

Fixation of lumbar vertebral fracture-luxation using spinal stapling and tension band wiring in young companion animals

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Segmental spinal fixation for lumbar spinal injuries was performed in three young companion animals (rabbit, dog, and cat) presented with traumatic posterior limb paralysis. Neurological and radiographic examinations confirmed lumbar vertebral fracture-luxation at L1-L2 (cat), L2-L3 (dog), and L3-L4 (rabbit). Under general anaesthesia, fractures were reduced and stabilized using tension band wiring (dog and cat) and K-wire spinal stapling. K-wires were placed through the base of spinous processes and secured with orthopaedic wires to provide segmental stabilization. Nociception improved within 24 hr in the dog and rabbit. However, the dog and cat later died due to surgical site infection. The rabbit showed improved reflexes and general health but remained paraplegic.

Keywords: Cat, Dog, Rabbit, Spinal stapling, Tension band wire, Vertebral fracture

A variety of techniques have been employed to stabilize vertebral fractures and luxations in small animals, including external splinting, spinal stapling, modified segmental spinal instrumentation, spinous process plating, vertebral body plating, spinal process plating combined with a Kirschner-Ehmer apparatus, composite fixation using pins or screws with polymethyl methacrylate, and external skeletal fixation (Voss and Montavon, 2004; McCullough *et al.*, 2012). The present report describes the outcomes of lumbar vertebral fracture-luxation fixation using spinal stapling and tension band wiring in three young companion animals: a dog, a cat, and a rabbit.

Three young companion animals (a cat, a dog, and a rabbit) were presented with a history of traumatic injury 2-4 days prior, caused by dog bites (cat and rabbit) and an automobile accident (dog). All animals exhibited hind limb paralysis with dragging and urinary and faecal incontinence (except the cat). On clinical examination, all animals were paraplegic but generally alert (except the cat). Additional injuries included bilateral tibial fractures and a cruciate ligament injury in the cat, and a skin avulsion wound over the right lateral chest in the dog. Palpation of the lumbar region revealed pain, swelling, asymmetry, and instability in all cases. Neurological examination showed absence of superficial nociception in all animals, while deep nociception was present in the

dog and rabbit but absent in the cat. Spinal reflexes (patellar, perineal, withdrawal, and cutaneous trunci) varied among cases, with the rabbit retaining most hind limb reflexes (Table 1). Radiographic evaluation (lateral and ventrodorsal views) confirmed lumbar vertebral fracture-luxation at L1-L2 (cat), L2-L3 (dog), and L3-L4 (rabbit).

Internal fixation using modified spinal stapling and tension band wiring was undertaken in all the animals. All the animals were fasted for 6 hr prior to surgery. The surgical site, extending from the thoracic to sacral region along with bilateral thoracic and flank areas, was aseptically prepared by shaving, scrubbing, and application of povidone iodine. Surgery was performed under general anaesthesia. The dog was premedicated with atropine sulphate (0.04 mg/kg body weight, s.c.) and xylazine (1.0 mg/kg, i.m.), followed by anaesthetic induction with ketamine (5 mg/kg, i.v.); the cat and rabbit were induced using midazolam (0.5 mg/kg, i.m.) and ketamine (15 mg/kg, i.m.). In all animals anaesthesia was maintained with 1-2% isoflurane in 100% oxygen.

Anaesthetized animals were positioned in sternal recumbency with the forelimbs extended cranially and hind limbs caudally, secured to the operating table using bandages. A wide cotton pad was placed beneath the abdomen to maintain an upright posture and facilitate intraoperative vertebral reduction by allowing controlled extension of the spine. The prepared surgical field was aseptically draped, exposing the incision site.

A dorsal midline skin incision was made extending three vertebrae cranial and caudal to the lesion (Fig. 1A). The dorsal fascia was incised bilaterally adjacent to the spinous processes while preserving the supraspinous and interspinous ligaments. The epaxial muscles were elevated from the dorsal lamina using a periosteal elevator, keeping the attachments to the mammillary and accessory processes intact, and retracted using a self-retaining Gelpi retractor.

For spinal stapling, a smooth-ended K-wire (1.0 mm in rabbit, 1.5 mm in cat, and 2.0 mm in dog) was passed laterally through the base of the spinous process caudal to the affected segment (L4 in cat, L5 in dog, and L6 in rabbit). The K-wire was then bent into a

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Table 1: Neurological examination findings in the affected cases.

Animal	Withdrawal (flexor reflex)	Patellar reflex	Perianal reflex	Cutaneous trunci (Panniculus reflex)	Nociception		Radiological diagnosis
					Superficial nociception	Deep nociception	
Cat	Absent	Absent	Normal	Absent	Absent	Absent	L1-L2 fracture and luxation
Dog	Reduced	Absent	Normal	Normal	Absent	Present	L2-L3 fracture and luxation
Rabbit	Normal	Normal	Normal	Normal	Absent	Present	L3-L4 fracture and luxation

U-shape and positioned bilaterally along the dorsal lamina within the groove between the spinous and articular processes, spanning six to eight vertebrae.

Fracture/luxation reduction was achieved using cranio-caudal manual traction (in cat and rabbit) or with Allis tissue forceps applied to adjacent spinous processes (in dog). Following confirmation of proper alignment, reduction was maintained using tension band wiring across the spinous processes in the dog and cat. In the rabbit, due to spinous process fracture during manipulation, stabilization was achieved using a 24 G hypodermic needle passed through the articular processes. The cranial arms of the U-shaped K-wire were secured within the groove using 24 G orthopaedic wire passed through the spinous processes (one cranial fixation in cat and dog; additional cranial and caudal fixation in rabbit). In the dog and cat, the K-wire arms were incorporated into the tension band construct (Fig. 1B). Excess wire ends were trimmed and the cut end was bent along the bone surface. Following spinal stabilization, the wound was closed routinely without saline flushing. Epaxial muscles were sutured in the first layer, followed by subcutaneous and skin closure.

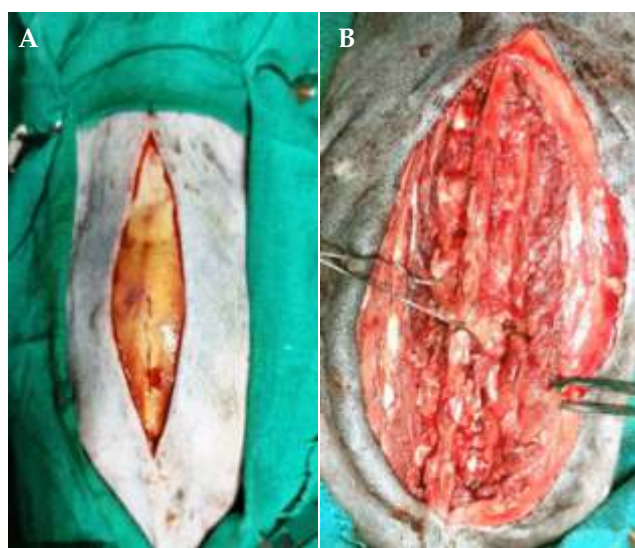


Fig. 1: Vertebral column midline surgical incision (A); reduction and stabilization with help of tension band wiring with 24 G orthopaedic wire (B).

Postoperatively, external support was provided using thoracoabdominal bandaging reinforced with a dorsal cardboard splint extending along the thoracolumbar region. Immediate postoperative radiographs were obtained in all cases to evaluate spinal reduction and implant positioning. Postoperative medication included antibiotics (ceftriaxone 22 mg/kg, i.m. in dog and cat; cefpodoxime 5 mg/kg, i.m. in rabbit), analgesic (tramadol 2 mg/kg, orally), and corticosteroid therapy (prednisolone 0.4 mg/kg, orally), in tapering doses. Supportive therapy comprised Ca²⁺ channel blocker (pregabalin, 4 mg/kg, orally) for neuropathic pain, vitamin B-complex, and multimineral supplementation, administered for variable durations depending on survival period. Strict cage rest was advised during the acute phase to facilitate healing and prevent further injury, followed by physiotherapy to improve mobility and functional recovery. Short-term follow-up examinations were conducted one week postoperatively.

In the present study, stainless steel K-wires, applied as spinal staples, effectively resisted ventral bending forces, thereby limiting flexion and extension (Voss and Montavon, 2004). Although screws or pins are commonly recommended for stabilizing larger vertebral bodies, their use was not feasible in these young animals. The U-shaped K-wire, when appropriately positioned, primarily functions as a lateral splint along the dorsal aspect of the spinal column. It can assist in achieving and maintaining fracture reduction while still permitting a limited degree of motion in accordance with normal spinal movements (Voss and Montavon, 2004). Rotational stability of the vertebral column is largely dependent on the integrity of the annulus fibrosus and the articular facets (McKee, 1990; Wheeler and Sharp, 2000). In the present cases, the application of the tension band wiring technique contributed additional rotational stability to the dorsal compartment. Furthermore, the quantity and strength of the surrounding soft tissues play a crucial role in maintaining spinal stability following vertebral fracture or luxation.

In the rabbit, drilling into the spinous process for K-wire placement in the lumbar vertebrae was more challenging than in the dog or cat due to the smaller

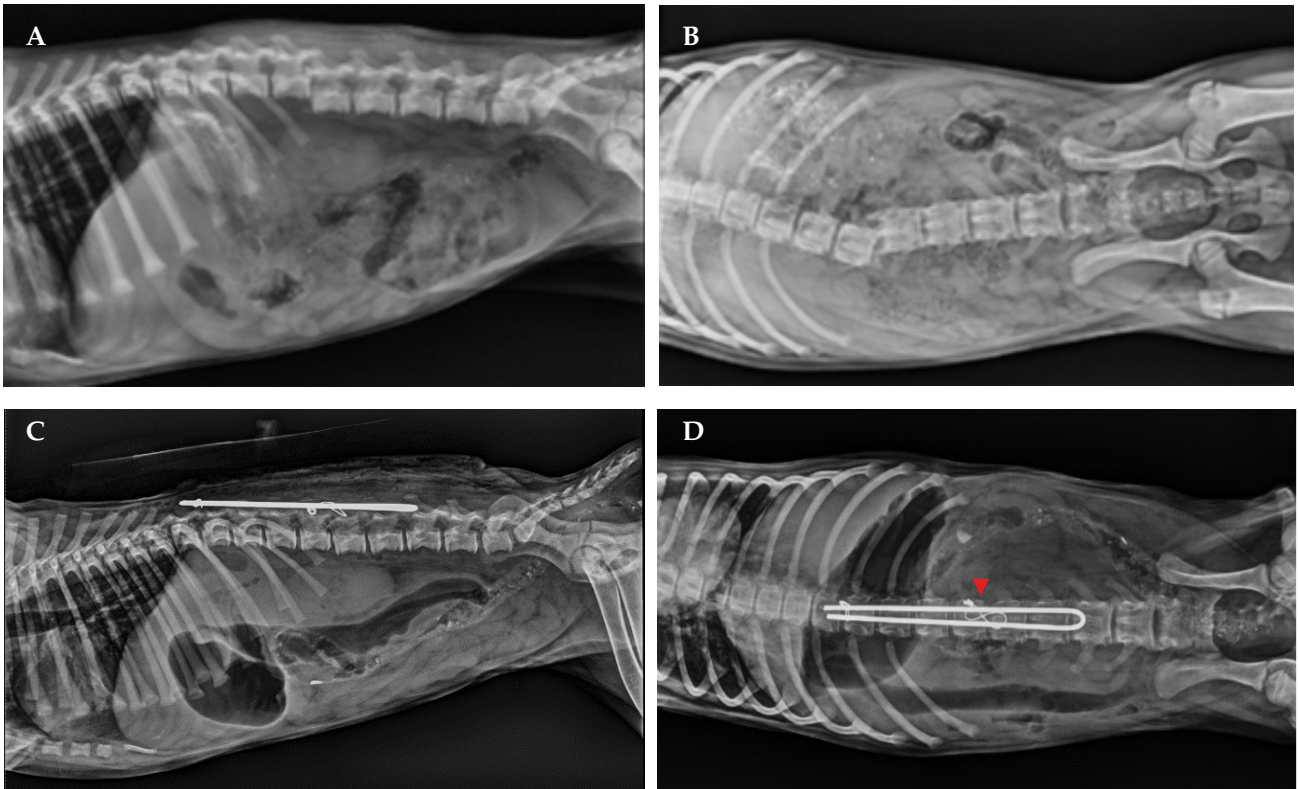


Fig. 2: Preoperative lateral (A) and ventro-dorsal (B) radiographic projections in the demonstrate fracture and luxation of the L2-L3 joint; postoperative lateral (C) and ventro-dorsal (D) viewsshowing stabilization with tension band wiring and spinal stapling technique. Notice the reduction and alignment achieved in the fractured vertebral segments (red arrow).

size and brittle nature of the bone. Tension band wiring could not be performed because of tearing of the spinous process during wire application. Although rabbits possess a Haversian bone structure, their cortical bone is thinner than that of dogs or cats, contributing to poorer surgical outcomes (McCullough *et al.*, 2012). Nevertheless, surgical fixation was attempted due to fracture instability and the risk of further displacement and spinal cord injury.

Immediate postoperative radiographs confirmed successful reduction and satisfactory alignment in the cat and dog (Fig. 2C, 2D). However, in the rabbit, proper anatomical alignment was not achieved, likely due to the severity of the fracture and the inherent fragility of the bones.

During the first postoperative week, the rabbit and dog showed slight improvement in patellar, perineal (anal), and cutaneous trunci (panniculus) reflexes, as well as nociception. In contrast, the cat exhibited no neurological recovery. The dog died in the first postoperative week due to unknown causes, while the cat died in the second week following purulent surgical site infection. In the rabbit, physiotherapy consisting of hind limb massage and passive flexion-extension exercises (10 min, twice daily) helped prevent muscle atrophy and maintain joint mobility, consistent with previous reports (Bagley *et al.*, 2000). At long-term follow-up, the rabbit remained paraplegic but did not exhibit signs of severe vertebral pain.

The study suggests that tension band wiring is a feasible technique for vertebral stabilization, but its application should be tailored to the strength and quality of the bone.

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