Synthetic Patellar Ligament Prosthesis for Treatment of Patellar Fracture in a Dog

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Abstract

The aim of this report was to describe the clinical use of a synthetic ligament prosthesis for surgical treatment of a comminuted patellar fracture with disruption of the quadriceps mechanism in a dog. A 17 kg, 3-year-old, female spayed Kelpie was presented with a nonweight-bearing right pelvic limb lameness, after sustaining an acute traumatic comminuted fracture of the patella. The patellar fragments were left in situ and the patellar ligament was replaced with a prosthetic implant to restore continuity of the quadriceps mechanism. The dog showed excellent recovery at 2 and 6 weeks postoperatively and showed no evidence of lameness at both 10 weeks and 5 months postoperatively. This case report describes the clinical use of a commercially available prosthesis for the repair of a disrupted quadriceps mechanism with excellent outcomes despite nonunion of the patellar fracture.

Keywords

- patellar fracture
- canine
- synthetic ligament
- quadriceps mechanism

Introduction

Traumatic patellar fractures are a relatively uncommon occurrence in dogs.[1] The patella is the largest sesamoid bone in the body and is embedded within the patellar tendon, which connects the quadriceps femoris muscle to the tibial tuberosity, effectively augmenting its muscular force by acting as a fulcrum.[2] A displaced patellar fracture results in disruption of the quadriceps extensor mechanism, and fractures incorporating the articular surface of the patella can also result in patellofemoral incongruity and result in early development of osteoarthritis.[3]

The most commonly described patellar fracture repair methods in both the veterinary and human literature include fixations with tension band apparatus, cerclage wires, and plates, with a combination of these modalities usually employed in each repair.[3,4] Additionally, primary repairs in dogs are usually augmented with the placement of a transarticular external skeletal fixator or external coaptation to mitigate the negative effects of quadriceps muscle contraction on the healing patella postoperatively.[3] This is particularly important given the relatively small size of the fracture fragments compared with the force placed on them by the quadriceps mechanism.[4] Complications such as implant breakage, loosening, or soft tissue irritation are common and revision surgery for implant removal, frequently in the face of fracture nonunion, is readily reported.[3,4] External skeletal fixator complications such as superficial pin-tract infection, irritation and loosening, and bandage-associated complications are also well documented in dogs.[4]

The most common type of patellar fractures encountered in companion animals are transverse fractures,[4] which makes fixation challenging but feasible with the above-mentioned methods. There are currently no published veterinary reports on successful osseous union of canine traumatic patellar fractures repaired by pin and tension band wiring or plating.[3,4] Comminuted patellar fractures are less common and even more challenging to repair, given the number and small size of the fragments, as well as the curved shape of the bone, which can limit appropriate implant application.[4]

The case below outlines a novel approach for repair of a traumatic comminuted patella fracture, with repair of the

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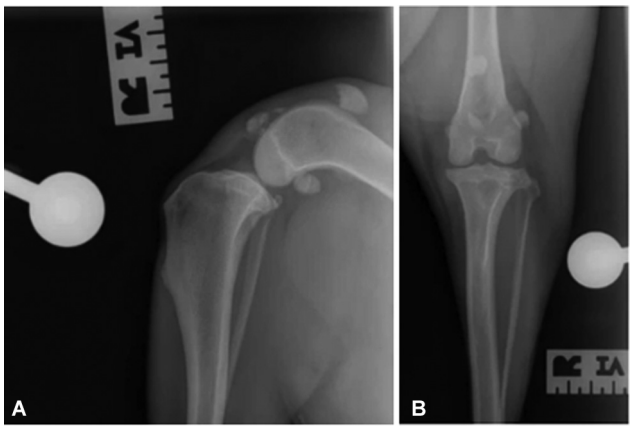

Fig. 1 Preoperative orthogonal radiographs of the right stifle joint showing a comminuted patellar fracture. Mediolateral view (**A**) and craniocaudal view (**B**).

quadriceps extensor mechanism by inserting a prosthetic patellar ligament and leaving the fractured patellar segments in situ. To the authors' knowledge, this type of repair method and its short-term functional outcome has not been previously reported.

Case Description

History

A 17 kg, 3-year-old, female spayed Kelpie presented following a history of acute right pelvic limb lameness secondary to trauma sustained after running into a guy wire cable attached to a telecommunications pole. Sedated examination and radiographs revealed a comminuted fracture of the patella and an overlying medial superficial skin laceration, which was lavaged and closed primarily. The dog was subsequently referred for surgical evaluation. On presentation, general physical examination was unremarkable. The dog was nonweight-bearing on the right pelvic limb with a moderate amount of swelling around the right stifle joint and pain on stifle flexion and extension. The remainder of the orthopaedic exam was unremarkable.

Diagnostics

Mediolateral and craniocaudal radiographs of the right stifle joint were obtained under sedation with medetomidine 0.01 mg/kg intravenous (IV) (Ilium, Troy Laboratories, NSW, Australia) and butorphanol 0.2 mg/kg IV (Ilium), which confirmed the presence of a closed, complete, displaced comminuted fracture of the right patella, with a large proximal segment and several small distal patellar fragments (►**Fig. 1**). A Spica splint was applied to the limb with the stifle maintained in extension until definitive surgical repair could be performed. Surgery was delayed by 3 days.

Treatment

Surgical treatment was performed by reestablishment of the quadriceps extensor mechanism using a Novalig 4000 prosthetic ligament (Novetech Surgery, Munich, Germany), without attempts at patellar fracture repair.

The dog was premedicated with methadone (Ilium) 0.2 mg/kg IV, induced with propofol (B. Braun, NSW, Australia) 6 mg/kg IV, and maintained with isoflurane in oxygen following endotracheal intubation. Cephazolin (AFT Pharmaceuticals, NSW, Australia) 22 mg/kg IV was administered shortly after induction and repeated at 120-minute intervals throughout the procedure. The patient was placed in dorsal recumbency with a suspended limb preparation of the right pelvic limb. The limb was covered with an adhesive antimicrobial dressing (Ioban 2, 3M Medical Solutions Division, Minnesota, United States). A lateral parapatellar skin incision was performed from proximal to the patella to just distal to the tibial tuberosity. A biceps femoris fascia lata graft was harvested, leaving the graft attached distally to the tibial tuberosity. This was wrapped in sterile saline-soaked swabs until further utilisation. Two bone tunnels were drilled in the proximal tibia; one in the sagittal plane from the point of insertion of the patellar tendon on the tibial tuberosity and exiting the caudal tibial cortex caudally, and the other from medial to lateral through the proximal tibial diaphysis just distal to the exit point of the first tunnel (►**Fig. 2**). The proximal patellar tendon was partially incised longitudinally from the patella to the musculotendinous junction of the quadriceps. The implant was sandwiched inside the patellar tendon and sutured in place with 5-metric ultrahigh

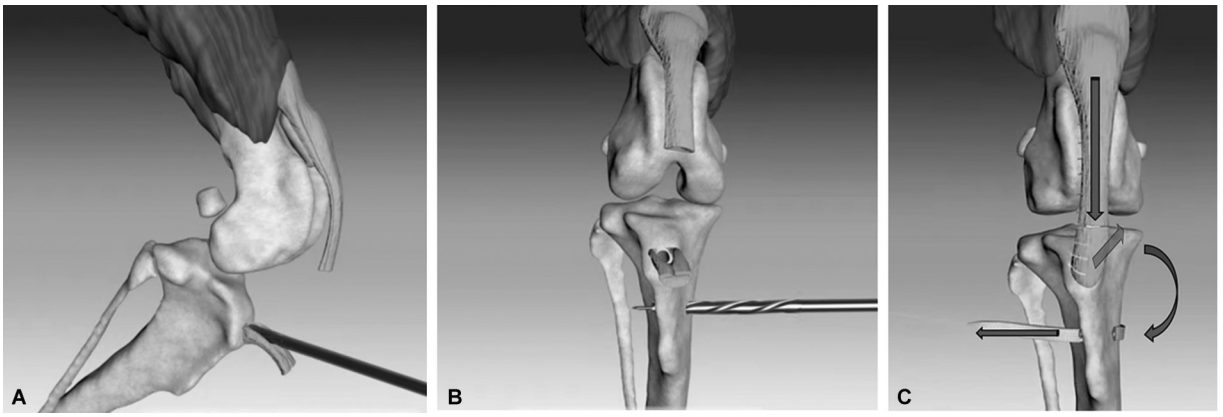

Fig. 2 Landmarks for the two drilled bone tunnels (**A**, **B**) and insertion direction of the patellar ligament prosthesis (**C**). Reproduced with permission from Morton and Buttin 2023.[18]

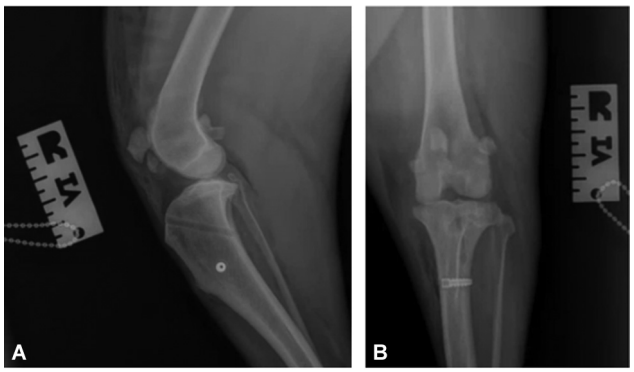

Fig. 3 Immediate postoperative orthogonal radiographs of the right stifle joint showing the location of the bone tunnels and interference screw placement. Mediolateral view (**A**) and craniocaudal view (**B**).

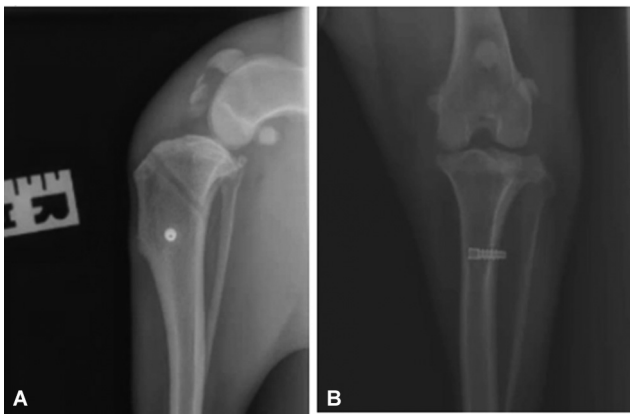

Fig. 4 Six-week postoperative orthogonal radiographs of the right stifle joint. Mediolateral view (**A**) and craniocaudal view (**B**).

molecular weight polyethylene suture (FiberTech, Novetech Surgery, Munich, Germany). The distal end of the prosthetic implant was passed through the cranioproximal to caudodistal tunnel, around the caudomedial aspect of the tibial diaphysis, mediolaterally through the second bone tunnel and secured with a 4-mm interference screw (Novetech Surgery, Monaco, UK; ►**Fig. 2**). The prosthetic implant was then covered with the fascia lata graft, which was sutured in place with 2-metric polydioxanone (PDS II, Ethicon, Somerville, New Jersey, United States) in a simple continuous pattern. The area was copiously lavaged with sterile saline and the fascia, subcutaneous tissues, and skin were closed routinely. No external coaptation or any kind of joint stabilisation device was applied postoperatively.

Postoperatively, manipulation of the right stifle revealed a markedly decreased range of motion in flexion (~120 degrees) and the stifle remained in near full extension at rest. Radiographs confirmed adequate positioning of the tibial bone tunnels and interference screw (►**Fig. 3**). A sterile adhesive dressing was placed over the wound before recovery (Primapore, Smith and Nephew, Hertfordshire, United Kingdom). Following surgery, the patient was maintained on IV lactated Ringers solution at 2 mL/kg/h for 12 hours and a tapering fentanyl (Generic Health, VIC, Australia) constant rate infusion beginning at 3 µg/kg/h and weaned over 12 hours. Meloxicam (Ilium) 0.1 mg/kg was administered orally once daily for 7 days, cephalexin (Dechra NSW, Australia) 22 mg/kg was administered orally three times daily for 5 days, and a 50 µg/h transdermal fentanyl patch (Durogesic, Janssen, NSW, Australia) was applied to the left caudal metatarsal skin immediately after surgery. The patient was discharged from hospital the following morning and was nonambulatory on the operated limb.

Outcome and Follow-up

Following 2 weeks of strict cage rest, the patient was reassessed. The wounds had healed, and orthopaedic examination of the right stifle revealed decreased flexion of approximately 100 degrees, full extension and no pain on stifle manipulation. The dog was toe-touching on the right pelvic limb when standing and walking but predominantly remained nonweight-bearing with the stifle partially flexed at faster gaits. Slow, controlled 10-minute leashed walks twice daily were recommended as well as instigating physical rehabilitation, comprising of physiotherapy assessment and once weekly sessions of hydrotherapy, in addition to at-home daily stifle flexion and extension exercises.

The dog was reassessed at 6 weeks postoperatively for follow-up radiographs. On orthopaedic examination, the patient was ambulating with no appreciable lameness in the right pelvic limb, and full stifle flexion and extension could be achieved without signs of discomfort. The patient was sedated with medetomidine (Ilium) 0.01 mg/kg IV and butorphanol (Ilium) 0.2 mg/kg IV, for orthogonal right stifle radiographs (►**Fig. 4**). The radiographs revealed no evidence of osseous union of the patella fracture fragments. The patella was tracking well within the femoral trochlear groove on sedated examination, with no medial or lateral patella laxity evident. The interference screw in the proximal tibia had not migrated and there was no evidence of periimplant lucency. An increase in exercise levels, consisting of two 20-minute leashed walks per day with continued physiotherapy and hydrotherapy, was advised. At the final follow-up examination 10 weeks postoperatively, the dog was ambulating with no lameness at all paces and was pain-free on manual palpation and manipulation of the right stifle. There was a slight discrepancy in thigh muscle circumference between the right and left pelvic limbs, with the right proximal thigh measuring circumferentially 5 cm less than the left. A full return to activity was recommended. A final phone call follow-up was conducted 5 months postoperatively, with the owner describing the dog as 100% sound with no lameness even after high-intensity exercise. The owner was very satisfied with the outcome of the surgery.

Discussion

The patella has two principal functions—to act as a transmitter for tensile forces generated by the quadriceps muscle, and to act as a lever arm of the stifle extensor mechanism.[2,5,6] When the integrity of the quadriceps–patellar ligament unit is compromised, stifle joint function is impaired and therefore primary surgical repair is recommended.[1,7,8] However,

to the author's knowledge, there are no published reports on the successful osseous union of primarily repaired canine comminuted or transverse patellar fractures[3,4] and only a single successful repair in a dog has been reported, which was a longitudinal patellar fracture repaired using lag screw fixation.[9]

The multiple documented reports of patellar fracture nonunions in veterinary patients can be attributed to the relatively small size of the fracture fragments precluding optimal bone purchase, and the inability to counteract the large distractive forces placed on the repair by the quadriceps mechanism.[1] It is also noted that most cases that do result in nonunion require implant removal secondary to implant migration and chronic irritation, which can add significant morbidity to the patient.[1,3,4] Interestingly, despite the high implant failure rate, excellent long-term clinical outcomes have been reported in two canine case reports following primary repair failure and patellar fracture nonunion following implant explantation[3,4] and favorable outcomes have also been documented in feline patellar fractures treated both conservatively or following fracture nonunion after attempted primary surgical repair.[10,11] One theory for the excellent clinical outcome following conservative management in feline patients is that most patella fractures in cats are not associated with trauma but are rather secondary to stress fatigue. Therefore, significant soft tissue damage is limited and the quadriceps mechanism remains intact.[10,11] In one study, all cats treated conservatively returned to normal activity with no gait abnormalities or evidence of degenerative joint disease when followed up 4.5 years after initial presentation. It is interesting to note that in those cats, 83% of the surgically treated patellar fractures and 100% of the conservatively treated fractures had no evidence of radiographic healing, and it is speculated that the patella may stabilise from fibrous union rather than osseous union in these instances.[11] In the human literature, patients with low functional demands with patella nonunions or delayed unions are also able to manage their activities of daily life with few impairments. However, it has been documented that they have difficulty with heavy work or sports activities, as most experience weakness and frequent collapse of the affected knee as well as difficultly when climbing stairs.[12]

Besides restoring the lever arm for the quadriceps mechanism, primary patellar fracture repair has been advocated to minimise the development of patellofemoral osteoarthritis.[13] There are currently no studies documenting the severity or frequency of patellofemoral osteoarthritis following patellar fractures in the veterinary literature. In humans, the incidence of osteoarthritis after nonunion and delayed union of patellar fractures is debatable.[12] One study showed similar patellofemoral osteoarthritis scores in conservatively and surgically treated patellar fractures[14] and another found no increase in the frequency of osteoarthritis of the patellofemoral joint due to delayed and nonunion of the patella.[15] It has been hypothesised that the development of osteoarthritis primarily depends on the amount of cartilage damage that occurs at the time of initial injury as well as the presence of an incongruency of more than 2 mm on the articular surface of the patella.[8,12]

In people, it is well established that total patellectomy is a salvage procedure only, as removal of the patella markedly reduces the optimal function of the stifle joint.[12,16] The preservation of the patella is deemed necessary to prevent loss of normal knee motion, instability of the knee, reduction in the strength of the extensor mechanism, and a reduction in the stance phase flexion excursion in both level walking and stair climbing.[12] Even partial patellectomy has been shown to cause delayed rehabilitation, decreased range of motion, persistent pain in extension, and overloading of the knee joint. Patellectomy decreases the lever arm of the quadriceps mechanism, leading to an eccentrically loaded knee joint and early degenerative change.[16]

This case report aims to advocate for a novel treatment option for canine comminuted or transverse patellar fractures, wherein primary fracture repair is likely to be difficult or near impossible. This case as well as the above-cited examples from the human literature and veterinary studies show that when the quadriceps mechanism is intact, patients with patellar fracture nonunions can go on to have a functional stifle joint with minimal long-term complications.

This case report as well as the favorable clinical outcomes documented following functional nonunion after primary repair in other veterinary patients suggest that fracture stabilisation with neutralization of the distractive forces and compression of the bony fragments may not be the primary goal for surgical treatment of patellar fractures in dogs. Importance should instead be placed on restoring the integrity of the quadriceps mechanism, while leaving most of the patellar fracture fragments in situ. This treatment choice is also associated with decreased surgical time and early postoperative limb usage with a reduced time frame of activity restriction[17] and has no requirement for postoperative external coaptation. Using a prosthetic ligament to restore the quadriceps mechanism, we have herein described the successful repair of a traumatic, comminuted, displaced patellar fracture in a dog by restoring the quadriceps mechanism and leaving the fracture fragments in situ with an excellent short-term clinical outcome.

Ethics Statement

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as this is a case report with no original research data.

Authors' Contributions

S.K. was the lead surgeon with J.K. as the assistant. J.K. was the primary author with input from S.K., T.S., and J.N.

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Conflict of Interest
None declared.

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