



# Use of Epiphysiodesis as Treatment for a Proximal Physeal Tibial Fracture in a Dog

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## Abstract

**Objective** The aim of this study was to describe the use of epiphysiodesis by the means of a screw to treat a proximal tibial Salter–Harris II fracture associated with a tibial tuberosity avulsion in a 4.5-month-old Airedale Terrier.

**Study design** A healing proximal tibial epiphyseal fracture was observed after a 10-day period. Tibial plateau angle was 40°. The fracture was treated by the insertion of a fluoroscopy-guided 3.5-mm cancellous screw.

**Results** Successful healing of fractures and levelling of tibia plateau were obtained. Final tibial plateau angle was 8°. At long-term follow-up (18 months), owners reported sustained and full functional recovery.

**Conclusion** Prior to ossification of the proximal tibial physis, epiphysiodesis with a screw can be used as a treatment of sub-acute, moderately displaced, Salter–Harris I or II fractures.

## Keywords

- ▶ tibial plateau slope
- ▶ epiphysiodesis
- ▶ growing dogs
- ▶ Salter–Harris II fracture

## Introduction

Fractures of the proximal tibia are identified in about 7% of all canine tibial fractures.<sup>1–4</sup> Avulsion of the tibial tuberosity and Salter–Harris type I or II fractures of the proximal physis are the most reported in immature dogs.<sup>1–3</sup> Avulsion of the tibial tuberosity may occur either independently or in association with fracture-separation of the tibial epiphysis. Incidence reported in the literature varies from rare to common.<sup>5–8</sup> Small breed dogs, particularly terriers, seem predisposed to the latter.<sup>5,7–10</sup> This association of fractures has been reported in dogs aged between 3.5 and 8 months.<sup>7,9,10</sup> The typical distocaudal displacement of the proximal segment is of concern as it is accompanied by subsequent increased tibial plateau angle. This predisposes to increased stress on the cranial cruciate ligament, possibly leading to its rupture.<sup>11</sup>

Currently, there are several ways to manage proximal tibial epiphyseal fractures in puppies. Kirschner wires with or without tension band are mostly used,<sup>7,8</sup> reduction and fixation being performed either by open technique or percutaneously.<sup>12,13</sup>

Proximal tibial epiphysiodesis has been described as a therapy for growing dogs with cranial cruciate ligament deficient stifles. It aims at closing the cranial part of the proximal tibial physis with a cancellous screw.<sup>14,15</sup> This case report describes a hitherto unreported use of proximal tibial epiphysiodesis as mini-invasive treatment of a displaced Salter–Harris II proximal tibial fracture, associated with a tibial tuberosity avulsion, in a puppy.

## Clinical Report

A 13.8-kg, 4.5-month-old, female, Airedale Terrier was presented with a right hindlimb lameness after trauma while playing with another dog, 10 days earlier. Faced with no improvement after conservative management, the dog was referred at the 'Clinique Vétérinaire Universitaire de Liège University'. General physical examination and neurological assessment were within normal limits. A numerical lameness scale (0–5), as previously described, was utilized.<sup>16</sup> Orthopaedic examination revealed a severe weight-bearing lameness (4/5). In comparison with the contralateral thigh, low-grade amyotrophy of the right thigh was present. Deep

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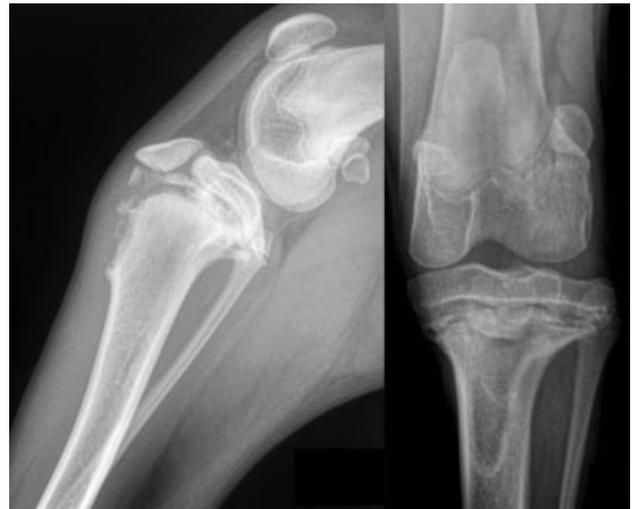


static pressure caused pain at the level of the tibial crest, but no crepitation could be elicited upon stifle mobilization. Direct and indirect drawer signs were negative. Patella was in normal position and stable within the trochlea. Radiographs of the affected stifle joint revealed soft tissue swelling cranial to the right tibial tuberosity and a Salter–Harris type II fracture of the right tibial proximal epiphysis associated with tibial tuberosity avulsion. The tibial plateau and tibial tuberosity were displaced as a single block, with the first being caudadistally tilted and the latest cranioproximally elevated with the presence of several mineralized nuclei distal to it (►Fig. 1). The tibial plateau angle was 40°. It was measured on the mediolateral view according to the method described by Slocum.<sup>17</sup>

Sedation was obtained with methadone (0.2 mg/kg, intravenous [IV]) and midazolam (0.2 mg/kg, IV). Anaesthesia was induced with propofol (2–6 mg/kg, IV) given to effect and maintained with isoflurane. A peridural locoregional analgesia was performed (morphine 0.2 mg/kg and levobupivacaine 1 mg/kg).

The surgical procedure was based on the one described by Vezzoni and colleagues.<sup>14</sup> The lateral skin incision extended from slightly distally to the patella to the tibial tuberosity. The patellar ligament was reclined medially to allow, under a fluoroscopic guidance, the intra-articular insertion of a 32 mm × 3.5 mm cancellous screw in a positional mode. The desired point of insertion was the mediolateral centre of the most proximal part of the tibial plateau. The joint was lavaged with saline. The surgical wound was routinely closed. Postoperative radiographs confirmed appropriate placement of the screw. Immediate postoperative tibial plateau angle was 36° (►Fig. 2).

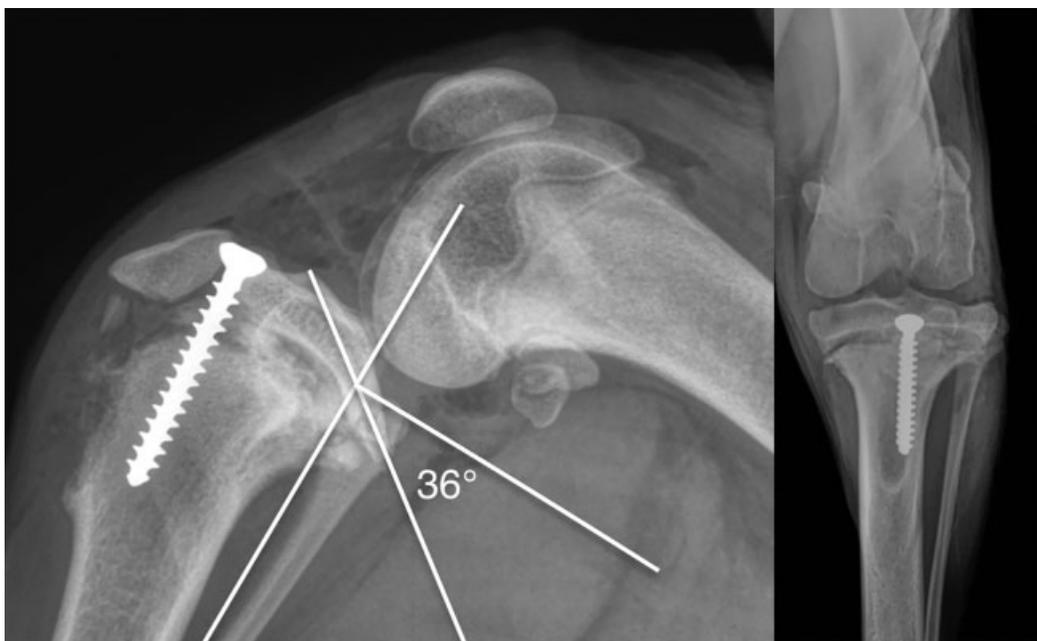
Cephalexin was administered 20 mg/kg perioperatively, methadone 0.2 mg/kg every 4 hours 24 hours postoperatively and carprofen 2 mg/kg twice a day for 5 days. Cold



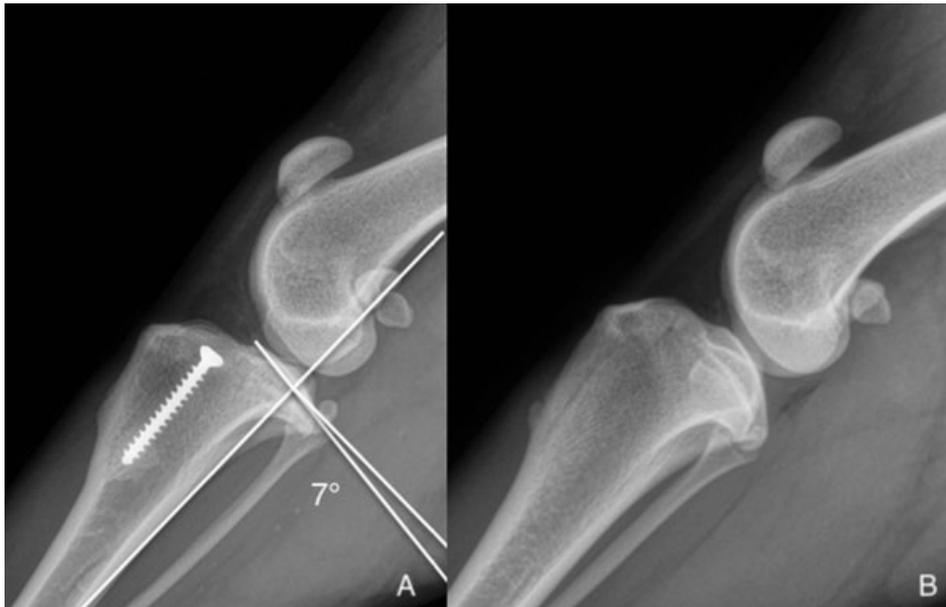
**Fig. 1** Preoperative radiographs showing a moderately displaced Salter–Harris II fracture of the right tibial proximal epiphysis associated with tibial tuberosity avulsion.

packs were applied on the stifle four to six times a day for 5 minutes for 4 days. The dog was discharged from the hospital the day after surgery with a 5-day carprofen 2 mg/kg twice a day and 3-day tramadol 2 mg/kg twice a day prescription. Strict exercise restriction was recommended until re-evaluation.

At recheck 3 weeks postoperatively, owners mentioned a decrease in the lameness at home. The dog still presented a stiff gait and a mild right hindlimb lameness (¾) but no stifle pain. Direct and indirect drawer signs remained negative. Radiographs revealed patellar ligament thickening and joint swelling. Ongoing bone healing of tibial tuberosity fracture was present. Tibial plateau angle was 32°. Leash walking and passive mobilization of the right stifle were advocated.



**Fig. 2** Immediate postoperative radiographs showing adequate screw position.



**Fig. 3** Bilateral follow-up radiograph 8 months after surgery. (A) Operated side: No signs of osteoarthritis are visible. The final plateau angle is 7° with caudal overhang of the proximal tibial epiphysis. (B) Contralateral side without overhang of the proximal tibial epiphysis.

Six-week postoperative follow-up revealed a dog free of lameness, pain-free mobilization of the stifle, normal range of motion and negative drawer signs. Healing of the tibial tuberosity avulsion fracture was progressing well on radiographs. Tibial plateau angle was 21°. The dog was re-evaluated 12 weeks after surgery. The tibial tuberosity growth plate was nearly closed on radiographs. Tibial plateau angle was 9°.

Last follow-up evaluation was performed 8 months postoperatively. The dog presented no lameness, and thighs' muscle masses were symmetrical. The operated stifle was stable and pain-free upon manipulation. Radiographs showed complete healing of the tibial tuberosity avulsion fracture and full closure of the tibial plateau growth plate. The screw head was covered by smooth, regular, new formed bone. The proximal tibia exhibited a tibial plateau caudally displaced, creating an overhang. There were no radiographical signs of osteoarthritis. Final tibial plateau angle was 7° (► **Fig. 3**). At telephone follow-up 18 months postoperatively, owners reported sustained and full functional recovery of the dog.

## Discussion

This report illustrates the use of the proximal tibial epiphysiodesis as described by Vezzoni and colleagues<sup>14</sup> for the successful treatment of a proximal tibial Salter-Harris type II fracture associated with avulsion of the tibial tuberosity in a 4.5-month-old Airedale Terrier. Reduction and stabilization of a proximal tibial physal fracture can be challenging, and several ways of treatment have been proposed.<sup>7,8,12,13,18</sup>

Our elected method of treatment was based on the combination of several fracture features; that is, displacement of the fragments with a 40° tibial plateau angle, undisrupted connection between tibial plateau and tuberosity, a growing patient, a 10-day period of time elapsed

since the fracture occurrence, leading to a rather good stability of the fracture site. An attempt to reduce the tibial tuberosity would have disrupted soft tissues and early callus. Since the displacement was moderate, no functional handicap was expected. Non-surgical management is usually recommended as the initial treatment for dogs with minimally displaced tibial tuberosity avulsion fracture.<sup>19</sup>

The difference between pre- and immediate postoperative tibial plateau angles may be explained by the fact that although the screw was initially inserted in a neutral mode, it must have slightly displaced the tibial plateau in relation with the proximal tibial metaphysis.

Proximal tibial epiphysiodesis is a mini-invasive technique described by Vezzoni and colleagues<sup>14</sup> to treat puppies affected by cranial cruciate ligament deficiency. The screw inserted in the centre of the cranial part of the tibial plateau arrests the cranial part of the tibial plateau growth. Consequently, the tibial plateau slope progressively decreases during the residual growth. Alternatively, proximal tibial epiphysiodesis by electrocauterization has been recently described.<sup>20,21</sup> This procedure is thought to be less invasive than the screw technique, with a lower morbidity. It seems to provide the same final tibial plateau angle in a shorter time.<sup>21</sup> However, we considered it non-applicable in our case as electrocauterizing the early callus could have affected the fracture healing process. Moreover, the screw contributed to the maintenance of reduction, and added stability.

We acknowledge the fact that using one single position screw to stabilize a type II Salter-Harris proximal tibial fracture might be seen as risky. When proposed by Vezzoni and colleagues,<sup>14</sup> the epiphyseal screw had no role of stabilization and was only placed to prevent further growth of the cranial tibial plateau. We were not able to quantify, on one hand, the shear force that could be applied to the tibial

plateau and, on the other, the shear strength of one 3.5 mm cancellous screw. Although guidelines for evaluating mechanical properties of implants are provided by the American Society for Testing and Materials, realistic clinical conditions evolving complex cortical geometry, cancellous architecture or bone properties cannot be fully duplicated.<sup>22</sup> We nevertheless assumed that due to the 10-day period of time elapsed between the fracture and the surgical treatment, and given the very young age of the patient, some fibrous callus had already developed, hence some stability was already regained, mimicking more closely the use of one epiphysiodesis position screw, as previously described.

As mentioned by Vezzoni and colleagues,<sup>14</sup> screw removal may be required in very young dogs. Occurrence of physis closure is in fact individual and breed related. The potential of remaining growth should be evaluated by looking at the physis width on pre- and post-op radiographs.<sup>14,15</sup> A radiographical follow-up allows monitoring of the decreasing tibial slope. In case of overcorrection, the screw should be removed before the end of the growth phase. No screw removal was necessary in our case. Our final tibial plateau angle was 7°, an optimal result to prevent excessive strain on the cranial cruciate ligament, according to *in vitro* experimental testing.<sup>23</sup>

Radiographical follow-up is recommended for early diagnosis of angulation deformities secondary to epiphysiodesis screw insertion. Physeal closure can be symmetrical or asymmetrical.<sup>24</sup> Angulation deformities have been found to be more frequent with a medial than with a lateral approach.<sup>14</sup> Hence, our choice for a lateral approach with no final angulation observed. Screw position is essential, and the use of intraoperative fluoroscopy or radiographs is highly recommended. Despite a slight eccentricity of the screw observed on the postoperative radiograph, we could not detect any adverse consequence throughout the follow-up period.

No radiographical signs of osteoarthritis appeared during the growth of the dog. This highlights a major advantage of the mini-invasive procedure and suggests a stable knee joint and a cranial cruciate ligament integrity over time.

The noticeable increase in caudal overhang of the proximal tibial epiphysis is probably due to the proximal tibial plateau pivoting around the screw insertion point. This is also noticeable on the cases described by Vezzoni and colleagues,<sup>14</sup> yet not reported previously.

To our knowledge, this is the first documented case of epiphysiodesis to treat a displaced proximal tibial physeal fracture in a growing dog. Thus, this is another indication of this technique, which, in this case, yielded excellent long-term outcome. As overcorrection could be a possible complication, radiographic follow-up is essential, allowing to decide whether and when screw removal may be required.

Based on this report, authors believe that epiphysiodesis has its place in the treatment arsenal of sub-acute, moderately displaced, Salter–Harris I or II proximal tibial fractures. Further cases are needed to demonstrate the efficiency of a single screw epiphysiodesis in the treatment of various types of proximal metaphyseal tibial fractures.

#### Author Contribution

Pierre P. Picavet, Martin Hamon and Marc Balligand contributed to the acquisition of data, data analysis and interpretation. Bernard Bouvy and Michael Lefebvre contributed to the conception of the study and study design, acquisition of data, and data analysis and interpretation. All authors drafted and revised and approved the submitted manuscript.

#### Conflict of Interest

None declared.

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