



## Intramedullary locking nail elastic osteosynthesis in a cat femoral proximal fracture – case report

Page 1 a 7

[*Osteossíntese elástica com haste intramedular bloqueada em fratura proximal de fêmur em felino – relato de caso*]

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### ABSTRACT

Intramedullary nails are the focus of scientific studies in small animal orthopedic surgery because the use of these materials in fractures of immature, small-sized patients, and in proximal bone regions is challenging. In this context, elastic osteosynthesis has been strongly advocated for the treatment of patients under four months of age. Therefore, the objective of this study was to report two cases of non-exposed complete fractures of proximal femurs in felines, resulting from trauma, both patients under six months of age, treated with the elastic technique using a locked intramedullary nail. Both cases were treated through a surgical approach to the fracture site using the "open, but don't touch" method. In both cases, the bone consolidation process occurred in less than 60 days, along with satisfactory and early patient ambulation. Given the advocated osteosynthesis technique in the two patients and the promising results obtained, it is admitted that the use of locked intramedullary nails is a viable alternative for the treatment of proximal bone fractures in young felines.

Keywords: bone consolidation, diaphyseal fracture, cats, orthopedic implant

### RESUMO

As hastas intramedulares são foco de estudos científicos na cirurgia ortopédica de pequenos animais, pois o uso desses materiais em fraturas de pacientes imaturos, de porte pequeno e em regiões ósseas proximais é desafiador. Nesse contexto, a osteossíntese elástica vem sendo fortemente defendida no tratamento de pacientes com menos de quatro meses de idade. Assim, o objetivo do presente trabalho foi relatar dois casos de fraturas completas de fêmures proximais em felinos, não expostas, decorrentes de traumatismos, ambos pacientes com idade inferior a seis meses, tratados com a técnica elástica utilizando haste intramedular bloqueada. Os dois casos foram tratados por meio de abordagem cirúrgica ao foco de fratura, pelo método "abra, mas não toque". Em ambos os casos, o processo de consolidação óssea ocorreu com tempo inferior a 60 dias, assim como a deambulação satisfatória e precoce dos pacientes. Diante da técnica de osteossíntese preconizada nos dois pacientes e dos resultados promissores obtidos, admite-se que a utilização da haste intramedular bloqueada é alternativa viável para o tratamento de fraturas ósseas proximais em felinos jovens.

Palavras-chave: consolidação óssea, fratura diafisária, gatos, implante ortopédico

### INTRODUCTION

The use of isolated orthopedic plates or double plates, combined with intramedullary pin and locked intramedullary nails, are options for internal stabilization of femoral fractures in

felines, aiming for effective bone consolidation and early return to ambulation (Piermattei and Flo, 1999; Beale, 2004; Freitas *et al.*, 2013).

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In young animals, the surgical treatment of diaphyseal fractures of long bones should consider the specificities of bone growth, ensuring proper alignment and apposition of bone fragments, while avoiding iatrogenic damage to the growth plates (Moses *et al.*, 2002), as well as preserving the periosteum (Beale, 2004; Horstman *et al.*, 2004).

In this scenario, elastic osteosynthesis has been strongly recommended for the treatment of diaphyseal fractures of long bones in patients under four months of age (Sarrau *et al.*, 2007), advocating the concepts of biological osteosynthesis, such as minimal manipulation of bone fragments, avoiding damage to muscular, vascular, and neurological integrity, and the osteogenic potential provided by the initial fracture hematoma, aiming to accelerate hypertrophic callus formation (Beale, 2004; Schmaedecke *et al.*, 2005). Thus, the locked intramedullary nail provides the necessary characteristics for the principles of biological osteosynthesis, utilizing the concepts of minimal damage to the fracture environment, promoting anatomical alignment and relative stability for bone consolidation (Moses *et al.*, 2002; Horstman *et al.*, 2004; Shani *et al.*, 2015).

Considering the aforementioned advantages, the aim of this study was to report femoral osteosynthesis (diaphyseal fractures) in two young feline kittens using the elastic technique with locked intramedullary nails.

### CASES REPORT

A female feline patient, four months old, mixed breed, weighing 1.7 kg, presented to the Small Animal Surgery department of the School of Agricultural and Veterinary Sciences (Jaboticabal) with a history of functional impairment of the left pelvic appendicular limb due to a motor vehicle accident. A female cat, four and a half months old, mixed breed, weighing 1.9 kg, with a similar medical history and orthopedic condition, was also attended to at the Veterinary Hospital of Universidade Brasil (UB - Fernandópolis). The cat presented with lameness of the same limb and antimer following a fall.

During the orthopedic examination, instability and tenderness on palpation of the mentioned limbs were observed. Radiographic examinations

were performed, which indicated in the first case a complete, short oblique, non-exposed fracture in the proximal diaphysis of the left femur (Fig. 1A), and in the second patient, a complete, comminuted, non-exposed fracture in the proximal diaphysis of the left femur (Fig. 2A and 2B).

After radiographic evaluations of the fractures, elastic osteosynthesis with locked intramedullary nails was chosen in both cases. The surgical planning for the first case was performed using digital radiography, measuring the diameter and length of the contralateral femur (Fig. 1B); a 4 mm diameter and 70 mm length intramedullary nail were selected. In the second case, a digital template was used to template the diameter and length of the nail and respective locking implants, based on the contralateral limb; a 3.5 mm diameter and 100 mm length nail were selected (Fig. 2C and 2D).

Both cases were treated through a surgical approach to the fracture site using the "open, but don't touch" technique (Beale 2004, Schmaedecke *et al.*, 2005); thus, the proximal bone fragments were immobilized using a bone reduction forceps for micro fragments, and perforations were made in them using drills compatible with the dimensions of the used nails, creating the openings of the medullary channels for the insertion of the intramedullary nails into the proximal bone fragments.

The distal portions of the limbs in both cases were distracted and realigned using traction with bone forceps fixed near the knees, restoring the anatomical lengths. Then, the intramedullary nails were introduced in a normograde proximal manner, reducing fractures. In the first case, 2 mm diameter screws were placed with the aid of an external guide, while in the second case, 1.5 mm pins were fixed to the bone, replacing the screws.

The radiographic examinations of the immediate postoperative period showed anatomical alignments of the left femurs, apposition of the bone fragments, correct positioning of the intramedullary nails and fixation of only one of the holes of the nails in the proximal fragments of the implants with screw and pin, respectively and, two holes in the distal ones (screws and pins, respectively) (Fig. 1C, 2E and 2F).

### *Intramedullary locking...*

In the first case, on the 15th day postoperatively, the patient demonstrated intermittent claudication of the left pelvic limb, but no sensitivity to palpation or mobility at the fracture site; the radiographic examination at this time revealed the formation of exuberant bone callus (Fig. 1D). In the second case, the patient was reassessed on the 15th and 21st days postoperatively, demonstrating satisfactory ambulation throughout the entire treatment.

At 35 days postoperatively, the radiographic examination of the first case showed consolidation of the left femur, with signs of bone remodeling (Fig. 1E). In the second case, the radiographic study was conducted on the 37th day postoperatively, revealing bone consolidation, with evident absence of the fracture line and moderate formation of bone callus (Fig. 2G and 2H).

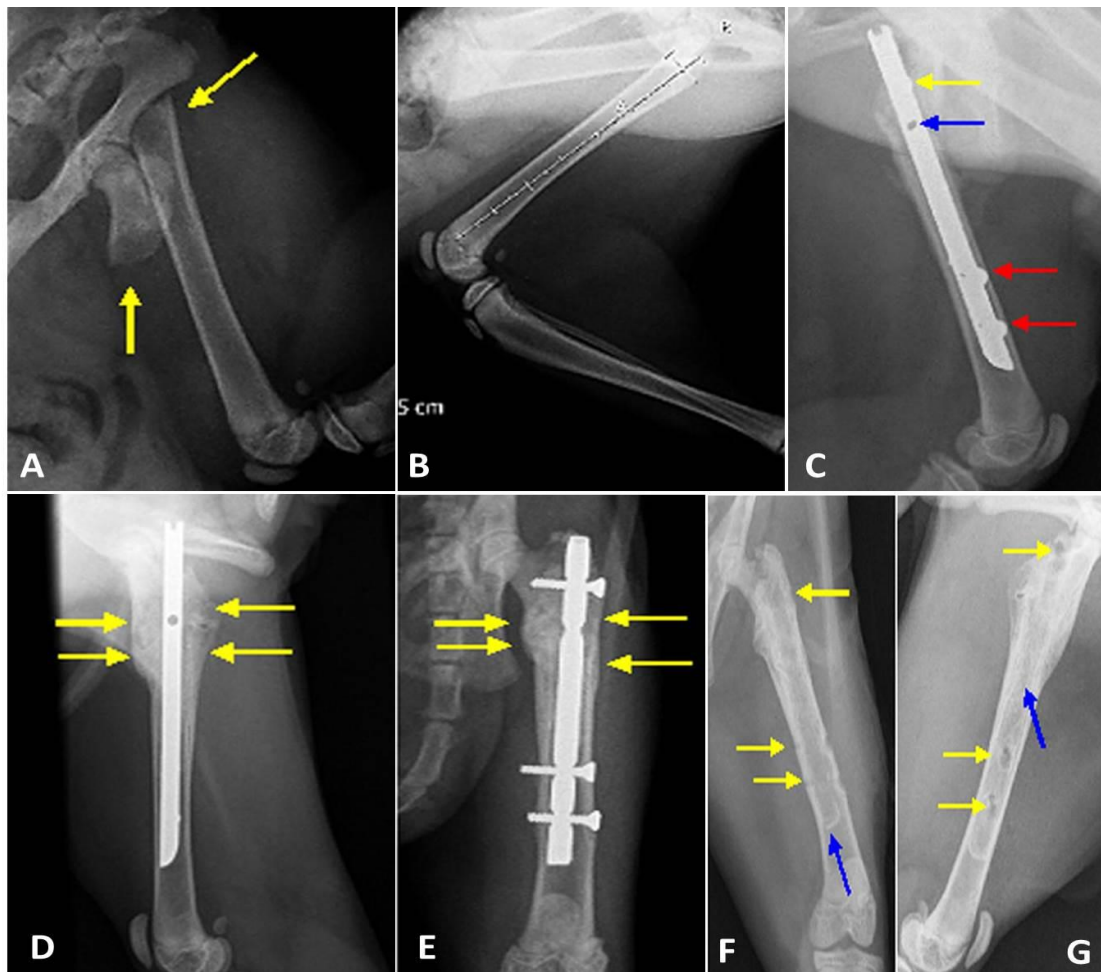


Figure 1. Radiographic images of the left and right femurs of a young feline (four months old). **A**: complete, closed, short oblique fracture of the proximal diaphysis of the left femur (arrows). **B**: right femur used for measurement of length and diameter of the medullary canal (isthmus). **C**: immediate postoperative image of osteosynthesis of the left femur with a blocked intramedullary nail, using one proximal locking orthopedic screw (yellow arrow), absence of the other proximal locking screw (blue arrow), and presence of two distal locking screws (red arrows); note considerable bone alignment, with apposition of the fractured fragments. **D**: radiographic image at 15 days postoperative, showing the presence of exuberant bone callus in the left femur (yellow arrows). **E**: bone consolidation of the left femur fracture, with signs of remodeling (yellow arrows) at 35 days postoperative. **F** and **G**: images after the removal of orthopedic implants, showing the absence of orthopedic locking screws (yellow arrows) and the intramedullary nail (blue arrows).

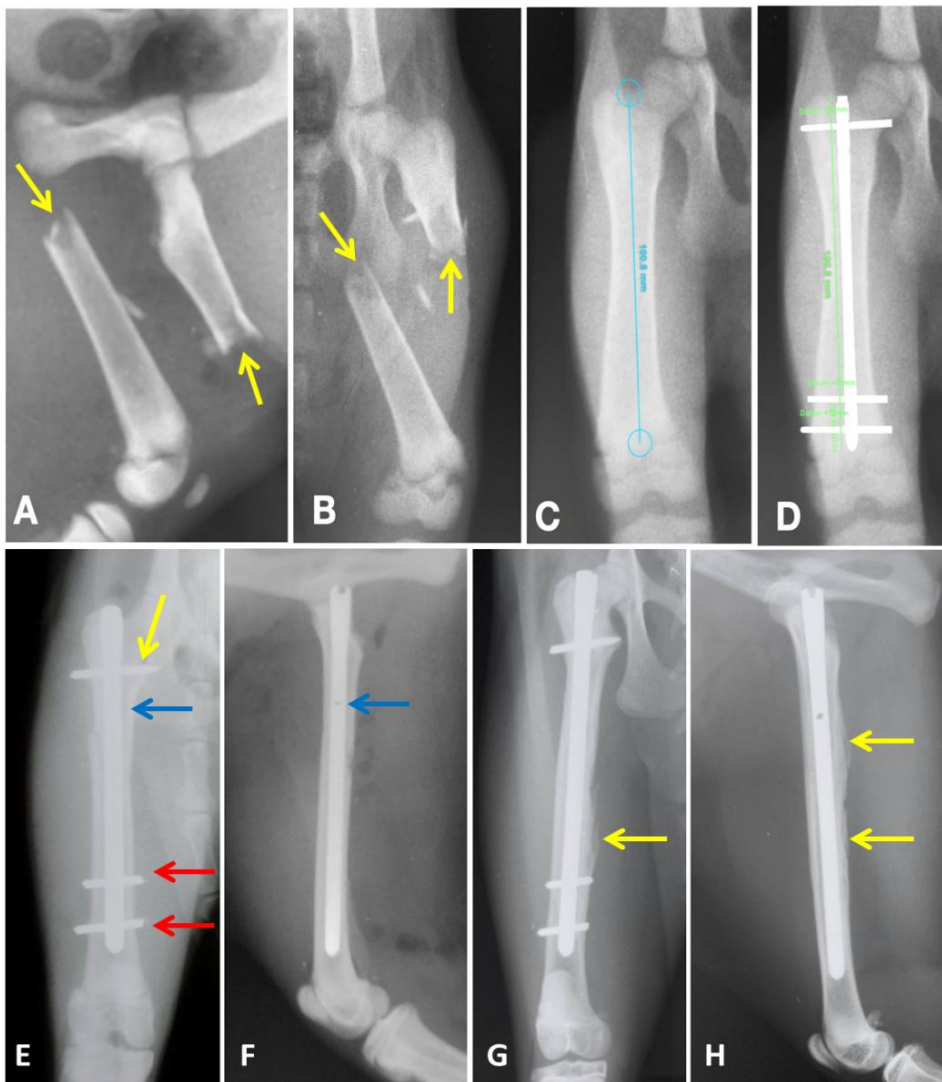


Figure 2. Radiographic images of the left and right femurs of a young feline (four and a half months old). **A** and **B**: complete, closed, comminuted fracture of the proximal diaphysis of the left femur (arrows). **C**: right femur used for measurement of length and diameter of the medullary canal (isthmus). **D**: right femur with the use of a digital template for confirmation of the length and diameter of the nail and respective locks. **E** and **F**: immediate postoperative images of osteosynthesis of the left femur with a blocked intramedullary nail, using an orthopedic pin for fixation of the nail in the proximal segment (yellow arrow), absence of the other proximal locking screw (blue arrow), and presence of two pins providing distal locking on the nail (red arrows); note considerable bone alignment, with apposition of the fractured fragments. **G** and **H**: bone consolidation of the left femur fracture and moderate bone callus formation (yellow arrows).

In the first case, the implants were removed, and for that, the animal underwent a second surgical intervention performed minimally invasively, through two incisions of approximately 1cm in length each. One incision was made in the distal region of the left femur, allowing for the removal of the two distal screws, and the second incision

was made in the proximal region of the left femur, enabling the removal of the proximal screw and intramedullary nail. The immediate radiographic examination showed bone healing and absence of orthopedic implants (Fig. 1F and 1G). In the second case, the implants were not removed.

## DISCUSSION

According to Beale (2004), young patients are more predisposed to fractures due to hyperactivity and resulting traumas. In this context, the femur is one of the most affected appendicular bones, especially in the proximal and distal epiphyseal regions, as well as in the proximal, middle, and distal diaphysis, coinciding with the locations of the two reported patients. Furthermore, according to the same researcher, the two fractures described were probably closed by the well-developed muscles that overlap such bones.

The use of elastic osteosynthesis in the treatment of long bone fractures in young patients has been employed with promising results (Cabassu, 2001; Sarrau, 2007), being the formation of exuberant bone callus is stimulated by instability and movement in the fractured focus, regardless of the type of fracture line (Schmaedecke *et al.*, 2005). Thus, the choice of the surgical technique of elastic osteosynthesis with blocked intramedullary nails for the cats in question was based on both mechanical (size and intensity of physical activity) and biological factors (age and health of the patient), in addition to the type and location of the fractures and concerns about maintaining the integrity of the growth line (Beale, 2004; Fossum, 2014).

Still regarding the location of the fractures of the cats described, other orthopedic techniques, such as plates, could indicate chances of complications (Craig *et al.*, 2017), as they would make it difficult to fix at least two bicortical screws in the small proximal bone fragments, in addition to Furthermore, they require moldings to occupy the greater trochanter of the femur, which could impair the insertion of some tendons. Furthermore, manipulation of the small proximal bone fragment for the placement of this type of orthopedic implant could predispose to the occurrence of iatrogenic fracture (Freitas *et al.*, 2013).

Despite the unavailability of fluoroscopes in teaching institutions, similar to most veterinary surgical centers, for the allocation of orthopedic implants in a minimally invasive manner, as indicated by Freitas *et al.* (2013), it was possible to perform the “open, but do not touch” technique in said feline patients (Pozzi and

Lewis, 2009), characterized by exclusive surgical exposure to inspect the fracture and perform implant fixation, without manipulation of the hematoma primary, following recommendations by Beale (2004) and Schmaedecke *et al.* (2005). Thus, the introduction of the intramedullary nail was performed in a proximal normograde manner, which also allowed minimal contact with the soft tissues adjacent to the fracture site, preserving the osteogenic potential of the initial hematoma, minimizing the loss of extra-epiosteal vascularization, and reducing surgical time, in line with Schmaedecke *et al.* (2005) who identified these points as crucial for successful bone repair. Thus, the careful execution of the surgical techniques, with minimal manipulation of the fractured foci, probably positively influenced the surgical outcome in both cases, with consolidation close to 30 days after the surgeries.

According to Schmaedecke *et al.* (2005), the selected locked intramedullary nails used for osteosynthesis in feline patients were chosen prior to the surgical procedures, based on the lengths and diameters of the medullary cavities of the femurs, visualized through radiographic images and digital templates of the contralateral bones to the fractures. In both patients, the selected intramedullary nails occupied approximately 90% of the medullary canals, and the screws were fixed in the metaphyses, following the recommendations of Dejardin *et al.* (2014).

Results regarding the use of blocked intramedullary nails in young feline patients are scarce in the scientific literature, supposedly due to the reduced diameter of the intramedullary cavity in this species and the absence, until recently, of dedicated mini system intramedullary nails for toy and feline patients (Larin *et al.*, 2001). However, these obstacles did not preclude the allocation of intramedullary nails in the two cats described, and even the slight difference between the diameters of the nails and the femoral medullary cavities became favorable, by facilitating fracture reductions, despite Horstman *et al.* (2004) argue that the intimate contact of the nail with the endosteum can cause endosteal ischemia. Thus, to alleviate the vascular impairment in both patients, conventional preparations of the medullary canals with milling cutters were not performed.

Generally, the nail in the medullary canal acts on the central axis of the bone, preventing the folding force, while the transcortical locking screws in the proximal and distal fragments of the fracture guarantee resistance to axial and torsional forces (Moses *et al.*, 2002; Horstman *et al.*, 2004). However, Horn *et al.* (2009) suggested that the lack of rigid interaction between the holes in the nail and their respective blocking implants is responsible for an unstable construct, which, according to DeJardin *et al.* (2014), leads to movement between the bone fragments, negatively impacting the biomechanics of the bone callus and delaying its healing, thus increasing the likelihood of implant failure. Despite these statements, the conventional orthopedic models used in the feline patients proved to be efficient, with no apparent complications so far (630 days after the orthopedic surgeries).

The fixation of intramedullary nails in felines is recommended with the assistance of two screws per bone segment to prevent screw fatigue failure (Slatter, 2007), especially in overweight patients (Marturelo *et al.*, 2021). However, it is believed that the use of only one orthopedic screw in the fragment, despite the mentioned risk, may have allowed for successful bone healing due to the low weight of the described patients, which were less than 2 kg, and the rapid progression of bone consolidation, which is typically expected in young animals.

The biomechanical principle of elasticity at the fracture site predisposes to the early formation of bone callus, associated with minimal changes in blood flow due to low manipulation at the fracture site and minimal injury to the orthopedic implant and bone cortex (Cabassu, 2001); thus, in the two described cases, the use of intramedullary nails was associated with minimal injury to the periosteal tissue (Wheeler *et al.*, 2004), along with minimal damage to the extraosseous vascularization and the age of the patients, which are crucial factors for the promising results obtained. Furthermore, the use of locked intramedullary nails in this study allowed for a rapid recovery with functional restoration of the affected limbs, as reported by Stiffler (2004), without evidence of complications such as, for example, non-union, delayed union or implant failure, reported in cats

by Craig *et al.* (2017), being within the period reported by Beale (2004), from four to 16 weeks. With the use of locked intramedullary nails, bone consolidations occurred early, before 45 days post-surgery, when compared to other orthopedic techniques in companion animals (Marturelo *et al.*, 2021). Thus, the satisfactory outcomes observed in the two reported patients are associated with factors such as the age and weight of the felines, as well as the use of techniques that preserved vascularization.

Cabassu (2001) highlighted that the use of a long and less rigid plate, fixed with two screws in each fracture fragment (bridge plate), is widely applied in the treatment of fractures and satisfies the criteria of biological osteosynthesis, and can be used in young patients up to four months of age; however, frequent studies have described a high failure rate of this method in cats, requiring the association of orthogonal plates, which includes greater and more intense trauma to the extra bone tissue, which may delay bone healing (Craig *et al.*, 2017). Thus, the use of intramedullary nails in feline fractures has been increasingly recommended, especially with the availability of veterinary implants compatible with these patients (Marturelo *et al.*, 2021). However, the cases presented here reinforce such information and describe the possibility of using intramedullary nails in skeletally immature feline patients.

The removal of the locked intramedullary nail, after bone healing, was performed in the first patient to avoid potential bone complications due to the age of the feline and stress on the orthopedic implant, as described by Endo *et al.* (1998) and Cabassu (2001).

## CONCLUSIONS

Given the recommended orthopedic technique and the observed results, it can be inferred that the use of locked intramedullary nails in elastic osteosynthesis was effective in the treatment of proximal femoral fractures in young feline patients, with early bone repair and rapid functional recovery of the affected limb. However, more similar cases need to be surgically treated in this way and scientifically reported, to support the promising data presented here.

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