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Patella Fracture Repair Using Multiple Fixation Modalities in a Dog

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Abstract

The aim of this study was to describe the clinical use of a titanium locking plate and screws as an adjunct for the surgical treatment of an open, transverse, mid-body patellar fracture. A 2-year-old crossbreed dog was diagnosed with an open, transverse, mid-body patellar fracture. Initial fracture reduction and compression were achieved with two parallel Kirschner wires and a figure of eight tension band wire. This was followed by a titanium locking plate and screws placed on the cranial aspect of the patella. A transarticular circular external skeletal fixator was used as an additional augmentation for 5 weeks. Wire failure was noted in the transarticular circular external skeletal fixator at 10 days postoperation, necessitating wire replacement. Complete return to previous activity level and progressive radiographic osseous union were observed 8 weeks after surgery. Breakage of the Kirschner wires at the proximal pole of the patella was noted 3 years after surgery and explantation of all implants was performed. Recheck evaluation at 8 months after explantation confirmed full return to athletic function. This case report described the clinical use of a locking plate and screws as an adjunct for transverse patellar fracture repair and its long-term functional outcome.

Keywords
- patellar fracture
- locking plate fixation
- external skeletal fixator
- advanced locking plates
- canine

Introduction

Traumatic patellar fracture is a relatively uncommon occurrence in both veterinary and human medicine.[1]

The patella is the largest sesamoid bone in the dog and plays a crucial role in the extensor mechanism of the stifle.[2] It is embedded within the patella tendon, which connects the quadriceps femoris muscles to the tibial tuberosity, effectively augmenting its muscular force by acting as a fulcrum. The patella also offers protection to the quadriceps femoris tendon while increasing its load bearing surface area over the femoral trochlea. A displaced transverse patellar fracture results in disruption of the extensor mechanism. Fracture of the articular surface of the patella can also result in patellofemoral incongruity and potentiate subsequent osteoarthritis.[3]

Due to the paucity of literature on canine patellar fracture, most of the described fracture repair methods are extrapolated from human biomechanical and clinical studies which include several forms of tension band apparatus fixation,[4–9] cerclage wire fixation[3] and plate fixation.[6,10–15]

Pin and tension band wire (TBW) approaches have long been the recommended treatment for patellar fracture repair in both veterinary and human patients.[3–5] The use of a TBW is theorized to counteract the tensile force created by muscular contraction and convert it into a compressive force, resulting in interfragmentary compression and fracture stabilization.[2,3,16] However, complications such as wire breakage, wire loosening or soft tissue irritation are not infrequent and may result in the requirement for re-operation, implant removal or even fracture repair failure.[17–19] Such complications have been reported to contribute to decreased functional outcomes in humans.[20,21] There are currently no published veterinary reports on successful osseous union of canine traumatic patellar fractures repaired solely by pin and TBW.[4,5,22]

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An alternative approach is the application of a locking plate and screws to the patella. In human biomechanical studies, a locking plate fixation model demonstrated less interfragmentary gap movement, increased ultimate failure load and a reduction in fracture gap immediately prior to failure when comparing to the traditional TBW fixation model.[13,23–25] A recent biomechanical study in a canine patellar fracture model has also shown similar superiority of a prototype locking implant over a TBW construct.[6] In addition, human clinical studies reported an improvement in overall patient outcomes when compared with the traditional TBW technique.[26] The present case describes the use of a locking plate and screws as an adjunct for the repair of an open, traumatic, transverse, displaced, mid-body patellar fracture in a dog. To the authors' knowledge, the clinical use of a locking plate and screws in dogs with a patellar fracture and its long-term functional outcome has not been previously described.

Case Report

History

A 2-year-old 31 kg male neutered crossbreed dog presented to the referring veterinarian 12 hours after sustaining a traumatic injury to the left stifle. A 4-centimetre full skin thickness linear wound was identified on the cranial aspect of the left stifle joint.

Treatment received prior to referral included wound lavage with sterile saline, surgical debridement and primary closure of the cutaneous wound.

Physical Examination and Radiographic Finding

On presentation, the patient was non-weight bearing on the left pelvic limb with a sutured wound over the cranial left stifle. Pain was elicited on stifle manipulation and palpation. Radiographs of the left stifle joint (►**Fig. 1**) revealed a complete, displaced, transverse, mid-body patellar fracture with moderate soft tissue swelling and joint effusion.

Surgical Procedures

Surgery was performed the day after the initial injury. The dog was positioned in dorsal recumbency with the left pelvic limb suspended and aseptically prepared. A lateral parapatellar skin incision was made, centred over the patella. Subcutaneous tissues and fascia overlying the patella were dissected until the cranial surface of the patella was fully exposed. The stifle joint was extended while pointed bone reduction forceps was placed over the proximal and distal pole of the patella to reduce the fracture. A lateral parapatellar stifle arthrotomy, ~50% the length of the patella was performed. Arthroscopic assessment of the femoropatellar joint via this arthrotomy was performed to confirm anatomic reduction and realignment of the patellar articular surface. The cranial aspect of the insertion of the patellar tendon and the origin of the straight patellar ligament were elevated partially to expose the proximal and distal pole of the patella respectively. Two 0.9 mm Kirschner wires were placed normograde from the proximal pole of the patella into the distal fragment, exiting at the distal pole of the patella, approximately mid-way between the cranial and caudal

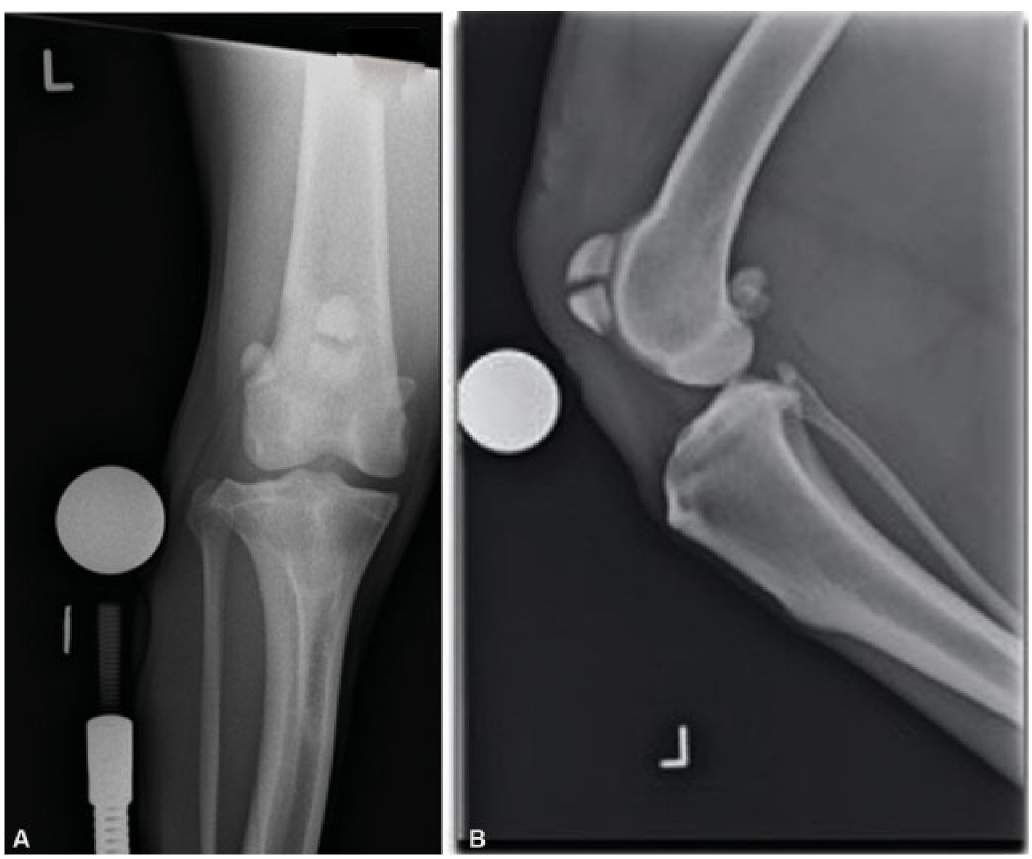

Fig. 1 (A) Craniocaudal and (B) mediolateral preoperative radiographic projection documenting the transverse mid-patellar fracture.

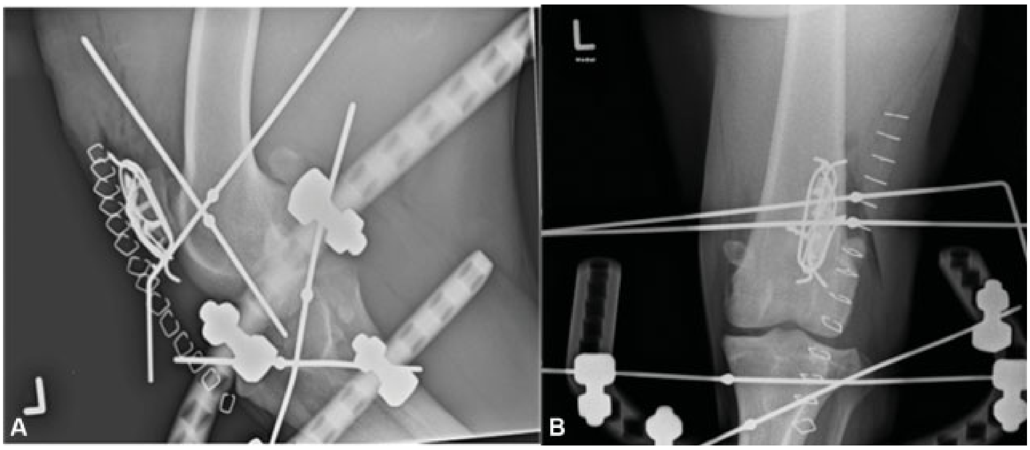

Fig. 2 Orthogonal radiograph of the left stifle postoperatively. Mediolateral (A) and craniocaudal projection projection (B) showing anatomic union of the proximal and distal patella fragments.

surfaces of the patella. Repeat arthroscopic visualization via the lateral arthrotomy confirmed the wires had not penetrated the articular surface of the patella. A figure of eight TBW consisting of 20 Gauge orthopaedic wire encircling the caudal aspects of the proximal and distal Kirschner wire ends and over the cranial aspect of the patella was placed. A four-hole titanium locking plate (6.5mm Advanced Locking Plate System, Kyon, Zurich, Switzerland) was contoured to the cranial surface of the patella. Two 2.4 mm self-tapping titanium monocortical locking screws were placed in the proximal and distal fragments respectively. Arthroscopy was again utilized to confirm the screws had not penetrated the articular surface. The fascia, subcutaneous tissues and skin were closed routinely.

A transarticular circular external skeletal fixator (TA-CESF, IMEX Veterinary, Longview, Texas, United States) was then placed over the stifle joint, at ∼135 degrees in extension, to limit stifle range of motion. A 1.6 mm stopper fixation wire was inserted mediolaterally through the proximal tibia, parallel to the joint surface. This fixation wire was then secured to a 118mm stretch ring with two fixation bolts. Another fixation bolt was then placed over the stretch ring, at ∼60 degrees to the first wire. Using this fixation bolt as a guide, a second wire was inserted through the fixation bolt into the proximal tibia and secured to the stretch ring with a second fixation bolt. Two 1.6mm stopper fixation wires were placed in the distal femur in a similar manner and secured to a 118mm stretch ring.

The stretch ring over the distal femur was temporarily removed to facilitate visualization of the patella on radiographs. Postoperative radiographs documented requisite implant placement and fracture reduction (►**Fig. 2**). The distal femoral stretch ring was then replaced. Both stretch rings were secured to each other via hinges and threaded rods (►**Fig. 3**). The stopper fixation wires were then tensioned to 60 kg.

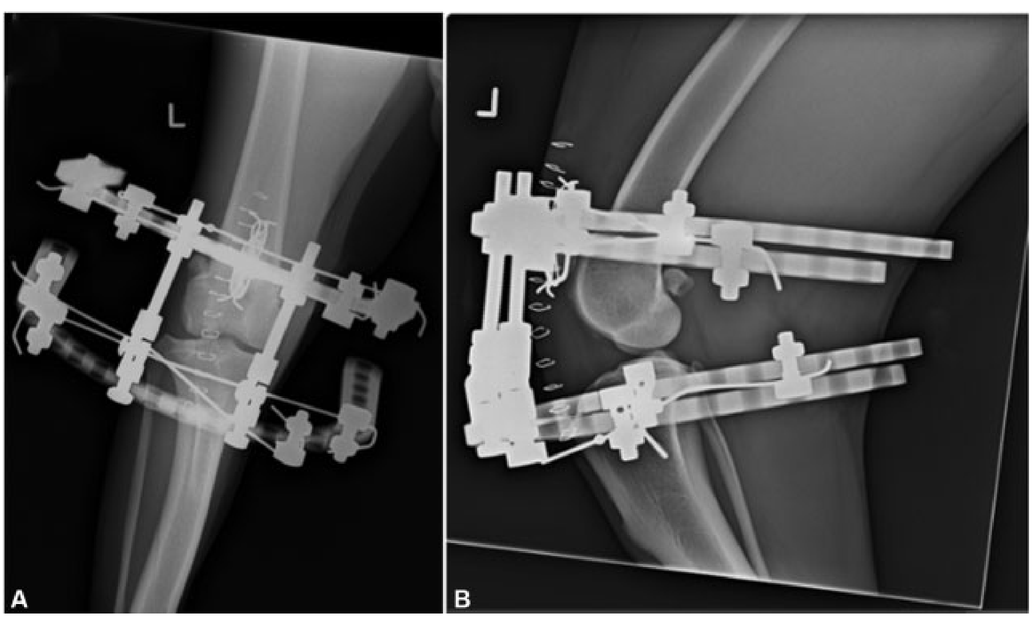

Fig. 3 Orthogonal radiograph of the left stifle postoperatively. (A) Craniocaudal projection and (B) mediolateral projection demonstrate the placement of the circular external skeletal fixator.

Postoperative medication consisted of 0.1 mg/kg intravenous methadone injection (Methone; Ceva Animal Health Pty Ltd, NSW, Australia) every 4 hours as required for the first 36 hours, Robenacoxib (Onisor 40 mg tablet; Novartis Animal Health Pty Ltd, NSW, Australia) every 24 hours for 2 weeks and amoxycillin-clavulanic acid (Curam Duo 625 mg tablet, Sandoz Pty Ltd, NSW, Australia) twice daily for 7 days. Postoperative instructions consisted of 8 weeks of cage confinement with short lead walks only for toileting purposes.

Outcome and Follow-Up

At 10 days postoperation, the dog represented when the owner reported the sudden onset of a 'clicking' noise while ambulating. Reassessment revealed failure of both a tibial and femoral wire. Both wires were replaced and tensioned.

At 2 weeks recheck following replacement of the wires, the dog was ambulating with a mechanical lameness, likely due to limited range of motion of the stifle joint. The TA-CESF remained stable and was subsequently removed at 5 weeks following the initial surgery due to ongoing discharge from the wire tracts. Follow-up examination was performed at 8 weeks postoperation which showed no noticeable lameness at walk and trot. Radiographs confirmed progressive healing of the fracture with stable implants (►Fig. 4).

At 3 years postoperation, the dog was represented for acute-onset left pelvic limb lameness. Prior to this incident, the owner reported there had been no visible lameness and the patient had remained very active. On physical examination, the dog was 6/10 lame on the left pelvic limb with palpable soft tissue swelling over the cranial aspect of the patella and pain and crepitus on stifle manipulation. Radiographs revealed failure of both Kirschner wires at the level of the proximal pole of the patella. Successful osseous union of the patellar fracture with no visible articular step was noted on the radiographs. Stifle radiographs also demonstrated mineralized tissue at the distal pole of the patella, possibly enthesophyte or a dislodged bone fragment.

Surgical explantation was then performed (►Fig. 5). Postoperative instructions consisted of 2 weeks of cage confinement with short lead walks only.

At 8 months follow-up examination post-explantation, the dog exhibited normal ambulation without noticeable lameness. No pain was elicited on direct palpation of the patella or stifle manipulation. Stifle range of motion was considered excellent. The owner reported that the dog had returned to full athletic function with no lameness.

Discussion

Traumatic, mid-body, transverse, displaced patellar fractures are considered unstable fractures that necessitate surgical stabilization due to their intra-articular location and the disruption of the extensor mechanism of the quadriceps femoris muscles.[3] Moreover, the magnitude of distraction force generated by the quadriceps femoris muscles requires the patellar fracture fixation to be inherently rigid, so that uncomplicated fracture healing can occur.[27]

A commonly recommended technique for canine patellar fracture repair is pins and figure-of-eight TBW approach.[4,22,28] However, recent canine[6] and human[13,24,25,29] cadaveric biomechanical studies indicated that TBW may be inferior to locking plate fixation for patellar fractures.

The application of a locking plate over the cranial surface of the patella was challenging due to its small fragment size. The curved cranial surface of the patella also made accurate plate contouring more difficult. In addition to this, bicortical screw placement would have resulted in violation of the patellofemoral joint. For these reasons, a plate with monocortical

Fig. 4 Orthogonal radiograph of the left stifle at 8 weeks after surgery: Mediolateral (A) and craniocaudal (B) radiographic projection. A radiolucent fracture line remains faintly visible. Note moderate soft tissue thickening and mild stifle effusion.

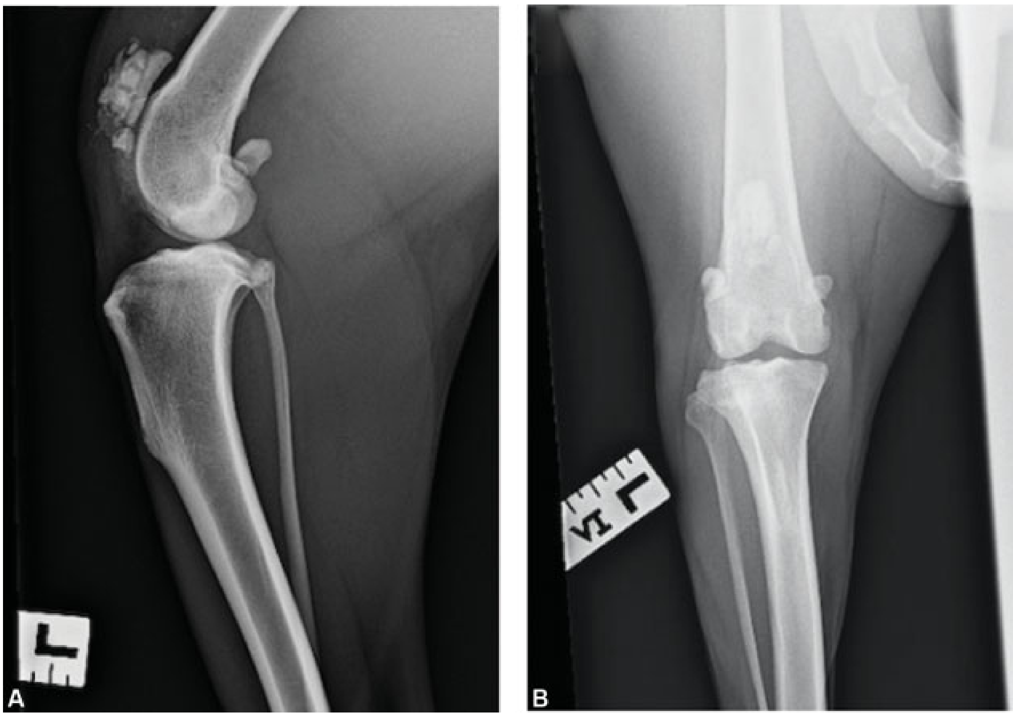

Fig. 5 Orthogonal radiographs of the left stifle immediately following surgical explantation. Note the mineralized tissue visible at the distal pole of the patella.

locking screws was used. Since a fixed angle plate and screws cannot generate a compressive force across the fracture fragments, temporary fracture compression and stabilization via cranial TBW fixation were performed prior to plate application. For a TBW apparatus to be effective, it requires active muscular distraction force to provide further interfragmentary compression force that would have been neutralized by the placement of locking plate and TA-ESF. As a result, the relatively undersized TBW apparatus served mainly to provide temporary fracture compression prior to placement of the locking plate and screws. It should be noted, however, that the TBW apparatus did limit the available bone stock for screw placement.

To overcome these challenges, careful preoperative measurement of the patella width on the craniocaudal radiographic projection was performed. Two 0.9 mm parallel Kirschner wires were then inserted proximodistally and as far apart from each other as possible, to allow placement of the 2.4mm screws.

The implants used in this case were relatively small when compared with the size of the dog, mainly due to the small fragment size seen in patella fractures. In fact, the maximal patella width measured only 13 mm in this case. The lack of available bone stock, in both the medial-to-lateral and proximal-to-distal dimensions, dictated the maximal implant dimension that could be employed to allow the placement of four monocortical screws and two Kirshner wires. There is currently no established guideline nor any study pertaining to the ideal implant size for canine patellar fracture repair. In human studies, 2.4 or 2.7 mm locking plates, with or without supplemental fixation such as circumferential wires, are typically recommended for patellar fracture repair.[10,11,14] In our case, we utilized an advanced locking plate 6.5 (equivalent to a 2.4mm titanium plate) and four 2.4mm locking screws, in addition to two 0.9mm Kirschner wires and a 20 gauge TBW. However, direct extrapolation from human studies is difficult due to the difference in anatomy and various designs of the locking plate systems.

Depending on the degree of disruption of the extensor mechanism, internal fixation of displaced patellar fractures may experience substantial axial distraction forces generated by contraction of the quadriceps femoris muscles.[27] Considering this, the use of a stiffer plate material such as stainless steel may be considered more appropriate.[30] The titanium locking plate (6.5 Advanced Locking Plate System, Kyon, Zurich, Switzerland) used in this case was selected as it had a lower profile and more screws holes per unit length than the alternative stainless steel locking plate (Locking compression plate, DePuy Synthes, Colorado, United States) that was available to the authors at the time of surgery, therefore permitting the placement of two screws in each fragment and tension-free closure of the soft tissues.

A transarticular ESF (TA-ESF) was used to limit the stifle range of motion, especially stifle flexion, during the early postoperative period. In human studies, it has been reported that 36% of fixation failures are due to non-compliance that included factors such as trauma or resuming daily activities without a knee brace.[19] Based on this, the postop rehabilitation protocol in humans usually includes immediate weight bearing with a knee brace locked in extension.[15,26] Due to the small fragment size, we were able to place only two screws in the proximal and distal fragment respectively. This fewer than optimal number of cortices purchased, combined with the magnitude of muscular distraction force the implants are required to resist during the initial convalescence period, we felt supported the usage of TA-ESF to augment the repair during early fracture healing.

Unfortunately, morbidity due to wire tract discharge necessitated the premature removal of the TA-ESF prior to the anticipated 6 weeks. This morbidity was no doubt accentuated by the use of an overly simplistic four-wire TA-ESF and the relatively short working length of the construct due to its close proximity to the centre of rotation of the stifle joint. Although the TA-ESF successfully resisted the destructive distraction force through stifle flexion, it did not neutralize any isometric contraction of the quadriceps femoris muscles. On retrospect, we believe that a more robust TA-ESF should have been utilized to more appropriately immobilize the stifle joint and augment the internal fixation.

Kirschner wire breakage was reported at 3 years postoperation which necessitated implant removal. Cyclic failure of the pins and TBW has been well reported in human and veterinary studies, likely as result of continuous movement from entrapped soft tissue during wires placement.[4,6,17,19] In this case, wire breakage occurred within the osseous–tendon junction of the quadriceps tendon and proximal pole of the patella, rather than within the patella itself, suggesting that failure occurred as a result of cyclic fatigue due to movement of the quadriceps tendon. More importantly, breakage of the wires was noted well beyond radiographically documented fracture union.

Although this dog sustained a Gustilo-Anderson (GA) type II open fracture,[31] there was no evidence of surgery site infection. Timely and appropriate antibiotic administration,[32] urgent irrigation, debridement and primary wound closure by the referring veterinarian might have contributed to the successful outcome in this case. It has also shown in a human open patellar fracture study that the infection rate paralleled the degree of soft tissue damage.[33] Torchia and Lewallen found that the infection rate of type I, II and III open patellar fractures to be 0, 7 and 60%, respectively, thus recommending immediate internal fixation and primary wound closure for GA type I and II open patellar fractures.[33]

Interestingly, patella alta was identified when comparing the pre (►**Fig. 1**) and long-term follow-up (►**Fig. 5**) radiographs of this dog. During the initial surgery, the origin of the straight patella ligament was partially elevated to facilitate TBW and plate placement. It is possible that this iatrogenic damage to the patellar ligament or its vasculature may have resulted in disruption or elongation of the straight patellar ligament, leading to patella alta. While unlikely, chronic implant irritation might also result in inflammation and elongation of the ligament. Patella alta has been shown to be associated with medial patella luxation in medium and large breed dogs.[34,35] As this dog did not appear lame and there was no evidence of patella luxation, the authors did not pursue any further diagnostic tests.

Non-surgical management has been recommended in some cases of canine and feline patella fractures.[36–38] These cases were non-traumatic fractures and often considered as stress or fatigue fractures with minimal to no displacement of the fragments.[36,37] Although radiographically demonstrated osseous union is rare, a functional non-union can occur and those cases can still achieve favourable functional outcome.[36,37] In contrast with traumatically induced, displaced patellar fractures, the soft tissue around these stress fractures is often intact which maintains its vascularity, as well as a certain degree of stability. The dog in our case report sustained an open, traumatic, transverse, displaced, mid-body fracture of the patella that has inherently disrupted the extensor mechanism. It is the authors' opinion that conservative management would have been inappropriate for this dog.

Using a combination of a locking plate and screws, pin and TBW and transarticular external skeletal fixator, we describe the repair of an open, traumatic, transverse, displaced, mid-body patellar fracture in a dog. To the authors' knowledge, this is the first reported successful management of such a fracture utilizing a plate and screws. However, further biomechanical and clinical studies are still needed to evaluate and establish the optimal approach to this uncommon fracture.

Conflict of Interest
None declared.

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