Scientific Works. Series C. Veterinary Medicine. Vol. LXX (1), 2024
ISSN 2065-1295; ISSN 2343-9394 (CD-ROM); ISSN 2067-3663 (Online); ISSN-L 2065-1295

THE USE OF EXTERNAL FIXATORS FOR THE REPAIR OF SEVERELY COMMINUTED BILATERAL FEMORAL FRACTURES IN A FELINE PATIENT - SINGLE CASE STUDY

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Abstract

Purpose: This article reports the outcome result of a single case study following the use of external fixators to stabilize bilateral comminuted femoral fractures in a cat.
Methods: The full history regarding signalment, radiographic evaluation and postoperative care were included in this article. The patient was regularly monitored with regards to time till onset of weight-bearing, callus formation, joint range of motion, pin site infection and implant reaction, implant stability and loosening-up. The patient obtained good functional recovery with full range of motion.
Conclusions: External skeletal fixators, offer an efficient repair method for severely comminuted femoral fractures in feline patients, obtaining early weight bearing and callus formation, with unimpeded mobility and range of motion.

Key words*: biological fixation, callus, comminuted fracture, diaphyseal femoral fracture, feline external skeletal fixator.*

INTRODUCTION

The use of external fixators in human orthopaedics was first reported in 1897 while a veterinary external fixator was designed by Ehmer in the late 1940s. In its early beginning, this method was associated with frequent complications such as pin tract infection and malunion and lost interest in favor to plates and screws later on (Butterworth, 1993).
Surgical management of diaphyseal fractures in felines can be challenging due to the implant size and strength limitations when approaching smaller feline bones while trying to avoid important neurovascular structures (Zurita et al., 2022).
External fixation has evolved nowadays establishing an appropriate patient specific surgical methodology with optimum pin placement sites for feline limbs for which canine anatomy is often nonapplicable (Prackova et al., 2022).
Usually, external fixation is considered ideal for fracture below the elbow and stifle. Nonetheless when used for above these joints, efficient stabilization may be obtained as well by using an intramedullary pin which will increase resistance to bending forces at the fracture site (Corr, 2012).

MATERIALS AND METHODS

A male feline, European common breed, aged 1 year and weighing 3 kg, was presented for difficulty in using its hind limbs, after being absent from the owners' yard. Owner believed it might have been hit by a car a couple of days prior to admission in the clinic.
On clinical examination, both hindlimbs had pain on palpation, edema, ecchymosis, no open wounds and crepitus on manipulation of the thigh region. The rest of the examination did not reveal other pathologies: TRC<2sec; T=39°C; pale pink moist mucous membranes; mobile, painless palpable lymph nodes; rhythmic heart and vesicular murmur on auscultation; supple abdomen without discomfort on palpation. The patient was bright and alert with unaltered sensation and reflexes.
Biochemical and hematological investigations did not reveal any notable changes (Tables 1 and 2)
Ultrasound and radiological examination of the thorax and abdomen showed no abnormal findings, raising no other concerns.
The radiological examination of the hind limbs revealed the presence of bilateral comminuted diaphyseal femoral fractures and an incomplete

longitudinal fracture involving the proximal femoral fragment of the Right Hind Limb (Figure 1). Such fractures usually result from high velocity trauma so we suspected road traffic accident or high-rise syndrome (Zurita et al., 2022).

Table 1. Biochemistry blood wok

Test	Result	Reference values	Measure unit
ALB	2.2	2.1-3.3	g/dL
TB	<0.06	0.00-0.30	mg/dL
GGT	3	0-5	U/L
ALT	48	0-112	U/L
ALP	90	0-115	U/L
Crea	0.9	1.1-2.0	mg/dL
TC	112.94	70.00-150.00	mg/dL
GLU	137.45	65.00-146.00	mg/dL
Ca	8.66	8.50-10.00	mg/dL
Phos	3.2	3.70-5.60	mg/dL
Bun	15.17	14.00-26.00	mg/dL

Table 2. Haematology blood work

Test	Value	Unit	Reference range
WBC	16.7	10’/mm^3	5.0-11.0
LYM%	11.8	%	0.0
MON%	1.1	%	0.0
GRA%	87.1	%	0.0-100.0
(EOS%)	1.4	%	00-100.0
LYM#	1.90	10’/mm^3	1.00-4.00
MON#	0.10	10’/mm^3	0.0-0.50
GRA#	14.70	10^3/mm^3	3.00-12.00
EOS#	0.23	10^3/mm^3	0.00-0.60
RBC	6.67	10^b/mm^3	5.00-10.00
HGB	10.0	g/dl	8.0-17.0
HCT	32.2	%	27-47
MCV	48	µm^3	40-55
MCH	15.0	pg	13.0-17.0
MCHC	31.1	g/dl	31.0-36.0
RDW	16.7	%	17.0-22.0
PLT	265	10^3/mm^3	180-430
MPV	11.4	µm^3	6.5-15

The patient was hospitalized for 24 hours prior to surgery. Buprenorfine 20 µg/kg and Meloxicam 0.2 mg/kg were given for pain management while maintained on fluids with Ringer solution at a rate 50 ml/kg/24 hours. Acepromazine 0.01 mg/kg + Buprenorphine 0.02 mg/kg was used for premedication. Induction was done with Propofol 3 mg/kg and maintenance with Isoflurane and oxygen. The patient was positioned in lateral decubitus, clipped and scrubbed with 4% chlorhexidine solution.

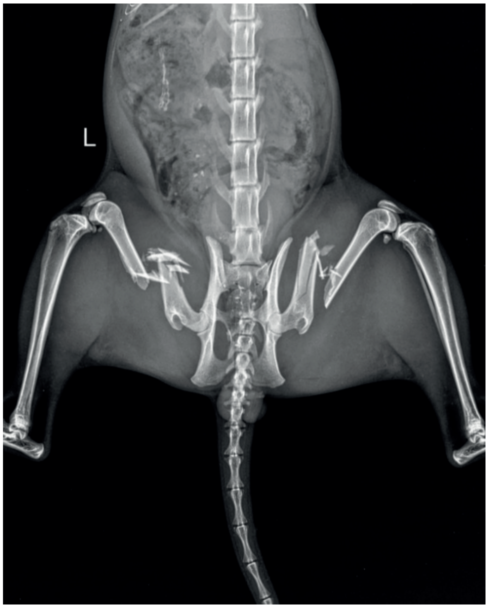

Figure 1. Initial radiological findings

Due to the severe comminuting aspect and the impossibility of obtaining an anatomic repair, it was decided to obtain stabilization using a system of “Tie-in” type external fixators.

The right hind limb was approached first through a lateral skin incision along the craniolateral region of the thigh. The Fascia Latta was then incised outlining the cranial edge of the *Biceps femoris*, the exposure of the diaphysis and the fracture site being achieved by caudal retraction of the *Biceps femoris* and cranial retraction of the *Vastus lateralis* muscle (Johnson et al., 2005).

After identifying the sciatic nerve, the proximal fragment was stabilized using two cerclage wires. While holding the hip extended and the femur adducted a Kirschner pin with a diameter of 2 mm and a length of 310 mm was inserted in a retrograde manner through the centro medullary canal perforating the trochanteric fossa, withdrawn to the edge of the fracture area and then inserted through the length of the entire femur after aligning the two fragments (DeCamp et al., 2016). A pin of the same length was used to assess the positioning of the implant in the distal fragment. The anatomical planes were repaired with PDS 2/0 absorbable monofilament suture material.

A total of 4 incisions of approx. 5 mm, 2 incisions proximal and 2 incisions distal to the fracture site for the lateral fixation of 4 Kirschner pins with a diameter of 1.6 mm. A 21G needle was previously used to puncture the soft tissues up to the level of the compact to avoid accidental injury to the neurovascular structures. A smaller 1.4 mm pin was used to engage at the most distal portion of the left hind limb for bone safety considerations. The pins were inserted using a rotational speed of 800 RPM at a sharp angle of roughly 70° (although it was not possible for all the pins in order to properly construct the apparatus) to the bone surface perforating both compacts while an assistant helped maintain a right angle between the greater trochanter and the patella (Piermattei et al., 2006). The free portion of the centro-medullary pin was bent at an angle of approx. 90° from the initial vertical plane and then bent once more at an angle of approx. 90° to the previously obtained horizontal plane and connected to the side pins using cerclage wire. After assessing the bone alignment and mobility of the knee and pelvis, the external connection pin was covered with epoxy putty material ensuring a distance of approx. 2cm from the skin surface (Scott et al., 2022) The left hind limb was approached and stabilized in a similar fashion (Figure 2).

Figure 2. Radiological presentation after stabilization of the fragments with external fixators and epoxy putty

The checkup radiological examination confirmed a good alignment of the bone fragments. The patient began to bear weight immediately postoperatively and was discharged after 3 more days of hospitalization. While being under medical supervision it received Ceftriaxone 20 mg/kg/12 hours, Meloxicam 0.1 mg/kg/24 hours. It was only in the first 24 hours that contiuous rate infusion was given at a rate of 50 ml/kg/24 hours with Ringer solution and a suplement of Buprenorfine 10 μg/kg every 8 hours for better pain management. Treatment at home consisted of: Amoxicillin + Clavulanic acid (50 mg+12.5 mg)/12 h - 10 days; Robenacoxib 6 mg/24 h - 5 days; Iodine for the daily sanitization of components in contact with the skin. The patient returned for regular weekly check-ups.

Figure 3. Post-operative radiological appearance at 6 weeks

After 6 weeks, the radiological examination confirmed callus viability, which allowed for the removal of the implant (Figure 3). The pins were cut near the junction with the epoxy putty material and then mobilized by gentle left-right rotation movements.

RESULTS AND DISCUSSIONS

After the removal of the implant, both hind limbs could take over and support the patient's weight, moving effortlessly. No changes were observed in terms of joint range of motion.

Although the resulting callus obviously exceeds the normal bone silhouette with the inclusion of several fragments (Figure 3), the patient did not exhibit discomfort on palpation or manipulation. The viability period of the implant depends on the loosening-up phenomenon, which involves the decrease of the contact surface between the bone tissue and the implant material, thus reducing its stability. This period can be extended by various methods such as the use of threaded pins, the complete perforation of both cortices and/or the application of hydroxyapatite on the contact surface of the implant with the bone (Fossum et al., 2018).

In the presented case, threadless Kirschner pins were used employing both cortices at a sharp angle to prolong the life of the implant and delay the loosening-up phenomenon (Piermattei et al., 2006)

Only ventro-dorsal exposures we're performed throughout the study as it was the best option to properly evaluate the healing process without the epoxy putty overlapping the femur.

On initial radiographic exposure the hind limbs we're not extended because of concerns about further injuring soft tissues and other neuro-vascular structures.

On the first postoperative radiological image (Figure 2), we could already observe some bending of the smaller size pin.

On the 6th week postoperative radiological image, we've decided to flex and abduct the right hind limb as to obtain a ventro-lateral exposure to better evaluate the cerclage repair used for the right femur (Figure 3). It's evident the left femoral external fixator, although retaining some bone contact, the smaller pin lost bone depth and migrated towards the lateral cortex losing stability because of its reduced stiffness.

CONCLUSIONS

It is generally recommended that a minimum of two pins must engage each fragment and an optimum of three to four pins for each may be used obtaining considerable stress reduction at the pin-bone site (Scott et al., 2022; Johnson et al., 2005). For this particular case only two pins were used for each fragment furthermore an intramedullary pin was added for better bending and compression support achieving an approximate normal bone length and alignment. This option also allowed for better pin stability as nonthreaded pins confer less retention force while at the same time cause less trans-cortical chip fractures compared to threaded pins (Anderson et al., 1993)

Epoxy putty once hardened makes it difficult for further adjustments and may require additional surgery if the device proves unstable after initial stabilization or during the patient's recovery.

Although this method of fracture reduction is not usually the first choice when it comes to excessively active patients, older or obese patients, and does require high owner compliance, it is up to each surgeon to properly assess each individual case as preoperative planning is key to obtaining the best possible outcome for each individual patient.

The main goal in orthopaedic surgery is to obtain early ambulation and optimum limb function. External fixators are a versatile reduction method offering surgeons numerous flexible options for the repair of long bone fractures. The device's frame can be modified and adapted so that it can effectively take over the mechanical forces of compression, tension, torsion, shear and bending involved for weight-bearing and natural movement.

We can thus recommend this as a viable and efficient method especially for the stabilization of feline femoral fractures with minimum to severe comminution, where an anatomical repair is not possible and a biological/functional repair is required instead.

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