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Lateral Patellar Luxations following Bilateral Hip Joint Replacement in a Dog

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Abstract

A 2-year-old male neutered crossbreed was presented with a 7-month history of left pelvic limb lameness. Following a diagnosis of bilateral hip dysplasia, staged hybrid total hip replacements (THR) were performed 16 months apart. An ipsilateral grade II lateral patellar luxation (LPL) developed within 24 hours after each THR. Both LPLs were successfully treated by block recession sulcoplasty. Subjective gait analysis showed an abnormal pelvic limb gait following each THR. Clinical examination detected a grade II LPL on each operated limb. Computed tomography of both pelvic limbs revealed mild trochlear sulcus hypoplasia but no other skeletal abnormalities. Trochlear block recession sulcoplasty was performed 10 and 4 weeks respectively after THR. Long-term follow-up 12 months after the last surgery found minimal (0–1/10) lameness, no pain on clinical examination in both PLs and an overall low client-based metrology instrument mobility score of 2 (Liverpool Osteoarthritis in Dogs). This case report documents that in predisposed dogs, with hypoplastic trochlear ridges, LPL can occur secondary to THR and can be successfully managed by standard techniques to address the luxation. Furthermore, despite anecdotal verbal reports of medial patellar luxation occurring secondary to THR in dogs, this is the first published report of the management of any patellar luxation subsequent to THR.

Keywords
- total hip replacement
- lateral patellar luxation
- dogs

Introduction

Total hip replacement (THR)[1,2] has been reported to provide consistent, excellent outcomes for dogs and cats with coxofemoral joint pathology.[3,4] Reported postoperative complications include implant luxation, septic and aseptic loosening, sciatic neuropraxia, and femoral fracture.[3–8] Similar complications are reported following THR surgery in people.[9] During THR, intraoperative medial patellar luxation in dogs was noted in 4 out of 78 procedures in one case series,[8] being corrected by rectus femoris release at its proximal origin in all cases. No reports of LPL associated with THR, either inter- or perioperatively, have been published in either human or veterinary literature.

* *It is with great sadness and regret that ASM sadly passed away in July 2020 and therefore this manuscript is being submitted in her memory and as testament to her great diligence and care with her patients.*

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Naturally occurring patellar luxation in dogs may be medial, lateral or bidirectional.[10,11] Medial patella luxation is commonly associated with conformational deformities including quadriceps mechanism malalignment, genu varum, coxa vara, femoral varus, shallow trochlear sulcus, poorly developed lateral or medial trochlear ridges, medial displacement of the tibial tuberosity.[10,12] Conversely, femoral valgus, genu valgum, coxa valga, increased angle of femoral anteversion, hypoplastic lateral trochlear ridge, long proximal tibia and patella baja may be associated with lateral patellar luxation (LPL).[12] The anatomical abnormalities as described above can cause a malalignment of medial–lateral forces acting on the patella versus alignment of the trochlear sulcus resulting in patellar luxation.[13] Four grades of patellar luxation are recognized[14]: with the higher grades typically causing more debilitating lameness, inability to ambulate, and development of osteoarthritis. Lateral patellar luxation is seen most commonly in large-breed dogs, although it can occur in dogs of any size.[10,11]

Surgical options for correction of LPL include femoral osteotomy to correct femoral malalignment, femoral sulcoplasty, tibial tuberosity transposition, lateral release, medial imbrication and tibial corrective osteotomy.[10] While THR surgery may result in adjustments in force direction through the patellar mechanism via changes in limb rotation, acetabular anteversion or retroversion and femoral neck length,[15,16] consequential postoperative patellar luxation and its management has not previously been reported.

Case Description

A 2-year-old, 14.4 kg male neutered poodle crossbreed was presented to the referral centre with a 7-month history of left pelvic limb lameness. On orthopaedic examination, a moderate-to-severe pain response was elicited on extension of both coxofemoral joints and moderate bilateral proximal pelvic limb muscle atrophy was present. No lameness was observed on walking or trotting, but a mild swaying gait was evident. Liverpool Osteoarthritis in Dogs (LOAD) clinical metrology score[17] was 14 indicative of a moderate impairment to mobility. General clinical examination was otherwise unremarkable. On the same day, a short anaesthetic was performed, to take four standard radiographs (►**Fig. 1**) for diagnosis and THR templating (Biomedtrix, Boonton, New Jersey, United States). Radiographs showed changes consistent with bilateral hip dysplasia and secondary osteoarthritis (►**Fig. 1A–D**). The dog's owners opted for THR surgery.

Left-Sided THR and Associated Lateral Patellar Luxation

A left-sided THR was performed under standard premedication, anaesthesia induction and maintenance protocols. An epidural anaesthetic with bupivacaine (1 mg/kg; Marcain, Aspen Healthcare, Australia) and morphine (0.1 mg/kg; Duramorph, HIkma Pharmaceuticals, USA) was given. Cefuroxime (10 mg/kg q90m; Zinacef, GlaxoSmithKline) was administered throughout anaesthesia and subsequently every 8 hours for 24 hours. Meloxicam (0.1 mg/kg intravenously [IV]; Metacam, Boehringer Ingelheim) was given at the completion of the procedure.

A hybrid THR was performed with a 22 mm cementless acetabular cup (BioMedtrix BFX, Boonton, New Jersey, United States), cemented number 5 femoral stem and 14mm (+3 mm) femoral head implant (BioMedtrix CFX, Boonton, New Jersey, United States). Satisfactory implant positioning was confirmed by radiography (►**Fig. 2**). Acetabular angle of retroversion (AR), angle of lateral opening (ALO) and angle of femoral inclination (AI) were measured according to Dyce and colleagues.[18] The AR was 19.4 degrees, ALO 46.7 degrees and AI 135 degrees and the femoral stem appeared appropriately anteverted. The cement mantle around the femoral stem measured 2 to 4 mm and was classified as grade A (excellent) according to Ota and colleagues.[19]

The dog began to tentatively weight-bear on the left pelvic limb 24 hours postoperatively, but examination revealed a medium (intermittent) grade II left LPL. It was hoped that the LPL would resolve with normal limb use in the recovery period, so the dog was discharged with detailed instructions (**Supplementary Material 1**).

Ten weeks after the THR procedure, the dog was reassessed. Subjective gait evaluation demonstrated a bilaterally 'crouched' pelvic limb gait due to an LPL in the left stifle joint and existing hip dysplasia/osteoarthritis in the right pelvic limb. Orthopaedic examination detected intermittent grade II LPL of the left stifle. The left coxofemoral joint was non-painful with normal range of movement but discomfort was elicited on manipulation of the right coxofemoral joint. The LOAD score was unchanged at 14.

At this time, advanced imaging of the stifle joints was performed to ascertain if any rotational deformities may have been contributing to the LPL. Computed tomography (CT) examination was performed under sedation using an 80-slice CT scanner (Aquilion Prime, Toshiba Medical Systems Europe, Zoetermeer, the Netherlands). Slice thickness was set as 0.5 mm with a helical pitch factor of 0.638. Transverse images were acquired and reconstructed with a sharp (bone) algorithm. All images were viewed as multiplanar reconstructions in a bone window (W = 2,700, L = 350). The femoral angle of anteversion (FAA) was measured for both sides as described by Barnes and colleagues.[20] The FAA for the unoperated right femur was 21.9 degrees, and the operated left femur was 19.4 degrees. No normal range for canine FAA has been established, with reported mean variation from 16 to 31.3 degrees.[21] The CT found no angular deformity of the left or right femoral or tibial diaphyses. Measurements for the depth of the trochlear groove and width of the lateral trochlear ridge for both left and right stifles[22] are detailed in ►**Fig. 3A–F** and ►**Table 1**. Neither tibial tuberosity was deviated medially or laterally. Preoperative femoral varus was retrospectively measured (from the THR templating radiographs shown in ►**Fig. 1D**) as 9 (left) and 6.7 degrees (right), within previously reported ranges.[23] The ratio for left patellar ligament:patella length was 1.77, suggestive of mild patella baja.[12] Trochlear groove depth could not be assessed from the preoperative radiographs.

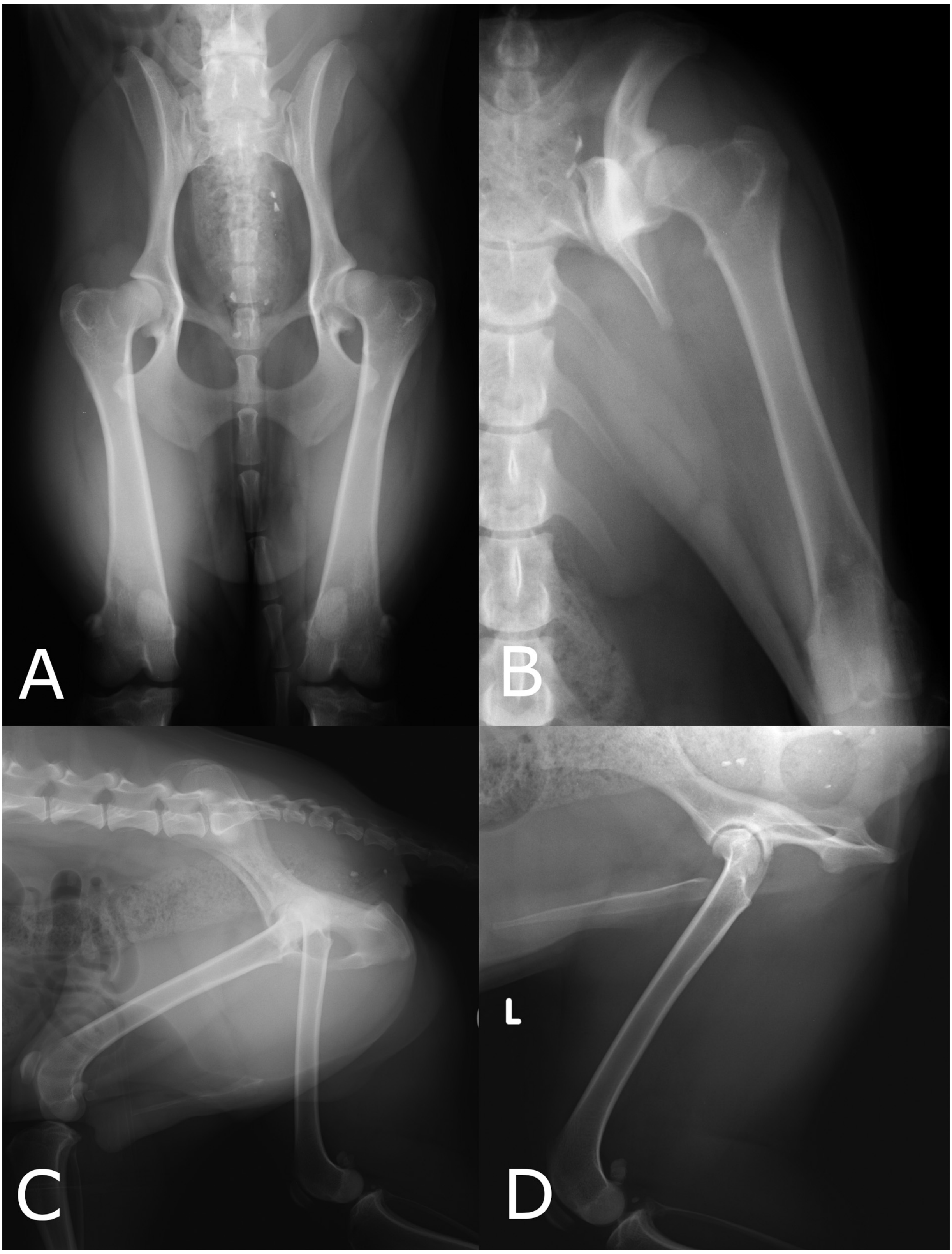

Fig. 1 Preoperative radiographic ventrodorsal extended hip joint view (**A**), caudocranial left femoral view (**B**), lateral pelvic view (**C**) and (**D**) mediolateral open-leg left femoral view of the dog. Moderate-to-severe bilateral subluxation is present, more severe on the left side. Additionally, mild-to-moderate osteophytosis is noted at the acetabular and femoral head margins. The patellae are in a normal position.

Thus, it was hypothesized that intermittent grade II LPL resulted from a combination of mild trochlear sulcus hypoplasia and internal femoral rotation causing relative medialization of the trochlear sulcus versus the quadriceps mechanism alignment axis. Given these observations and the degree of morbidity in this dog's left pelvic limb function

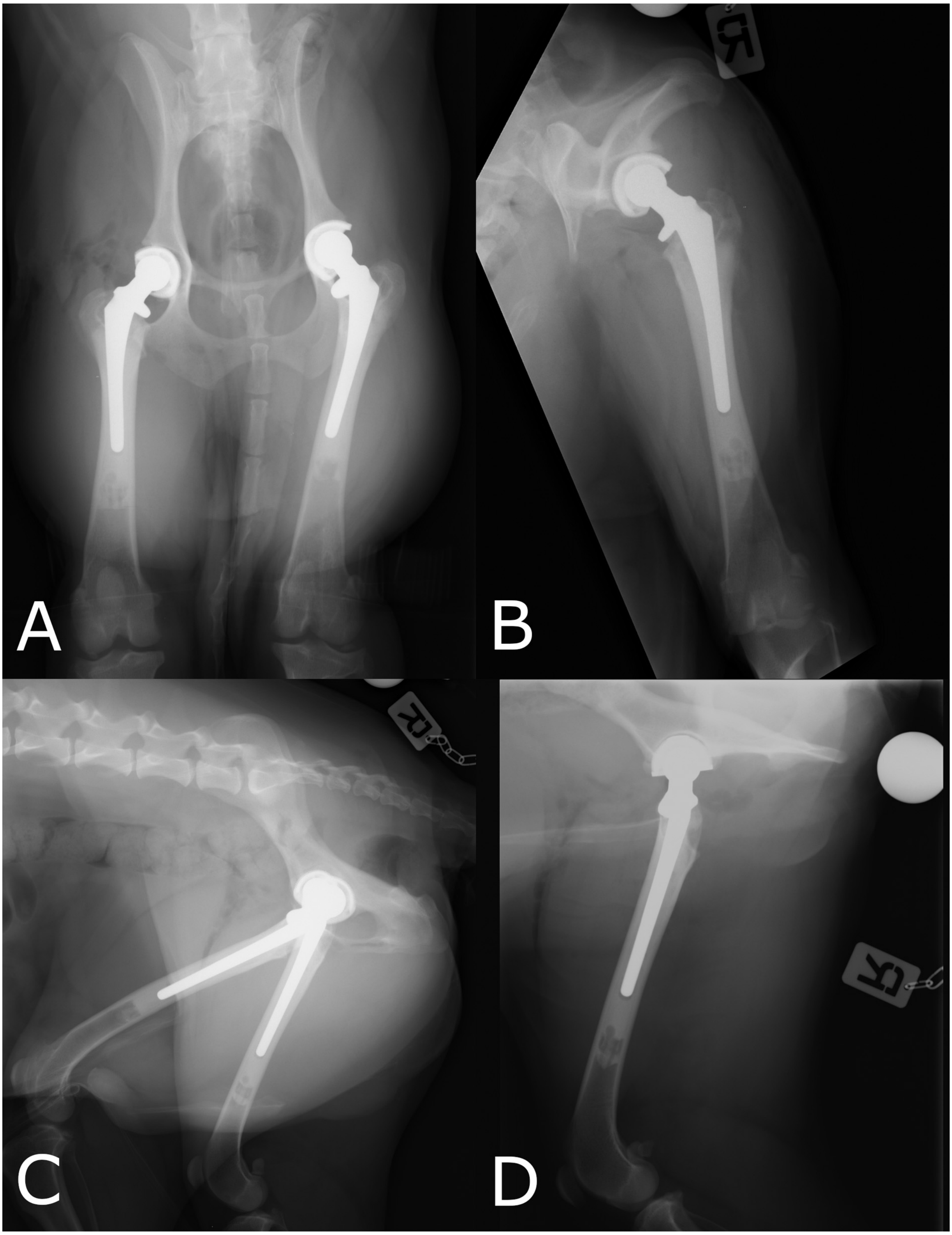

Fig. 2 Postoperative radiographic ventrodorsal extended hip joint view (**A**), caudocranial left femoral view (**B**), lateral pelvic view (**C**) and (**D**) mediolateral open-leg femoral view of the dog after left total hip replacement. The radiographs show satisfactory implant positioning with appropriate retroversion of the acetabular angle, angle of lateral opening and femoral inclination. The femoral stem anteversion is good.

and gait, block recession sulcoplasty[24] was planned to correct the LPL, 10 weeks following left THR surgery.

The dog was anaesthetized with standard premedication, anaesthesia induction and maintenance protocols with an ultrasound-guided femoral/sciatic nerve block with bupivacaine 2 mg/kg also being performed. On surgical exploration of the left stifle joint, the distal aspect of the lateral trochlear ridge was confirmed. The tibial tuberosity, alignment of the

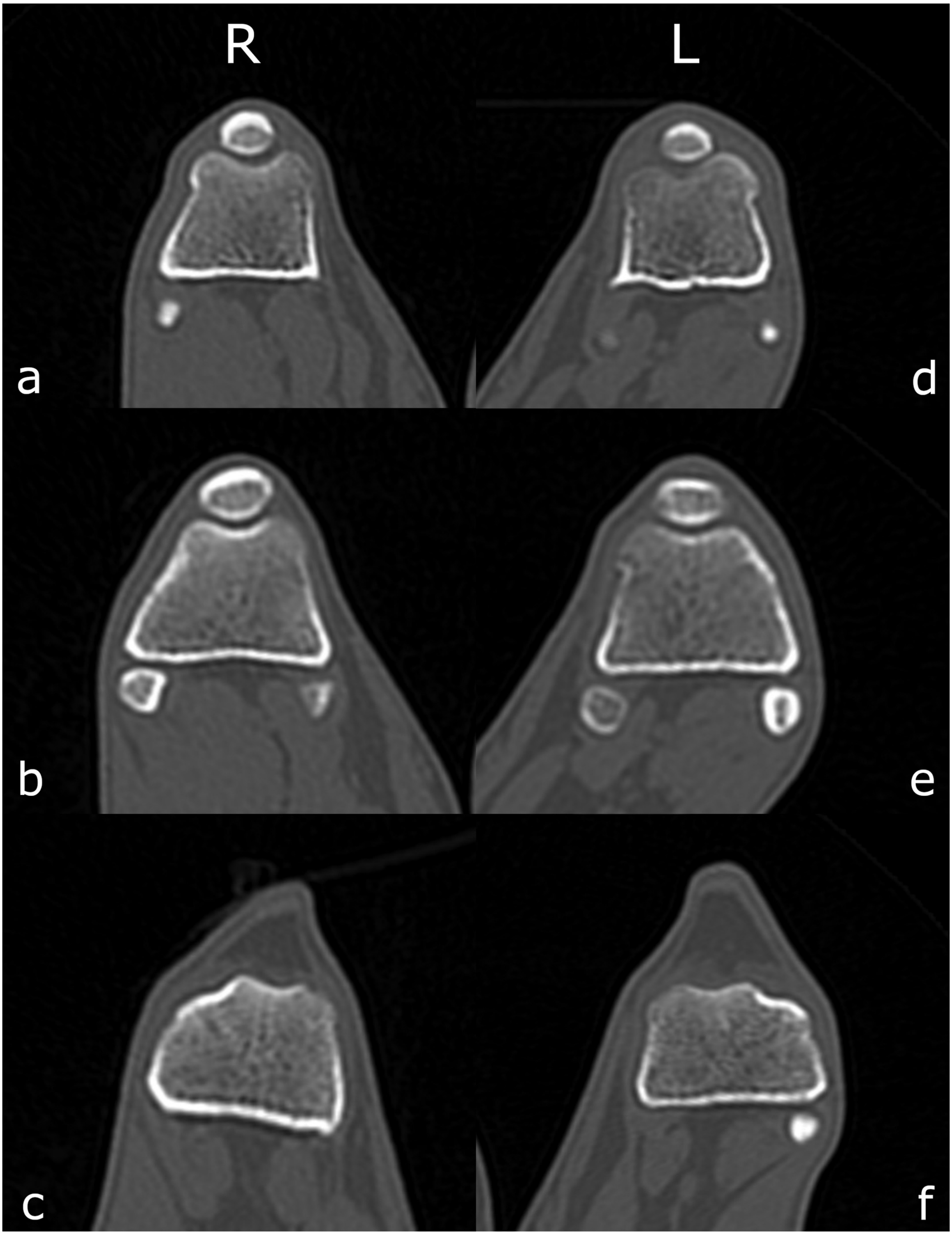

Fig. 3 Transverse computed tomographic images of the right (**A–C**) and left (**D–F**) distal femora reconstructed in a bone algorithm showing the proximal (**A** and **D**), mid (**B** and **E**) and distal (**C** and **F**) part of the femoral trochleae. Hypoplasia of the femoral trochleae is present bilaterally.

patellar ligament and quadriceps mechanism were deemed to be appropriate. This was an intraoperative subjective surgeon visual assessment completed by flexing and extending the stifle joint and noting the tracking and position of the patella and the direction of pull of the patellar ligament with reference to the relative positions of the patella (proximal) tibial tuberosity distal and the visible patellar ligament in-between. The patella was measured as 10 mm wide intra-operatively. An XACTO saw (Veterinary Instrumentation, Sheffield, United Kingdom) was used to create two

Table 1 Trochlear CT measurements from left and right stifles measured from transverse images as described by Towle et al[22]; the left and right trochlea were similar except that the trochlear grove was deeper proximally on the right side, and the lateral trochlear ridge was higher on the right side at distal and mid locations, but not proximally (see also ►**Fig. 3A–F**)

	Depth of trochlear groove (mm)			Height of lateral trochlear ridge (mm)		
	Proximal	Mid	Distal	Proximal	Mid	Distal
Left	1.6	1.9	1.6	2.9	1.6	1.0
Right	2.5	1.9	1.6	3.0	2.1	1.9

Abbreviation: CT, computed tomography.

osteotomies parallel to the trochlear ridges, 12 mm apart. A (10 mm wide) modular osteotome (Veterinary Instrumentation, Sheffield, United Kingdom) was used to create a third osteotomy perpendicular to the first two, creating the block. The block was then press-fit in its original position which yielded a block sulcoplasty 12 mm wide and 6 mm deep. Manual patellar luxation was not possible through a normal range of motion and prior to soft tissue closure.[13] Postoperative radiography confirmed appropriate positioning of the sulcoplasty block. The dog recovered well and was maintained postoperatively with methadone 0.2 mg/kg IV q4h and paracetamol 10 mg/kg IV q8h (Perfalgan, Bristol Myers-Squibb). The dog was discharged the following day with detailed instructions provided (**Supplementary Material 2**).

A telephone update reported that the dog was mildly lame at 2 weeks postoperatively but keen to exercise. Follow-up orthopaedic examination at 12 weeks found the patella tracked within the trochlear sulcus and there was mild quadriceps and hamstring atrophy. Subjective gait analysis found a mild (1/10) left pelvic limb lameness. The LOAD score had reduced from 14 to 12. The dog was discharged with instructions for ongoing physiotherapy to improve muscle bulk and continuing oral daily meloxicam for management of right coxofemoral pain.

Right-Sided THR and Associated Lateral Patellar Luxation

The dog was re-examined 12 months after left THR surgery and a right-sided THR, to address right-sided hip dysplasia and secondary osteoarthritis, was performed. A right-sided hybrid THR was performed with a 20mm cementless acetabular cup, cemented number 5 femoral stem and 13 mm (+0 mm) femoral head implant. Satisfactory implant positioning was confirmed except that cup impaction depth was suboptimal; measurements indicated AR 28.9 degrees, AI 135 degrees and ALO 42.8 degrees (►**Fig. 4A–D**). Femoral stem anteversion was appropriate. Recovery from the procedure was uneventful, with tentative weight-bearing on the right pelvic limb 24 hours following surgery. Right stifle grade II LPL was, however, present immediately after surgery whenever the dog flexed the right stifle. The dog was discharged with detailed instructions (**Supplementary Material 3**) and surgical intervention was scheduled for 4 weeks after THR if no improvement of the LPL was noted, during this period with medical management.

At 4 weeks post-right THR (as on the left side), no improvement was noted and surgical management of the right grade II LPL was planned as described previously.[24] A 12-mm-wide block sulcoplasty was performed as previously detailed. Congruency after block sulcoplasty was again judged to be excellent and manual luxation of the patella not possible. The dog was discharged 24 hours later with instructions as detailed in **Supplementary Material 4**.

Fourteen days postoperatively normal patellar tracking was confirmed and telephone follow-ups at 3 and 6 months reported progressive reduction in lameness. Final re-examination (33 months after the first THR and left LPL and 12 months after second THR and right LPL surgery) found the dog undertaking two miles of off-lead exercise daily without no reported mobility issues. Subjective gait evaluation found a mild (graded 0–1/10) right pelvic limb lameness and both patellae were in place with normal tracking. A clinical metrology score (LOAD) of 2 revealed a marked improvement from the original score of 14.

Discussion

Lateral patellar luxation occurs less frequently than medial patellar luxation, representing approximately 19% of cases of patellar luxation in medium breed dogs.[8] Skeletal deformities associated with LPL include distal femoral valgus, lateral condylar dysplasia, patella baja, and genu valgum.[11,12,22] Lateral patellar luxation occurring in skeletally immature dogs may lead to a shallow or absent trochlear groove resulting in progressive wearing of the lateral trochlear ridge increasing instability and the tendency to luxate.[11,25]

Patella baja has been associated with LPL[12] and was present on preoperative radiographs in this case, although LPL was not present before THR surgery. Hypoplastic lateral trochlear ridges and bilaterally shallow trochlear grooves were identified at CT examination and surgery. These were not identified on preoperative THR templating radiographs; there was no indication to perform stifle CT any earlier as the dog showed no clinical signs of patellar luxation prior to THR surgery, including multiple detailed orthopaedic examinations by numerous orthopaedic clinicians including board-certified surgeons.

We cannot be sure why this dog developed LPL post-left and right THR surgery. We reason that this was due to a combination of the hypoplastic lateral trochlear ridges and an imbalance of quadriceps mechanism versus femoral

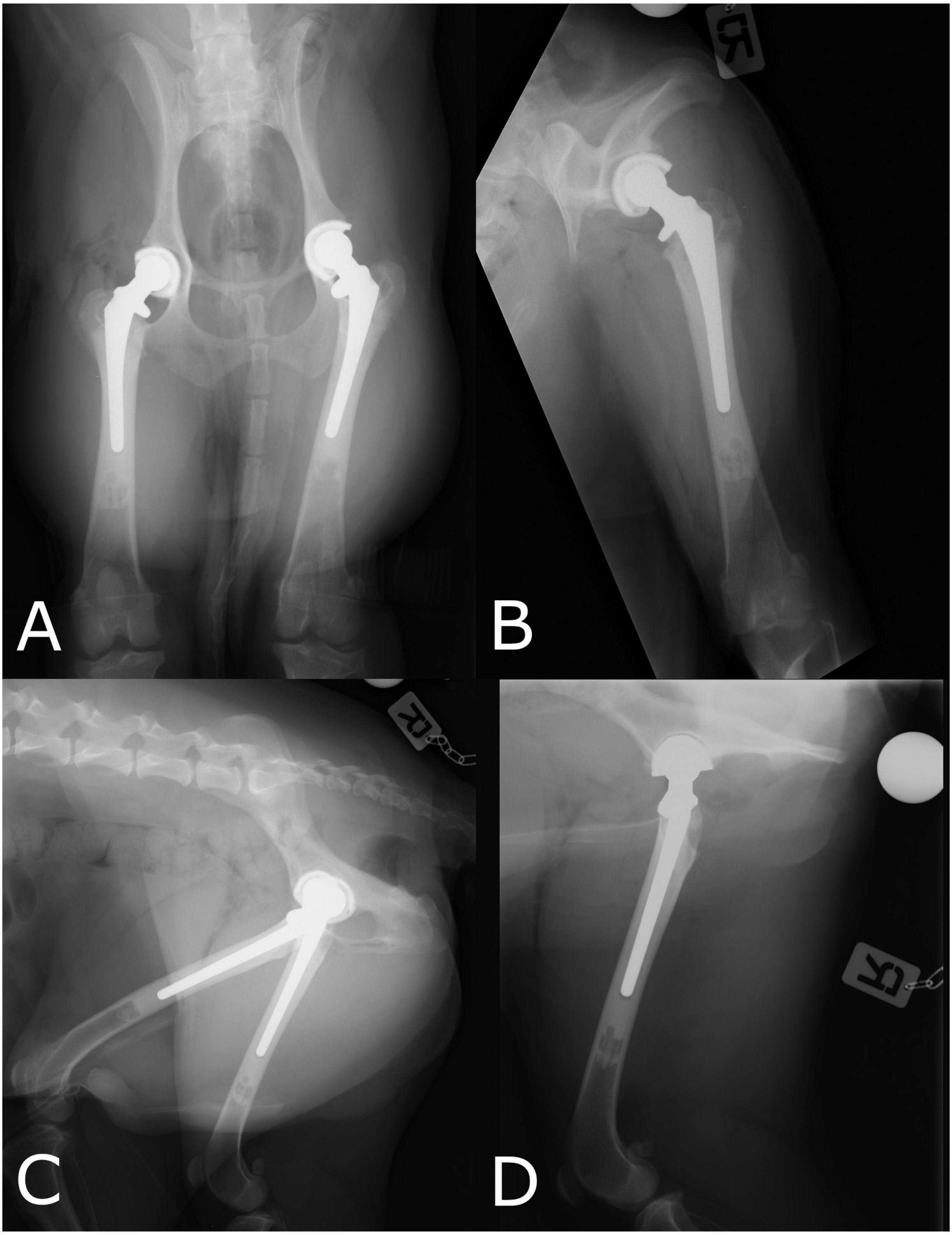

Fig. 4 Postoperative radiographic ventrodorsal extended hip joint view (**A**), caudocranial right femoral view (**B**), lateral pelvic view (**C**) and (**D**) mediolateral open-leg right femoral view of the dog after right total hip replacement. The radiographs show satisfactory implant positioning with appropriate retroversion of the acetabular angle, angle of lateral opening, femoral inclination and femoral stem anteversion. Cup impaction depth is considered suboptimal.

trochlear alignment and that have been exacerbated by the dog holding its femora in a more internally rotated position post-THR compared with pre-THR. Such changes in femoral axial alignment in the dog would be very difficult to assess accurately in the standing conscious dog and have not previously been reported in dogs. Similar changes in femoral axial alignment after THR have been described in humans, with a mean increase in internal femoral rotation of 11 degrees.[15]

The alignment of the THR components was considered to be within normal /acceptable limits postoperatively. Assessment of acetabular component positioning postoperatively was very close to the commonly accepted target of 34 to 45 degrees for ALO[5] and 15 to 25 degrees of retroversion[16] for both hips. The left cup was very mildly open 46.7 degrees, and retroversion was ideal at 19.4 degrees. The right cup had an ideal ALO of 42.8 degrees and slightly more retroverted than ideal with an AR of 28.9 degrees. It is a complex argument to determine the consequence of THR implant positioning and alignment on limb carriage vs hip luxation. Certainly, luxation can occur following malalignment and neck-cup impingement, but an absolute or direct relationship has been difficult to prove.[7] It is possible that implant mal-positioning could lead to altered carriage of the femur relative to the pelvis. However, as femoral versus pelvic bone position is constrained by peri-articular soft tissue tension, it seems unlikely that THR implant mal-position or relative mal-alignment would lead to altered carriage or position of the femur, and that this would rather be affected by peri-articular soft tissue tension and/or pain. Peri-articular soft tissue tension would be altered by changes in relative neck length with increases in neck length increasing soft tissue tension and reduced or lost neck length resulting in reduced soft tissue tension. A 'tight' THR at the time of reduction typically has increased soft tissue tension and the limb may be held externally rotated in the early postoperative period. By contrast, this dog may have had relative loss of neck length resulting in reduced soft tissue tension and therefore possible internal rotation of the femur but no gross reduction in neck length was identified on the postoperative radiographs.

The surgical management of LPL is primarily aimed at addressing abnormal alignment of patellar tendon/quadriceps mechanism and deepening the trochlear groove.[13] However, due to a paucity of data on LPL, many conclusions have been extrapolated from MPL data.[24] Trochlear block recession sulcoplasty was considered the most important component of correcting the LPL in this case due to the hypoplastic lateral trochlear ridges and consequent shallow sulcus.[23] In other words, the judgment of the surgeon was that LPL could be more reliably corrected by block recession sulcoplasty rather than tibial tuberosity transposition; given the shallow trochlear sulcus, the risk with tibial tuberosity transposition would be that under-correction could lead to recurrent LPL, whereas over-correction could lead to medial patellar luxation. It is possible that medial tibial tuberosity transposition would have been equally effective in controlling the dog's LPL. In one evaluation of post-surgical recurrent LPL, sulcoplasty was found to be the only surgical treatment that was shown to significantly reduce re-luxation.[24]

In conclusion, we report a case of a dog that developed bilateral LPL immediately following staged Biomedtrix hybrid THR. This is a previously unreported and apparently rare complication of canine THR surgery; it may have occurred due to the presence of predisposing factors to LPL, such as hypoplastic femoral trochlear sulcus/lateral trochlear ridge combined with internal femoral rotation, which were exacerbated by the changing biomechanical forces post-THR. The LPL was successfully corrected by femoral trochlear block recession sulcoplasty in both cases 4 and 10 weeks after THR surgery with complete return to full activity and excellent client reported mobility scores 33 months following the initial THR surgery.

Ethical Statement

Permission to use the case details in this case report was given with full owner consent and used under generic institutional ethical permission for use of clinical case material in research.

Authors' Contributions

It is with great sadness and regret that ASM sadly passed away in July 2020 and therefore this manuscript is being submitted in her memory and as testament to her great diligence and care with her patients.

ASM, EC, FS and GA contributed substantially to the conception, study design or acquisition of data, as well as participation in the analysis and interpretation of data. ASM, EC and GA were involved in drafting of the article or revising it critically for important intellectual content. EC, GA and FS (ASM sadly passed away in July 2020) were involved in approval of the submitted version of the manuscript, all revised versions and the final version to be published. EC, GA and FS agreed to be publicly accountable for the appropriate portions of the content.

Funding

None

Conflict of Interest

The authors have no conflict of interest.

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