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Supra-cutaneous plating for the repair of tibial shaft fracture in cats

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Abstract

The objective of the current study was to investigate the effectiveness of the supra-cutaneous plating technique for the repair of tibial shaft fractures in cats. Six cats with tibial shaft fractures were selected following a thorough physical and radiographic evaluation. 2.4 mm or 2.7 mm locking compression plate (LCP) was fixed on the medial side of the tibia with a minimum of two screws (of varying length) inserted bicortically in both the fracture fragments to stabilize the fracture fragments. By the 60th postoperative day, complete bony union and satisfactory functional recovery were observed in all the cats except for Cat 1, which experienced delayed healing and skin ulceration at the screw-skin interface. The supra-cutaneous plating technique was non-invasive, eliminating the need for skin incisions during its application and removal. It provided adequate stability for fracture healing without any implant failures and did not hinder the mobility of the contralateral limb due to its low profile.

Keywords: Supra-cutaneous plating, cat, tibial fracture, locking compression plate, LCP

Introduction

Tibial fractures are common in cats ranking as the second most prevalent type among feline long bone fractures (5–14%). The majority of tibial fractures occur in the mid and distal diaphysis, with open fractures being common in the distal aspect due to limited soft tissue coverage (Scott, 2005) ^[24]. Various methods available for stabilizing tibial fractures include external coaptation techniques, intramedullary pins and orthopaedic wire, interlocking nail, bone plates and screws and external skeletal fixators (Johnson, 2014) ^[8]. In most cases, many cats do not tolerate external coaptation devices. Open reduction and internal fixation (ORIF) techniques often disrupt fracture hematomas as they require soft tissue dissection. External skeletal fixators are frequently employed for tibial fracture repair. ESF offers various advantages, including minimal soft tissue dissection and no manipulation of hematoma at the fracture site (Roush, 2005) ^[23]. Tibia makes an ideal bone for ESF application due to the lack of overlying musculature which allows direct access to the bone for ease of realignment and the requirement for open wound management (Harari, 2002) ^[6].

The supracutaneous plating technique can be regarded as a modification of the Type 1 linear ESF frame where the bone plate is applied above the skin in a minimally invasive fashion (Kumar et al. 2023) ^[13]. The technique of plate fixation outside the skin was initially described in some Polish studies during the late 1980s and early 1990s, termed “ZESPOL- osteosynthesis”. Over the years, subsequent advancements were made by using a standard AO- plate (Marti and Werken, 1991) ^[16], Dynamic compression plate (Kerkhoffs et al. 2003) ^[10] and Locking compression plates (Apivatthakakul and Sananpanich 2007. and Kloen 2009) ^[1, 11] for supracutaneous plating. Some researchers also successfully repaired the fractures in animals (goat, sheep, dog and cat) by supracutaneous bone plating with good functional outcomes (Klos et al. 1995, Kumar et al. 2022, Nicetto and Longo 2017, Nicetto and Longo 2019) ^[12, 14, 18, 17]. Various studies have highlighted the considerable benefits of supra-cutaneous plating techniques such as the low profile of construct, reduced postoperative discomfort, preservation of fracture hematoma, rapid healing, lower risk of screw tract infection and ease of plate removal.

The present study describes the technique and results of supra-cutaneous plating for repair of traumatic tibial fractures in cats.

physical examination followed by radiographic evaluation in two orthogonal views were taken for diagnosis of tibial shaft fracture. Blood samples were collected for

hemato bio chemical examination. The confirmed cases of tibial shaft fracture were stabilised by supra- cutaneous plating technique using 2.4mm or 2.7mm locking compression plate (LCP).

Table 1: Anamnesis of the six cats under study

Cat No.	Breed	Sex	Etiology	Limb	Type of fracture
1.	Mongrel	F	Fall from height	Right	Splintered transverse overriding mid-diaphyseal fracture
2.	Persian cat	M	Fall from height	Right	Oblique distal 1/3rd diaphyseal fracture
3.	Mongrel	F	Fall from height	Right	Comminuted transverse mid-diaphyseal fracture
4.	Mongrel	F	Fall from height	Left	Comminuted oblique mid-diaphyseal fracture
5.	Mongrel	M	Fall from height	Left	Spiral distal 1/3rd diaphyseal fracture
6.	Mongrel	F	Fall from height	Right	Oblique distal 1/3rd diaphyseal fracture

All the cats were subjected to fasting by withholding food and water for 12 hours before the surgery. Cats were induced using Inj Ketamine hydrochloride 20 mg/kg body weight, and Diazepam 0.5 mg/kg body weight, administered intramuscularly. To achieve optimal muscle relaxation and to facilitate closed reduction, the hanging limb technique was employed for a duration of 10-20 minutes. Subsequently, the cats were positioned in lateral recumbency with the affected limb below, facing the medial side of the affected tibia upwards for surgical intervention. Fracture fragments were aligned to their normal to near-normal anatomical position by close reduction, exerting traction and countertraction and confirming the accurate opposition under the C-arm.

The standard medial surgical approach for the tibia was chosen, due to the lack of the neurovascular bundle and minimal musculature at the site. Two K- wires (1.2mm or 1.5mm) were drilled into the proximal and distal aspects of the tibia and fixed with pin stoppers to attain temporary stabilisation of the fracture fragments. A 2.4mm or 2.7mm locking plate was inserted through K-wires fixed at both bone ends until it reached the pin stopper, creating about 10mm space between the skin and the plate. The plate was then firmly fixed using a second locked pin stopper. The bone was palpated and securely held beneath the plate prior to drilling. A 1.5mm or 2mm drill bit, directed through a drill guide connected to the predetermined hole of supra-cutaneously placed LCP plate, was used to drill a hole perpendicularly into the distal tibial fragment, involving both cortices of the bone. Throughout the drilling process, the site was irrigated with normal saline to prevent heat induced tissue necrosis. The suitable screw length was determined using a depth gauge and selected based on depth of bone, including the plate and about 10mm gap between the plate and the skin surface. Self- tapping 2.4mm or 2.7mm locking screws of measured lengths were inserted using 2.4mm or 2.7mm hexagonal screwdriver. The proximal fragment of the tibia was stabilised using the same technique. Finally, the pin stoppers and K wires were removed and the same hole was drilled to place two locking screws at each end. The locking plate was fixed to the proximal and distal fragments using a minimum of two screws in each fracture fragment (Fig 1). A similar procedure was followed for all six cats.

Postoperatively, the pin tracts were flushed with povidone-iodine solution and two layers of bandaging were applied. The postoperative regimen included per-oral administration of the antibiotic Cephalexin at the rate of 25 mg/Kg BW given twice daily for seven days and Meloxicam at the rate of 0.2 mg/Kg for three days. Owners were instructed to restrict the animal's mobility for a period of one to two weeks and to avoid self-

mutation. Initially, alternate day dressing of the pin tracts by flushing the pin tracts with povidone-iodine (5%) solution was done till discharge from the site stopped and later once a week till the recovery.



Fig 1: A. K-wire drilled at proximal and distal end and pin stoppers being used as spacer b. Fixation of LCP placed between two pin stoppers c. Power drilling of holes guided through a drill guide into the fracture fragment d. Fixation of locking screws e. Locking screws fixed to the LCP (Side view) f. Locking screws fixed to the LCP (top view)

Postoperatively, sequential radiographic evaluation and lameness grading were performed at regular intervals (1st, 7th, 15th, 30th, 45th, and 60th postoperative day). Radiographs were assessed to evaluate the fracture apposition, limb alignment, status of the implant, fracture healing and any postoperative complication during healing. The stability of the supra-cutaneous plate and the occurrence of any postoperative complications were also evaluated by gross examination of the construct. The degree of clinical lameness was graded as per Fischer et al. (2004) [5], ranging from Grade I to Grade V: Grade I (no lameness), Grade II (mild lameness at a walk), Grade III (moderate lameness), Grade IV (toe touching), and Grade V (non-weight bearing lameness). The supra-cutaneous plate was removed in staged manner by initially removing the two screws proximal and distal to the fracture site based on clinical and radiographic evidence of healing. For most cases (except Cat 1) staged disassembly was performed on the 45th postoperative day followed by complete removal on the 60th postoperative day

(except Cat 1).

Results and Discussion Radiographic evaluation

Medio-lateral and anterior-posterior radiographs taken immediately after surgery revealed satisfactory fracture reduction and alignment in five cases. However, in Cat 1 the distracted fractured ends could not be brought to complete anatomical apposition. On the 1st postoperative day, there were no noticeable changes in fracture reduction from the day of the operation, indicating consistent maintenance of the fracture reduction. On 7th day, there was loss of sharp edges of the fracture fragment. The fracture line was apparent in all cases. On 15th day, an increased density of broken fragments along with small periosteal callus formation was noticed (except in Cat 1). Langley- Hobbs (2003) ^[15], Dilip (2007) ^[4], Voss and Steffen (2009) ^[26] and Raj (2022) ^[20] also made likewise observations.

On 30th day, bridging callus was evident at the fracture site (except in Cat 1), showing evidence of bony union. The fracture gap had reduced and the fracture line was not clearly appreciable. These observations indicated fracture healing, where callus formation suggested of osteosynthesis and osteoblastic activity. This was in accordance with Nicetto and Longo (2017) ^[18], Kumar et al. (2023) ^[13] and Shreeveni (2023) ^[25]. On 45th day, the fracture line was indistinct with the apposition of fracture fragments and the presence of bridging callus between the fragments was noticed in all cats (except for Cat 1). This indicated that the frame provided adequate stability. These findings were consistent with Rao et al. (2017) ^[21] and Radha (2023) ^[19]. Staged disassembly was performed in these five cases. Staged disassembly allowed for micromotion of the fracture fragment which aided in the gradual distribution of the load on the healing bone, allowing for early ambulation. Stage dynamization was also suggested by Corr (2005) ^[3], Kekatpure (2022) ^[9] and Radha (2023) ^[19]. On 60th postoperative day, complete obliteration of the fracture line and complete bridging of the fracture fragments by callus was noticed. The corticomedullary remodelling was evident by the re-establishment of the medullary cavity (Fig 2). This aligned with the findings of Nicetto and Longo (2017) ^[18], Rao et al. (2017) ^[21], Radha (2023) ^[19] and Shreeveni (2023) ^[25]. The entire construct was removed in these five cases.

Cat 1 experienced delayed healing as no radiographic signs of fracture healing were evident till 60th postoperative day, when only a slight increase in the density of fracture fragments was noticed. Despite this, the cat was completely bearing weight on the fractured leg and showed no signs of lameness. On 75th day, radiographs revealed evidence of callus formation and stage disassembly was performed. On day 90th, approximately 50% of the bone had bridging callus and the animal exhibited good weight bearing and normal usage of the limb (Fig 3). Consequently, the entire construct was removed at the owner's request, as they were unable to attend future follow-up appointments. The delayed evidence of radiographic healing could be due to improper fracture reduction, excessive fracture gap, and severe comminution of fracture fragments, which is associated with poor blood supply. Similar findings were reported by Corr (2012) ^[2]. Nicetto and Longo (2019) ^[17] also observed delayed bone union in two dogs with radius and ulna fractures treated using supracutaneous plating. This was attributed to rigid constructs used and it was managed with controlled staged dynamization to control implant flexibility.

Weight bearing pattern

All cats began to use the affected limb the day after surgery and lameness grade improved in the following postoperative days progressing from Grade V, IV to Grade I by day 15 to 30, where lameness was barely visible. By day 30, all the cats (except Cat 1) showed normal limb usage with no signs of lameness. All five cats were able to leap up and down from the height. This could suggest that the supra- cutaneous plate provided good stabilization. This was in agreement with the findings of Nicetto and Longo (2019) ^[17]. Similar findings were reported by Jagan (2020) ^[7] and Rathnadiwakara et al. (2020) ^[22] who recorded partial weight bearing in cats during the initial postoperative days and cats resumed normal walking by day 15 and day 14 respectively. However, Cat 1 experienced complications (delayed healing) during fracture healing period, which likely delayed the return to full weight-bearing by the 60th postoperative day.

Table 2: Grading of degree of clinical lameness score observed in six cats

Cat No:	Before surgery	Day 1	Day 7	Day 15	Day 30	Day 45	Day 60
1	V	IV	IV	III	III	II	I
2	IV	III	II	I	I	I	I
3	V	IV	III	II	I	I	I
4	V	III	II	I	I	I	I
5	IV	II	II	I	I	I	I
6	IV	III	II	II	I	I	I

Supra-cutaneous plate evaluation

The supracutaneous plate was well tolerated and did not interfere with contralateral limb mobility. No discharge was noticed in any case. However, in cat 1, the dressing guidelines were not followed by the owners leading to the accumulation of debris and subsequent formation of skin ulcers at the screw skin interface on day 90. This resolved after plate removal and by regular dressing of the site with povidone iodine.

Supracutaneous plating is the minimally invasive technique of fracture repair as it required no incision, causes minimal soft tissue damage and preserving the fracture hematoma resulting in early bone healing and limb usage. The locking mechanism of LCP, locking screws and bicortically insertion of the screw provided good stability for maintenance of the fracture reduction throughout the study period without any implant failure. The removal of supracutaneous plate was easy and quick, requiring no incisions and was performed under sedation

Conclusion

The present study concluded that the supra-cutaneous plating technique successfully repaired tibial shaft fractures in cats, offering good fracture stability and satisfactory functional recovery in all six cats. The supra-cutaneous plating technique was easy to apply and disassemble without any need for incision. It was well tolerated by all cats without causing any discomfort and did not affect ambulation due to its low profile.

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