old, male, German Shepferd dog with diaphysis / oblique, middle 1/3rd of tibial fracture.

Surgical Technique

The surgical techniques followed published procedures (3). The dogs selected for this surgical approach had evidence on preoperative radiographs that the proximal and distal fragments were of sufficient length to tolerate insertion of an ILN, so that locking screws could be positioned on proximal and distal fragments sides of the fracture with interlocking screws positioned at least 10 mm distant from the fracture. Finally, the bone had to have a radiographic appearance that suggested it should be able to hold screws firmly. In addition, with the measurements performed on these radiographs, the relation between the fracture line and the screw holes to be opened was assessed. If the fracture site was short with an unstable fracture, the ILN dimensions were determined by measuring the silhouette of the contralateral unfractured bone. Implant diameter was selected to provide the best fit within the medullary canal.

Food was withheld from each dog for 12 hours before anaesthesia. Preoperative flunixin meglumine (0.5-2 mg/kg BW, Flumed® inj., Alke, Istanbul, Turkey) was given IV before the operations. Anesthesia was induced with intravenous xylazine hydrochloride (Alfazyne 2% 20 mg/ml, Egevet, Izmir) and ketamine hydrochloride (Alfamine 10%, 100 mg/ml Egevet, Izmir). After 10 minutes, anesthesia was maintained with isoflurane in oxygen (AErrane, Baxter, Mississauga (Ontario), 2%-4%). After open fracture reduction and following the exposition of fracture line (humerus, tibia and femur) medullary canal of the proximal fragment was drilled of the same diameter with the nail to be used. If necessary the ILN was inserted initially in the distal fragment to verify that the diameter was adequate and to prepare the medullary canal for implant seating. Interlocking nail was placed in the proximal fragment in retrograde direction and pulled out from the hole opened by the drill's tip. The nail was pulled until the fracture line proximally with the use of the drill. The ILN was pushed into the metaphysis, without penetration of the articular surface, to reduce exceptionally distal fractures and in order to avoid damage to the proximal end of the ILN, which might prevent attachment of the guide jig. Instead, when the ILN was inserted to three-quarters of its length, a handle used for guide jig attachment was attached to the proximal end of the ILN, then, with alternating rotational movements of the handle, the ILN was fully seated in the distal aspect of the diaphysis. With the ILN seated, the guide jig was positioned close to the bone and attached to the slot in the handle. Holes in the jig corresponded in alignment with the holes in the ILN and were used to insert of a drill guide (2.5 mm) against the bone and a gliding hole was drilled through both cortices. After drilling, the drill guide was replaced by a screw guide. Screw length was measured with a special gauge. A screw and the screwdriver were inserted into the screw guide and the screw was inserted through the ILN and both cortices. It is essential that the distal aspect of the bone is locked first to ensure good mechanical stability. After the nail was locked, the jig was removed. The ILN can be implanted in a static or dynamic fixation mode, depending on whether it is desirable to neutralize part or all of the rotational or compression stress. In the static mode, both proximal and distal screws are inserted, whereas, in the dynamic mode, only proximal or distal screws, but not both, are locked.

Craniocaudal and mediolateral radiographs were taken postoperatively in order to view the results of the procedure, and 22,000 IU/kg of penicillin G (Devapen, Deva) and 2 days after surgery I.V flunixin meglumine (Flumed® inj., Alke, Istanbul, Turkey) or 0.4cc/10 kg S.C Meloksikam 20 mg (Maksikam, Sanovel, Istanbul, Turkey) was administered postoperatively.

Femur

The femoral diaphysis was exposed through a lateral approach.When the femur and fracture line were exposed, the medullary canal of the proximal fragment was opened using a drill tip of the same diameter as the nail to be used. The ILN was inserted into the proximal fragment in a retrograde direction and pulled out through the hole made by the drill tip. The nail was pulled to the fracture line proximally with the use of the drill. When reduction of the fracture was complete, a handle used for guide jig attachment was attached to the proximal end of the ILN. With alternating rotational movements of the handle, the ILN was fully seated in the distal aspect of the diaphysis.

Tibia

A craniomedial skin incision was made along most of the tibial length. Dissection through the subcutaneous fascia exposed the tibial shaft, with the cranial tibial muscle forming the cranial margin and the long digital flexor muscle the caudal margin. The ILN was placed in the proximal fragment in a retrograde direction and pulled out through the hole opened by the drill tip. The nail was pulled proximally to the fracture line with the use of the drill. When reduction of the fracture was completed, the nail was then placed in the distal fragment by launching with the drill.

Humerus

The proximal aspect of the shaft was exposed by a lateral approach, and the distal portion of the shaft was also exposed laterally. ILNs were placed in a retrograde manner.

Fracture Classification

Fractures were classified by their location; whether closed or open; new or pre-existing (delayed union, non-union, implant failure); comminuted or non-comminuted. The severity of comminution was graded according to the modified Winquist–Hansen criteria, which consider the stability and complexity of the fracture: class 0, non-comminuted fracture; classes I-V, comminuted fractures where class I has a small unimportant bone chip, class II has greater than 50% contact between proximal and distal fragments, class III has less than 50% contact between proximal and distal fragments, class IV has no contact between proximal and distal fragments, and class V has segmental fractures (19).

Outcome

Fracture healing and functional outcome were assessed 6 months after surgery.

Assessment of Fracture Healing

Radiographic assessment of fracture healing was made at 1, 3, and 6 months until there was radiographic evidence of healing and no pain could be noted during limb manipulation. Fracture healing was classified by use of a modified Meynard and Magnin method that assesses the quality of fracture reduction, the quality of healing of the interosseous space (size of this space, lack of bony substance, density of the callus), and periosteal callus volume (normal or exuberant) (3, 20).

Functional Outcome

The limb was scored as: 1, excellent (total absence of lameness); 2, good but favoring the limb after exercise); 3, fair (constant lameness); and 4, poor (no use of the limb for support). Intraoperative (technical errors during surgery or the incorrect choice of implants) and postoperative (implant failure, delayed healing, non-union) complications were recorded and analyzed (3). Delayed union was defined as a fracture that had not healed by 3 months and non-union as a fracture that had not healed by 5 months. Implant failure was defined either as the breakage of the nail before fracture union or removal of the ILN and replacement by another type of fixation.

Statistical Analysis

Outcome was assessed through recheck examinations by the primary surgeon at least until radiographic healing. Further follow-up was by re-examination or telephone interview by the primary author (M.A). The distribution of dogs with respect to fracture type, sex, age, fracture location in the involved bones, and outcome of treatment was reported as a percentage.

RESULTS

Twenty-six dogs were evaluated. Their ages ranged from 1 to 5 years (mean, 2.5 years) and they weighed 15-50 kg (mean, 28.5 kg). There were ten femoral fractures, 12 tibial fractures (Fig. 2 and Fig. 3) and four humeral fractures. Fourteen fractures (53.8%) were acute. Twelve fractures (46.2 %) were old fractures. All fractures were closed. Ten fractures (four femoral, five tibial, one humeral) were associated with other orthopedic problems (such as cranial cruciate ligament rupture and arthritis). The fractures in nine (34.6%) patients showed aseptic non-union or malunion. The static fixation mode was used for nine fractures, and the dynamic fixation mode in 17 (65.3%). In six fractures (23.0%), cerclage wires were used in association with the ILN to stabilize the fragments. The surgical time recorded for the 26 fracture repairs was 45-52 minutes since skin insicion start.

Outcome

Complete follow-up data were available for all cases (100%). Among all the animals, 23 (88.4%) showed fracture healing without complications. Three had a major complication requiring surgical intervention (one osteomyelitis, two non-union with an incorrectly locked ILN).

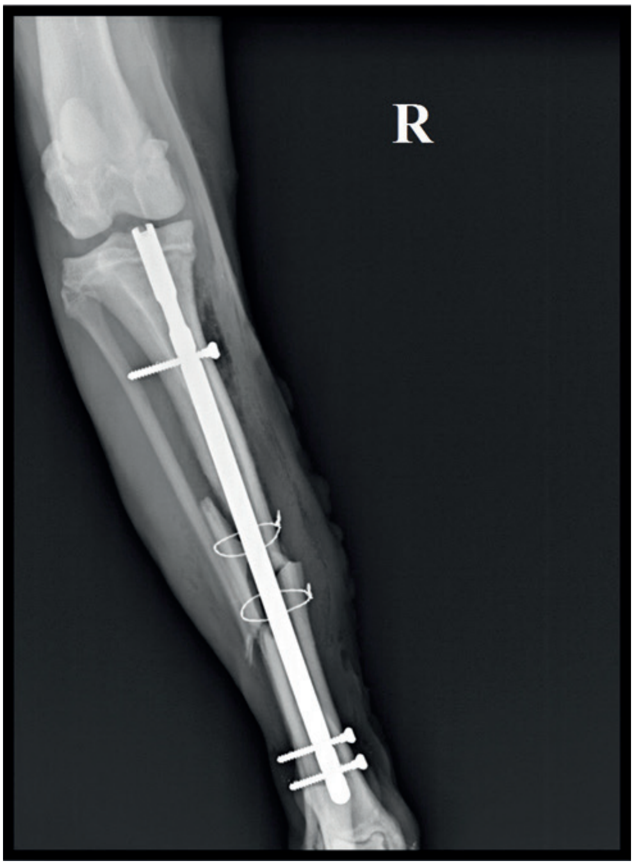

Figure 2: Post-operative, cranio-caudal position after interlocking nail fixation.

Figure 3: Post-operative, medio-lateral position after interlocking nail fixation.

Functional Assessment

At 6 months, the functional outcome was excellent in 15 (57.6%) animals, good in seven (26.9%), fair in three (11.5%), and poor in one (3.8%) (Table 2). The ILNs were removed from one dog with osteomyelitis in tibia. The case was a malunion.

Implant Failure

There were no nail failures associated with bending or fractures of locking screws in this study.

Locking Mistakes

Six ILNs were not locked correctly because of misdirected distal screws that failed to engage the ILN holes. In three of them only one screw was inserted distal to the implant but in the other three all distal screws were misdirected. There were not misdirected proximal screws.

Other Complications

Metal cerclage wires used in an one case showed evidence of aseptic necrosis on the tension surface of the femur and osteoporosis associated with stabilization that was caused by disruption of blood supply to bone fragments caused by micro-movement of the wires. The wires were removed, and healing was achieved 6 weeks after replacement. A slight lameness was noted after walking, and therefore functional outcome was classified as fair or good. Excessive callus production were seen in six cases.

DISCUSSION

Interlocking nail fixation (ILN) supports bone stabilization with or without minimal surgical intervention (2, 5, 9, 15, 21). ILN repairs offer several biomechanical advantages when compared with other fixation devices (17, 22). The method reduces blood loss during the procedure, it speeds up healing time and the recovery of limb function, and it minimizes the risk of complications, such as infections or incomplete bone union (8). Fracture repair involving intramedullary nails is a shorter procedure than plate osteosynthesis (23). As a biological osteosynthesis method, the ILN technique minimizes disturbance to blood supply at the fracture site (15). An ability to lock the cortices of each fracture segment to the nail by use of screws or bolts increases resistance to torsional, compressive, and shear forces when compared with intramedullary pins about the implant going through the neutral axis (24). In this study, ILNs were used to stabilize diaphyseal fractures of the femur, tibia, and humerus of dogs, with a high likelihood of an good and excellent functional outcome. In the study, 22 (84.6%) of 26 dogs with fractures healed with a good or excellent functional outcome. Twenty-two (84.6%) healed without complications, the outcome was considered excellent in 15 patients (57.6%), good in seven patients (26.9%), and fair in three patients. Sixteen patients (14%) required more than 6 weeks to achieve a functional outcome of good or excellent for periodic examination after surgery.

Interlocking nails, like other fracture repair modalities, have associated complications. Previously described complications include implant failure, including failure of the nail itself and failure of the locking bolt, misdirected locking bolts, joint penetration, delayed union, non-union and infection. In this study, no nail failures were associated with bending or fracture of locking screws. A relatively large retrospective study of 121 ILN fracture repairs documented problems with healing in 10%-12% of cases and a 4% incidence of stabilization failure (3, 15, 25). ILNs have better resistance to torsion, bending, and shearing than bone plates or external fixators (3, 26, 27). These advantages are especially important in the treatment of comminuted fractures. Likewise, superficial bone deformation, and bone demineralization occurs less with ILNs than with plate fixation (3, 20, 22). From a technical perspective, an ILN does not need to be contoured like a bone plate that must be altered to fit the bone surface. This can be difficult when bone segments are deformed in three dimensions (e.g., the humerus and distal femur of chondrodystrophic dogs). Cerclage wires were used in six cases with multiple fractures for secure and anatomic reconstruction of the bone segments.

In this study, surgical time was recorded at around 50 minutes, which should minimize the risk of postoperative infection. However, six ILNs were not locked correctly because of misdirected distal screws that failed to engage the ILN holes. In three cases only one screw was inserted distal to the implant, and but in the other three all distal screws were misdirected. This technical error was related to a failure to align the jig and the ILN accurately. Typically, this occurred if the fixation screw between the ILN and the jig was not applied tightly, if the slide of the jig was not controlled and supported by the muscle, or if the jig moved between locking screw insertions.

In conclusion, the use of ILNs to repair diaphyseal fractures of the femur, tibia, and humerus in dogs resulted in a good or excellent functional outcome in most patients.

CONFLICT OF INTERESTS STATEMENT:

The authors declare that there are no conflicts of interest in this research.

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