SHORT COMMUNICATION ijvs

Intramedullary interlocking nailing for diaphyseal fractures of humerus in dogs: a clinical study

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This study aimed to evaluate the effectiveness of intramedullary interlocking nailing in the stabilization of diaphyseal humeral fractures in eight dogs. Preoperative clinical, orthopaedic, and neurological examinations revealed poor functional limb use accompanied by neuropraxia in all cases. Fractures were classified based on radiographic evaluation, followed by surgical stabilization using the intramedullary interlocking nailing technique. Postoperative management included administration of analgesics and antibiotics, along with temporary limb immobilization using a modified Robert Jones bandage.

Postoperative assessment, based on clinical and radiographic findings, demonstrated excellent functional outcomes with improved range of motion in five dogs. Complications such as osteomyelitis, screw dislodgement, and implant breakage were observed in three cases; however, these did not significantly impair limb function. In conclusion, intramedullary interlocking nailing provided effective fracture stabilization and healing.

Keywords: Dog,Humerusfractures, Intramedullary Interlocking Nail, Neuropraxia, Osteomyelitis

Humeral fractures are classified as proximal, diaphyseal, and distal (Bardet *et al*., 1983). Due to the anatomical course of the radial nerve along the distal humerus, diaphyseal fractures frequently result in neuropraxia, which typically resolves after fracture stabilization (Tomlinson, 2003). Various surgical techniques are available for fixation of humeral fractures, among which intramedullary interlocking nails (IINs) provide stable fixation by resisting bending, rotational, and axial forces (Schrader, 1991). The present study was conducted to evaluate the efficacy of intramedullary interlocking nailing in the management of diaphyseal humeral fractures in eight dogs.

A detailed orthopaedic and neurological examination was performed on the day of presentation. The range of motion of the affected limb was assessed using a goniometer by measuring the degree of flexion and extension, and these values were later compared with postoperative findings following stabilization. Preoperative radiographic evaluation of the affected limb was carried out in standard craniocaudal and mediolateral views to determine the type and location of the fracture. Fractures were further classified according to the AO Vet alphanumerical morphological classification system (Unger *et al*., 1990).

Under general anaesthesia a standard craniolateral approach to the humerus (Piermattei and Johnson, 2004) was employed. A skin incision was made along the craniolateral border of the humerus, extending from the greater tubercle proximally to the lateral epicondyle distally. The subcutaneous tissue and brachial fascia were incised and separated. The approach was deepened through the brachial fascia, exposing the brachiocephalicus muscle proximally and the region over the cephalic vein distally.

The superficial pectoral and brachiocephalicus muscles were separated to visualize, isolate, and preserve the radial nerve. The brachialis and triceps muscles were retracted using a Gelpi retractor to expose the musculospiral groove of the humerus, to expose the proximal and mid-shaft regions of the humerus. Following exposure of both fracture fragments, a Steinmann pin of appropriate length and diameter mounted on a Jacob's chuck was inserted into the medullary cavity of the proximal fragment in a retrograde manner to create a pilot hole directed slightly caudomedially toward the distal aspect of the greater tubercle. The pin was advanced through the proximal fragment, after which fracture reduction was achieved by applying traction and gentle manipulation to align the fragments as close to their anatomical position as possible.

The fragments were stabilized using bone-holding forceps, and the pin was then advanced distally toward the medial condyle. Sequential reaming was performed using progressively larger Steinmann pins, up to 1 mm less than the selected interlocking nail diameter, in both proximal and distal fragments.

The selected interlocking nail was attached to the jig using a bolt secured with a wrench and introduced through the preformed pilot hole at the greater tubercle, advancing caudomedially into the distal fragment's medullary cavity. Interlocking holes were drilled through both cortices of the distal fragment using a pneumatic drill (AesculapInc, USA). The hole-depth was measured with a depth gauge, and proper

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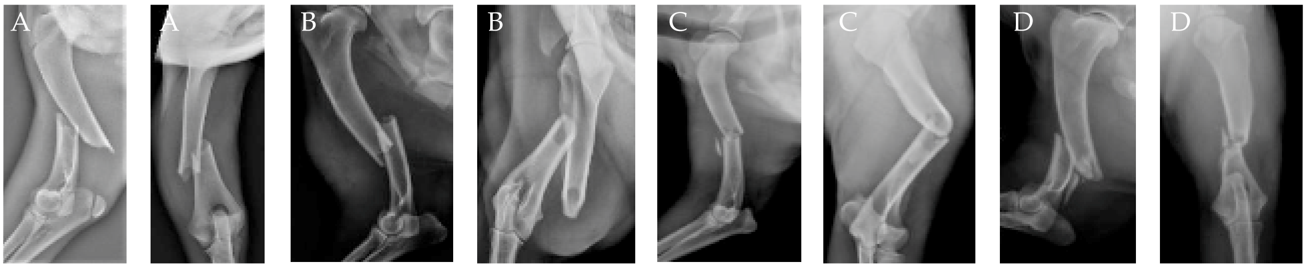

Fig. 1: (A) 12A2 Complete oblique diaphyseal fracture, (B) 12A3 Complete transverse diaphyseal fracture, (C) 12B1 Complete wedge diaphyseal fracture, and (D) 12B2 Multiple reducible diaphyseal fracture.

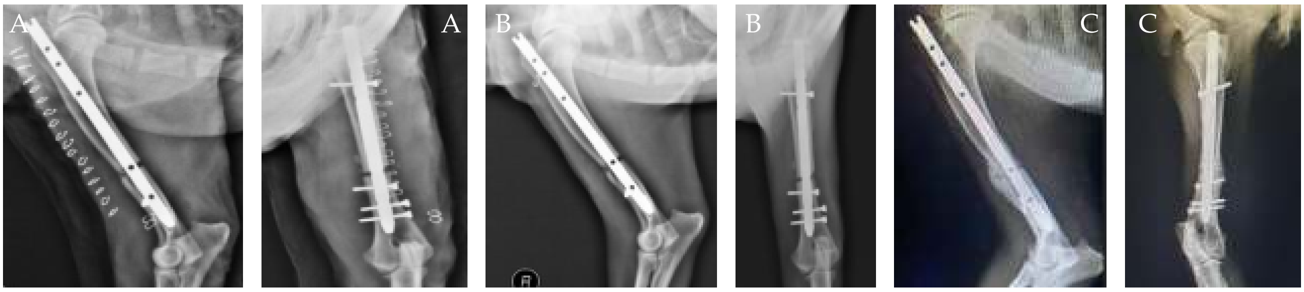

Fig. 2: (A) Immediate postoperative radiographs with IM ILN, (B) Day-30 showing homogenous bone callus, and (C) 60^{th} day showing radiographic union.

sized screws were inserted and tightened using a screwdriver through a drill sleeve. This procedure was repeated for both proximal and distal fragments, placing screws from lateral to medial direction to achieve stable fixation.

The superficial pectoral and brachiocephalicus muscles were apposed to the fascia using 2-0 polyglactin 910 (Vicryl®, Ethicon Inc.) in a simple interrupted pattern. The brachial fascia and subcutaneous tissues were closed separately using a simple continuous pattern. The caudal incision was closed by apposing the fascia of the flexor carpi ulnaris, ulnaris lateralis, and anconeus muscles. Additional simple interrupted sutures were placed proximally between the anconeus muscle and fascia using 2-0 polyglactin 910. Skin closure was performed using stainless steel staples.

Postoperatively, the limb was temporarily immobilized using a modified Robert Jones bandage. Antibiotic therapy with cefotaxime (20 mg/kg body weight, i.v.) was administered for 5-7 days, and meloxicam (0.2 mg/kg, s.c.) was given once daily for three days for analgesia. Postoperative evaluation was conducted through clinical and radiographic examinations, and any complications were recorded.

Clinical examination revealed concurrent injuries in two animals, namely a degloving injury (A2) and an elbow laceration (A4). Radiographic classification revealed that 50% (n=4) of dogs had complete transverse diaphyseal fractures (12A3), while 25% (n=2) exhibited multiple reducible wedge-type fractures (12B2) (Fig. 1). Complete oblique diaphyseal fractures (12A2) and complete wedge diaphyseal fractures (12B1) were each observed in 12% (n=1) of cases.

The mean length of the proximal fracture fragment was 10.8±0.5 cm (range: 8.4-12.9 cm), while the distal fragment measured 6.2±0.5 cm (range: 4.5-8.8 cm). The narrowest intramedullary radiographic diameter averaged 8.7±0.4 mm (range: 6.8-10.5 mm). Soft tissue damage was graded as moderate in 50% (n=4) and marked in the remaining 50% (n=4) of animals.

The extent of fragment overriding was slight in 37% (n=3), moderate in 25% (n=2), and marked in 38% (n=3) of cases. The length of the interlocking nail implant ranged from 12 to 18 cm, with a mean of 14.00±0.65 cm, while the implant diameter ranged from 5 to 10 mm (mean: 7.50±0.50 mm). The ratio of implant diameter (7.50±0.50 mm) to the narrowest medullary cavity diameter (8.71±0.41 mm) was 0.86±0.03.

Radiographic evaluation demonstrated homogeneous callus formation and progression to union in seven animals, with one exception (A5), up to 60 days postoperatively (Fig. 2). The grading system adapted from Hammer *et al.* (1985) was used to assess radiographic healing.

A significant improvement in the range of motion was observed, increasing from 98.25 ± 5.17^0 preoperatively to 116.87 ± 4.85^0 postoperatively. By 30 days post-surgery, five animals exhibited excellent limb usage without any signs of lameness. In Labrador Retrievers, the normal elbow joint range of motion is approximately 130°, with flexion around 36° and extension up to 165° (Langley-Hobbs, 2012). This comparison provides insight into the functional recovery achieved following surgical management of diaphyseal fractures.

Proprioceptive reflexes returned within 2 to 15 days (mean: 4.2±1.5 days), while initial weight bearing was observed within 2 to 15 days (mean: 4.8±1.5 days).

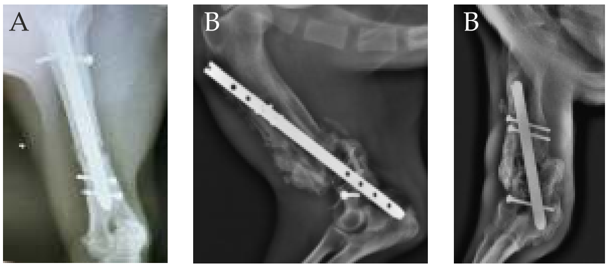

Fig. 3: Radiographs showing screw breakage (A), and osteomyelitis (B).

Functional usage of the affected limb was classified as poor in 50% (n=4) and good in 50% (n=4) of the animals. Between 15 and 20 days postoperatively, poor limb usage was observed in 12% (n=1), fair in 25% (n=2), good in 50% (n=4), and excellent in 13% (n=1) of the animals. By 25 to 30 days postoperatively, 63% (n=5) of the animals exhibited excellent limb function, while 12% (n=1) showed good limb usage, 12% (n=1) demonstrated fair limb usage, and 12% (n=1) continued to have poor limb usage.

Raghunath and Singh (2002) reported early weight bearing as early as on the third postoperative day and complete functional recovery by the 10th postoperative day in animals treated with interlocking nails. The early return to functional weight bearing observed in the present study may be attributed to the load-bearing properties of the implant.

Complications were observed in three animals during the convalescent period, including screw breakage (A3), osteomyelitis (A5) (Fig. 3), and screw dislodgement (A8). In one case (A5), the implant was subsequently removed due to poor functional outcome and persistent pain associated with osteomyelitis. Moses *et al.* (2002) similarly reported a low incidence of osteomyelitis in humeral fractures treated with interlocking nails. Hortsman and Beale (2002) and Reems *et al.* (2006) identified locking screw failure as a common complication, which is consistent with the findings of the present study. Despite the occurrence of complications, the majority of animals (n=5) achieved excellent functional limb usage, with the exception of the case affected by osteomyelitis (A5).

From the results of the present study, it can be concluded that the intramedullary interlocking nailing technique is an effective treatment modality for managing diaphyseal fractures of the humerus in dogs.

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