Interlocking Intramedullary Nail Method for the Treatment of Femoral and Tibial Fractures in Cats and Small Dogs

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ABSTRACT. We have developed an interlocking intramedullary nail method for the treatment of femoral and tibial fractures and used this method for the treatment of 7 cats and 6 dogs with these fractures. The interlocking nails, with a diameter of 4–6 mm and length of 60–140 mm, have holes at 10 mm intervals for screwing. The nail placed on the insertion device was inserted into the marrow cavity from the end of the fractured bone in the usual procedures for intramedullary fixation, then fixed by screws at the distal and proximal ends with a jig which was also attached to the insertion device. Animals were able to bear weight on the treated legs within three days, and the prognosis was excellent. — KEY WORDS: canine, feline, interlocking intramedullary nail.

Surgical procedures for long bone fractures at the diaphysis include internal fixation using plates, screws or intramedullary pins and external fixation. We must select a reliable method which can resist both bending and rotating of the fractured bone, taking into account location, morphological features and function. Interlocking intramedullary nails (IIN) have been used recently in human cases [4–6, 9] because they make closed surgery possible, the burden of surgery is less than with the plate fixing method, and the bone is more resistant to crushing and rotating than with the other intramedullary fixing methods. Veterinarians have used the IIN system for large dogs and animals [1, 7], but it has not been used in small animals. We, therefore, developed an IIN device for smaller animals, such as cats and small dogs, and have applied it to clinical practice.

The newly devised IIN system (Mizuho Ikakogyo, Tokyo) consists of a device for the insertion and removal of IIN and a jig for driving interlocking screws. The insertion device can be attached to a 4 to 6 mm IIN at the top with a screw. Accessory equipment is a guide sleeve, drill guide, tap guide, drill bits (1.5, 2.0, and 2.5 mm diameter), taps (2.0, 2.7, and 3.5 mm diameter), punch, depth gauge, reamers (4, 5, and 6 mm diameter), and driver (Fig. 1).

The IIN is made from solid SUS316 stainless steel and comes in the following sizes: 4 mm diameter × 60, 70, 80, 90 or 100 mm long; 5 mm diameter × 95, 110, 125, or 140 mm long; and 6 mm diameter × 105, 125, or 145 mm long. Each IIN has holes at 10 mm intervals for screws. The top end has a trocher cut, and the opposite end is a screwhead, making insertion and removal possible. Screws are manufactured based on A/O standard, and come in sizes of 2.0, 2.7, and 3.5 mm. The 2.0 mm screws are for the 4 mm diameter IIN, the 2.7 mm screws for the 5 mm diameter and the 3.5 mm screws for the 6 mm diameter IIN.

Clinical cases: These were 3 femoral and 3 tibial fractures of dogs and 7 femoral fractures of cats. Dogs were 4 males and 2 females between 0.5 and 9 years old (average, 3.6 years), and between 8 and 14.5 kg (average, 12.4 kg) in
body weight. Cats were 4 males and 3 females between 1 and 11 years old (average, 3.6 years) and between 2.9 and 4.2 kg (average, 3.5 kg). All injuries resulted from traffic accidents, and all were fresh fractures except one which was a non-union. The IINs were applied to 12 cases in open surgery and to one of closed surgery.

**Surgical method:** Animals were sedated by subcutaneous injection of 0.05 mg/kg atropine sulfate and 0.04 mg/kg medetomidine hydrochloride. Anesthesia was induced by intramuscular injection of 5 mg/kg ketamine hydrochloride and maintained by inhalation of oxygen, nitrous oxide, and isoflurane. Lactated Ringer’s solution was supplied intravenously during surgery and on the first postoperative day. An antibiotic, cefamezine, 25 mg/kg, was administered by intravenous injection for 5 days.

a) Open femoral surgery: Prior to the surgery, the size of IIN to be used was determined by radiography. The IIN was set on the insertion device and inserted from the distal end of the fractured bone to the proximal direction in a retrograde fashion so that its distal end would come out near the greater trochanter (Fig. 2-A). Special care was taken not to damage the sciatic nerve. After removing the IIN and reducing the fractured bone, we orthodromically inserted the IIN from the proximal side to the distal side of the fractured bone (Fig. 2-B). A large bone fragment was simply reduced without separation from the soft tissue. Comminuted bone pieces were also not removed or separated from the soft tissues. After the IIN was inserted into the distal end of the femur, a jig was attached to the insertion device. After the length and rotation of the bone was carefully checked, the distal bone segment and then the proximal bone segment were drilled through small skin incisions, followed by tapping and screwing in the jig to fix the bones (Fig. 2-C). There were no difficulty in screwing in the jig without fluoroscopy.

b) Closed femoral surgery: After exposure of the proximal end of the femur, we drilled into the trochanteric fossa with a medullary cavity driller. The IIN was inserted at the proximal part of the femur without dissecting the traumatic region and the fractured bone was reduced under fluoroscopy and screwed using the jig without the aid of fluoroscopy.

c) Open tibial surgery: Through a minimal skin incision, we dissected the stifle joint to expose it and drilled the antero-medial area of the anterior cruciate ligament insertion using a medullary cavity driller. The IIN was inserted orthodromically as in the femoral fracture (Fig. 3-A, B). If the bone fragment was large enough to drill, it was reduced and fixed with screws.

**Postoperative evaluation:** Two parameters were evaluated: the number of days postsurgery until the affected limb was able to support full body weight and until the animal walked without lameness. The callus formation and bone healing were examined by radiography taken 2 and 4 weeks after surgery. Shortening of the repaired leg was evaluated in radiography in comparison with the opposing leg. A difference between the two legs of more than 5 mm was considered “shortened.”

Forty to 80 min (average, 58 min) were required for the femoral operation, and 40 to 90 min (average, 63 min) for the tibial surgery. One screw was used on each segment of the fractured bones in 9 cases; two screws were used on each segment in 2 cases. The large bone fragment was fixed using a screw in 2 cases. External fixation was not done in any case.

Prognosis of all cases were shown in Table 1. Animals were able to support their body weight on the first postsurgical day in 8 cases, and the remaining 5 by the third day (average 2.3 days). Lameness was observed for between 14 and 30 days (average 21.6 days) and all animals walked normally within one month. In no case was rotating malformation observed. Shortening of a leg by more than 5 mm was not observed except in the animal with a non-union fracture.

Callus formation was seen radiographically 2 weeks postsurgery in all cases (Fig. 3-C). After 4 weeks, the remodeling of the callus was noted (Fig. 3-D). During follow-up periods of between 2 and 15 months (average 4 months), we have encountered neither loosened nor damaged nails, nor infection. The implant was removed after 3 months in one case at the owner’s request.
Table 1. Case studies of interlocking intramedullary nail procedure

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C (kg)</th>
<th>D (Years)</th>
<th>E*</th>
<th>F (Days)</th>
<th>G (Days)</th>
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A: Case number, B: Animal, C: Body weight, D: Age, E: Classification of fracture, F: Number of days required to support body, G: Number of days required to walk normally. *F: Femur, T: Tibia, n: non-union, t: transverse, o: oblique, c: comminuted.

The newly devised IIN system for small animals was found to be effective; skin incision was relatively small, the fractured bones were reduced and fixed without shortening or rotative malformation of the legs even when they were comminuted, and animals were able to support their body weight in a relatively short period without external aid.

One problem with this type of surgery is the difficulty in inserting the interlocking screws [7]. With our IIN system designed for small animals we experienced no difficulty in screwing using the jig without fluoroscopy. The short legs in small animals seem to be advantageous in application of the jig, because short jigs do not bend easily as do long jigs.

The IIN used in this study has holes at 10 mm intervals along its entire length. Multiple holes provided us versatility in selecting the position for the screws [2–4, 8]. In some cases, the extra holes were used to fix bone fragments. The drawback of a nail with multiple holes is lack of strength [1]; however, in none of our cases was there damage to the nail.

The size of the nail was chosen according to the diameter of the marrow cavity. In dogs, we used a nail with a diameter slightly less than that of the marrow cavity of the femur and the same diameter as the tibia. In cats, we used a nail with a diameter the same as that of the marrow cavity. IIN has the advantage of better fixation over ordinary intramedullary fixation because the interlocking nail can resist bending force and the screws can resist force caused by rotation and crushing. Another advantage of IIN is its applicability for bones that are not straight. For instance, in a canine femur which is bent, a nail with a diameter slightly less than that of the marrow cavity could be used or the bone was fixed by inserting the nail toward the distal end of the femur. Thus, bones could be repaired with minimal disturbance of normal anatomy.

A 4 mm nail was used for animals weighing less than 5 kg, while a 6 mm one for animals weighing less than 15 kg. One screw was used on each fragment in animals of 2.9 to 4.2 kg and two screws in dogs weighing 8 to 14.5 kg with excellent results. Although the appropriate nail size and number of screws necessary for small animals has not yet been definitely determined [1], we feel that nails in this system can be used for animals weighing 15 kg or less and that two screws on each side are appropriate for relatively large animals unless additional external support is used.

Although IIN can be kept in place as long as there is no infection or damage, as true of other internal fixing procedures, we feel that it is better to remove it when the fracture has healed to avoid stress shielding. While one could be concerned about the difficulty in removing the nail from the holes, removal was accomplished smoothly and easily in the one case done at the owner’s request.

REFERENCES

Fig. 3. Radiographs of a dog with tibial fracture (case 5). A: pre-surgery, B: post-surgery, C: Two weeks post-surgery, D: One month post-surgery.