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Femoral impingement after pelvic fracture in a dog

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Abstract: A 4-year-old intact male mixed-breed dog was evaluated for persistent pelvic limb pain and worsening weight-bearing after a road traffic accident that caused multiple pelvic fractures. Initial surgical stabilisation of the right iliac body was performed; however, pain and mechanical restriction of hip motion became more evident during early recovery. Follow-up computed tomography (CT) with three-dimensional reconstruction demonstrated direct contact between a laterally displaced ischial bone fragment and the femoral neck and proximal femur. Revision surgery was performed to remove the interfering bone while preserving pelvic stability. Through a lateral approach to the hip with greater trochanter osteotomy, the prominent ischial edge was contoured until impingement was no longer detected intraoperatively. Postoperative CT confirmed increased clearance between the pelvis and the proximal femur. Serial radiography showed maintained implant stability and progressive healing, and pressure-sensing walkway analysis at 2, 4, and 8 weeks after the revision demonstrated progressive improvements in limb loading and kinetic symmetry. This case report identifies post-traumatic femoral impingement caused by a displaced ischial bone fragment as a clinically relevant source of pain after pelvic fracture and highlights the value of repeat cross-sectional imaging and targeted osteoplasty in selected dogs.

Keywords: coxofemoral joint; gait analysis; osteoplasty; three-dimensional reconstruction

Pelvic fractures are common orthopaedic injuries in dogs and cats, accounting for approximately 16–32% of all fractures, and are most often associated with high-energy trauma, such as vehicular accidents or falls (Phillips 1979; Bouabdallah et al. 2020). The pelvis is surrounded by substantial musculature and has an abundant extraosseous blood supply, which may favour fracture healing (DeCamp et al. 2015). Acceptable long-term clinical outcomes have also been reported for select conservatively managed pelvic fractures (Bouabdallah et al. 2020). Pelvic limb load transfer occurs along a weight-bearing axis, which includes the acetabulum, ilium, sacroiliac joint, and sacrum. Fractures involving this axis are generally managed with surgical reduction and internal fixation to restore alignment and allow for early weight bearing (DeCamp et al. 2015). Previous studies have described radiographic and implant-related outcomes after the repair of canine ilial fractures. Locking plate constructs have been associated with a lower risk of short-term implant failure than non-locking constructs in dogs with iliac body fractures (Breshears et al. 2004; Petrovsky et al. 2021). In contrast, pubic and

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ischial fractures are usually managed without fixation because they do not contribute substantially to weight-bearing during ambulation (DeCamp et al. 2015). Nevertheless, the displacement of caudal pelvic fracture fragments should be assessed individually, particularly when there is a concern about instability, pelvic canal narrowing, articular involvement, or mechanical interference with adjacent structures.

Persistent pelvic limb lameness and gait asymmetry have been reported in some dogs after suffering pelvic fractures (Vassalo et al. 2015; Bouabdallah et al. 2020). Potential causes include malunion with pelvic deformity, pelvic canal narrowing, acetabular involvement with secondary coxofemoral osteoarthritis, and, less commonly, neurological injury (Jacobson and Schrader 1987; DeCamp et al. 2015). Femoral impingement caused by displaced caudal pelvic bone fragments has not been previously described in dogs. This report describes femoral impingement caused by direct contact between a displaced caudal pelvic bone fragment and the proximal femur, together with surgical relief from focal osseous conflict. Pre- and postoperative computed tomography (CT) with three-dimensional reconstruction was used to define the underlying spatial relationship and document the effects of osteoplasty. We evaluated clinical and functional improvements by serial radiography and objective gait analysis.

Case description

A 4-year-old intact male mixed-breed dog (8.9 kg; body condition score 5/9) was referred to us for severe pelvic limb pain and reduced weight bearing 5 days after a road traffic accident. The dog was bright and responsive but could only stand with minimal pelvic limb support. Physical examination revealed a heart rate of 150 beats/min, respiratory rate of 36 breaths/min, rectal temperature of 39.2 °C, capillary refill time of <1.5 s, and indirect systolic blood pressure of 120 mmHg. Pain was elicited on manipulating both coxofemoral joints. Withdrawal reflexes and superficial nociception were intact in both pelvic limbs, and rectal examination was unremarkable.

Complete blood count and electrolyte analysis results were within the reference range. Serum biochemistry showed marked increases in alanine aminotransferase (1 035.9 IU/l; reference range, 19–70 IU/l) and aspartate aminotransferase (284 IU/l; reference range, 15–43 IU/l) levels and mild increases in alkaline phosphatase (180 IU/l; reference range, 15–127 IU/l) and gamma-glutamyl transferase (7 IU/l; reference range, 0–6 IU/l) levels, which improved upon serial re-evaluation. Urinalysis identified bilirubinuria. Thoracic radiography (GXR-SD series; DRGEM, Gwangmyeong-si, Gyeonggi-do, Republic of Korea) revealed complete transverse fractures of the right fourth and fifth ribs without other thoracic abnormalities. Pelvic radiography revealed multiple closed fractures involving both hemipelves (Figure 1A,C), including a displaced long oblique fracture of the right iliac body, displaced transverse fracture of the right pubis, incomplete fracture of the right ischial table, complete transverse fracture of the left pubis, and complete fracture of the left ischiatic table. Three-dimensional CT reconstructions (Alexion; Canon Medical Systems Corporation, Otawara, Tochigi, Japan) were used to further define the fracture configuration and fragment relationships (Figure 1B,D). An incidental lumbosacral transitional vertebra with S1 lumbarisation was also identified.

Surgical stabilisation of the right iliac body was performed the following day. Premedication consisted of midazolam (0.2 mg/kg i.v., Bukwang Midazolam Injection; 3 mg/3 ml, Bukwang Pharmaceutical Co., Ltd., Seoul, Republic of Korea) and butorphanol tartrate (0.2 mg/kg i.v., Butopan Injection; 2 mg/ml, Myungmoon Pharm. Co. Ltd., Seoul, Republic of Korea). Anaesthesia was induced with propofol (6 mg/kg i.v., Anepol Injection; 10 mg/ml, Hana Pharm Co., Ltd., Seoul, Republic of Korea) and maintained with isoflurane (Ipran solution; Hana Pharm Co., Ltd., Seoul, Republic of Korea) in oxygen. Perioperative analgesia consisted of a fentanyl–lidocaine–ketamine constant-rate infusion (fentanyl 3.6 μg/kg/h, lidocaine 3 mg/kg/h, ketamine 0.6 mg/kg/h), which was continued for 3 days postoperatively. Cefazolin (22 mg/kg i.v., Cefazolin CKD 1 g; Chong Kun Dang Pharmaceutical Corp., Seoul, Republic of Korea) was administered preoperatively and every 90 min intraoperatively.

With the patient placed in the lateral recumbent position, the fracture was reduced with Kern forceps and stabilised with a 2.0-mm titanium locking T-plate (Jeil Medical, Seoul, Republic of Korea)

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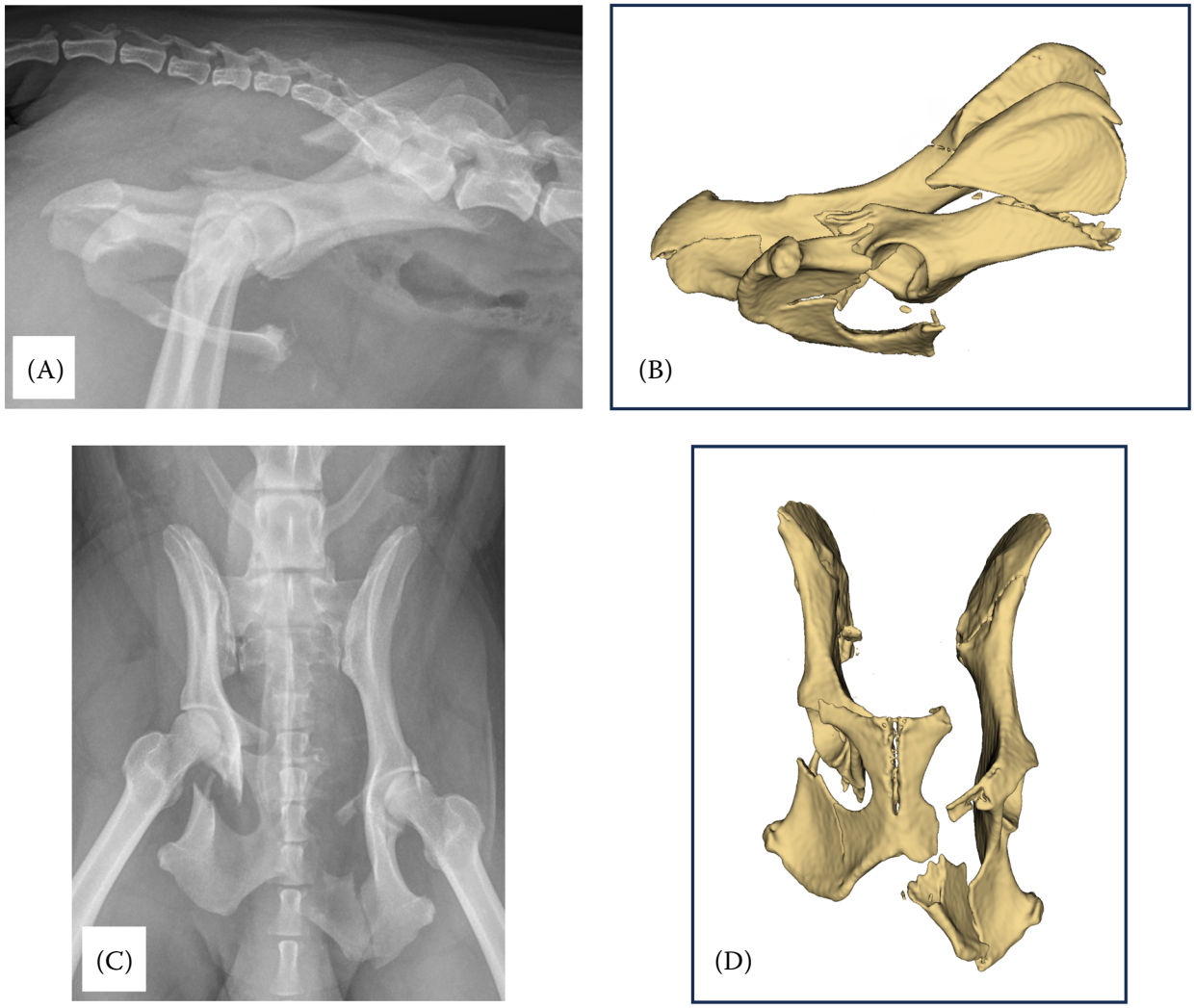


Figure 1. Preoperative pelvic radiographs and three-dimensional CT reconstructions
(A) Mediolateral pelvic radiograph. (B) Three-dimensional CT reconstruction with the right hemipelvis (fracture side) in view. (C) Ventrodorsal pelvic radiograph. (D) Three-dimensional CT reconstruction in a ventrodorsal view

and three bicortical locking screws in each main fragment. The alignment and implant position were confirmed fluoroscopically using a mobile C-arm unit (OEC Elite CFD; GE Healthcare, Chicago, IL, USA), and postoperative radiographs were obtained (Figure 2A). The dog was hospitalised for 5 days, during which a balanced isotonic crystalloid solution was administered at a maintenance rate of 2.5 ml/kg/h i.v. (Plasma Solution A Inj.; HK inno.N, Cheongju, Republic of Korea), and cryotherapy, passive range-of-motion (ROM) exercises, and assisted weight bearing were performed twice daily. Carprofen (2.2 mg/kg p.o. q12h, Rimadyl; Zoetis, Parsippany, NJ, USA) and esomeprazole (1 mg/kg p.o. q12h, Nexium; AstraZeneca Korea, Seoul, Republic of Korea) were prescribed for 7 days. Cefazolin (22 mg/kg i.v. q8h) was administered during hospitalisation and changed to cephalexin (22 mg/kg p.o. q8h; Dong Wha Pharmaceutical Co., Ltd., Seoul, Republic of Korea) after discharge to complete a 7-day course. Before the initial surgery, the patient was unable to bear weight on the pelvic limbs. During hospitalisation following initial surgery, the patient showed visible, progressive improvement in weight-bearing and was discharged with improved ambulation.

However, 3 weeks postoperatively, the patient returned for re-evaluation because the lameness had worsened markedly, and the patient was unable to bear any weight on the affected limb. Subsequent ventrodorsal pelvic radiography (Figure 2B) and three-dimensional CT reconstructions demon-

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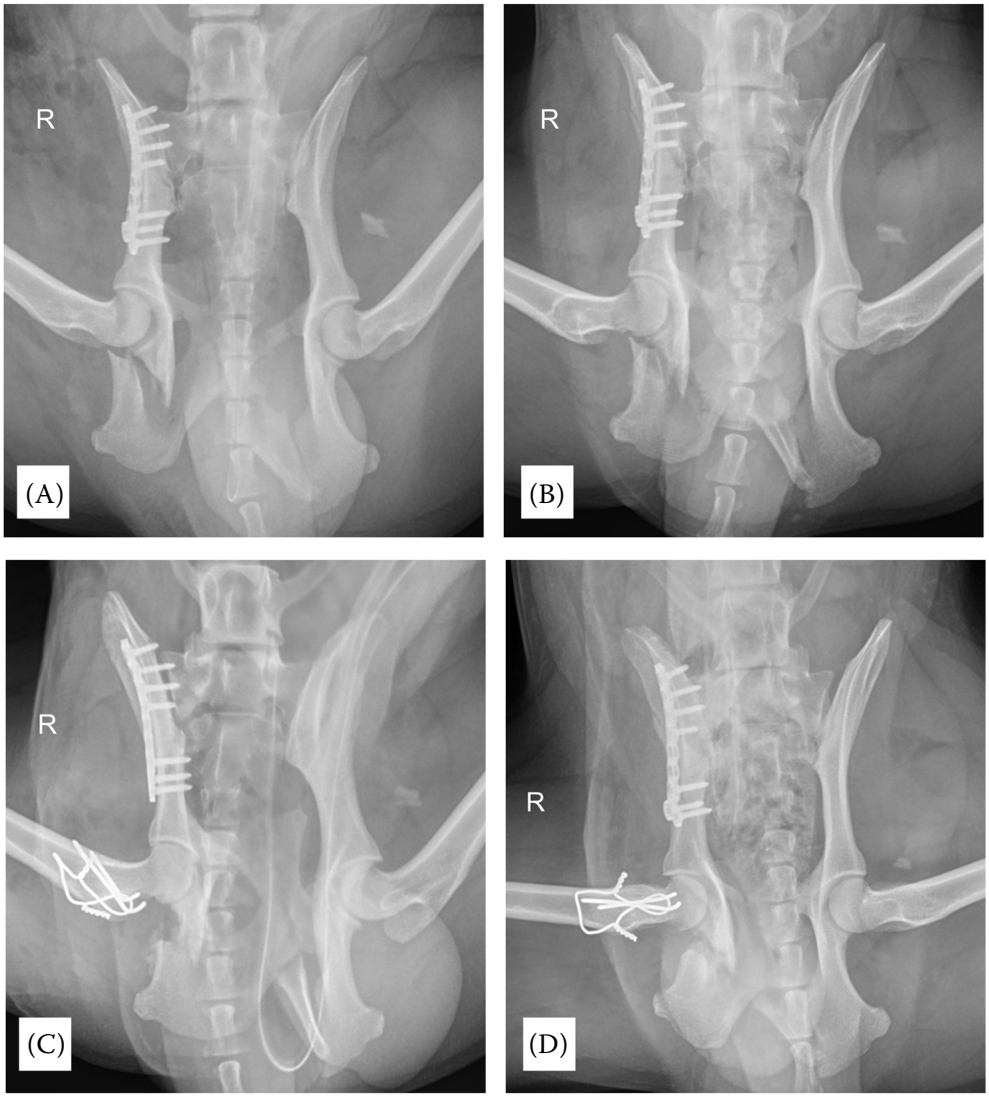


Figure 2. Ventrodorsal pelvic radiographs across the surgical timeline

(A) After the initial surgery, showing fixation of the right iliac fracture with a locking T-plate. (B) Before revision surgery. (C) After revision surgery, including stabilisation of the greater trochanter osteotomy with pins and tension-band wiring. (D) Four-week follow-up after revision surgery, showing stable implants and progressive healing

strated focal femoral impingement caused by a displaced caudal pelvic fragment (Figure 3A,B). Based on these clinical and imaging findings, revision surgery was performed 4 days later. A lateral approach to the craniodorsal and caudodorsal aspects of the hip joint was performed via osteotomy of the greater trochanter combined with tenotomy of the conjoined tendon of the internal obturator and gemelli muscles (Johnson 2013). The sciatic nerve was then identified and protected with a Penrose drain to facilitate the exposure of the caudal acetabular and ischial regions. The protruding fragment was removed using rongeurs and further contoured with a high-speed burr until impingement was no longer detected during hip manipulation under fluoroscopic guidance (Figure 4). The conjoined tendon was reattached with 2-0 nylon passed through the drill holes in the intertrochanteric fossa, and the greater trochanter osteotomy was stabilised with 1.2-mm pins and 1.0-mm tension-band wiring. Routine layered closure was performed.

The dog remained hospitalised for 5 days after revision surgery, during which a balanced isotonic crystalloid solution (Plasma Solution A Inj.; HK inno. N, Cheongju, Republic of Korea), the same fentanyl–lidocaine–ketamine constant-rate infusion for 3 days, and cefazolin (22 mg/kg i.v. q8h), carprofen (2.2 mg/kg s.c. q12h), and esomeprazole

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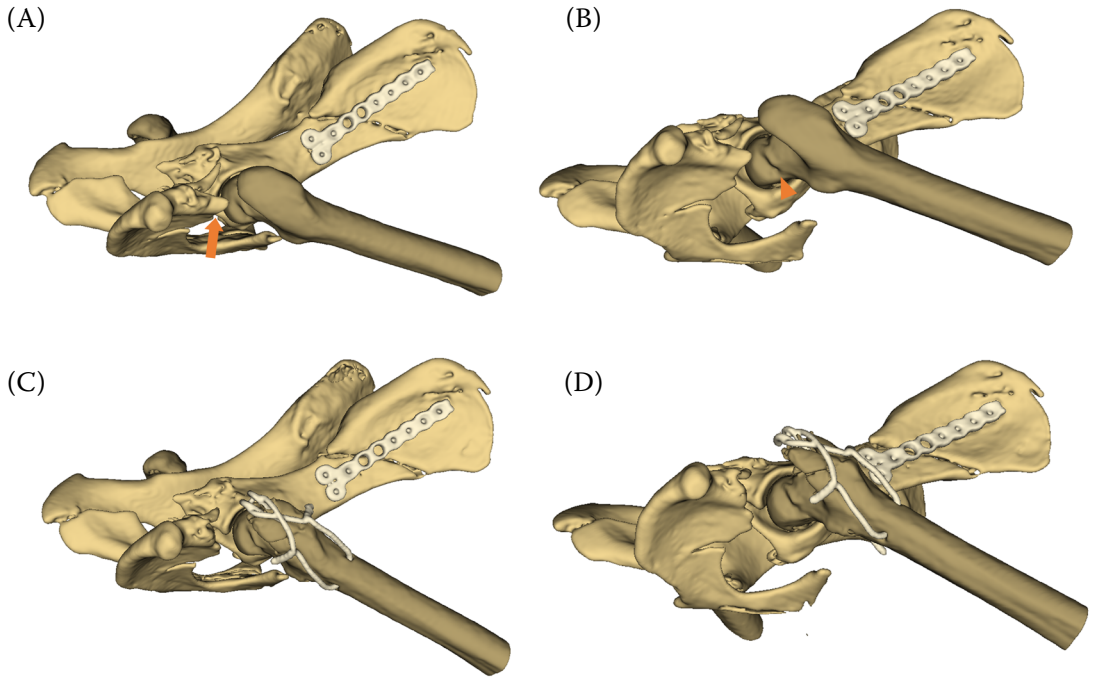


Figure 3. Three-dimensional CT reconstructions of the right hemipelvis and proximal femur before and after revision surgery

(A,B) Pre-revision reconstructions shown from the fracture side and in a slightly oblique projection; the suspected impingement site is indicated by an arrow (A) and abrasion of the proximal femur by an arrowhead (B). (C,D) Post-revision reconstructions demonstrating removal of the impinging ischial fragment and improved clearance between the proximal femur and pelvis

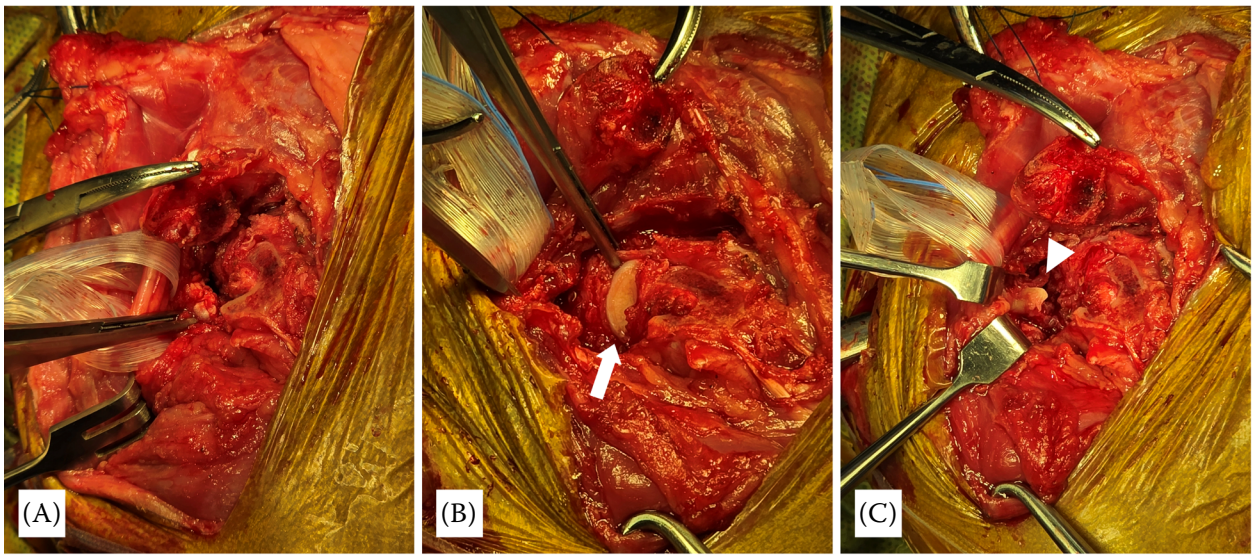


Figure 4. Intraoperative photographs obtained during revision surgery

(A) The sciatic nerve was identified and protected with a Penrose drain, and a greater trochanter osteotomy was performed to improve access to the caudal acetabular/ischial region. (B) Abrasion of the proximal femur consistent with bony impingement (arrow). (C) The impinging bony prominence on the ischial region is indicated (arrowhead)

(1 mg/kg i.v. q12h) were administered. At discharge, esomeprazole (1 mg/kg p.o. q12h), carprofen (2.2 mg/kg p.o. q12h), and cephalexin were prescribed for 5 additional days. Rehabilitation consisted of cryotherapy, passive ROM exercises, assisted weight-bearing, and controlled leash walk-

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ing. No mechanical restriction of the hip motion was detected postoperatively. Immediate postoperative radiographs showed removal of the impinging osseous prominence and fixation of the greater trochanter osteotomy site after revision surgery (Figure 2C). At the 4-week follow-up, radiographs showed mild callus formation and progressive pelvic canal narrowing, and the greater trochanter osteotomy site showed radiographic features consistent with direct bone healing (Figure 2D). Post-revision three-dimensional CT reconstructions confirmed removal of the impinging fragment and increased clearance between the proximal femur and pelvis (Figure 3C,D). Objective gait analysis was performed using a pressure-sensing walkway (Walkway; Tekscan Inc., Norwood, MA, USA) 2, 4, and 8 weeks after revision surgery. The dog traversed the walkway under consistent conditions using the same handler, and five valid walking trials were conducted at each time point. Peak vertical force (PVF) was recorded as % body weight (%b.w.), and vertical impulse (VI) was recorded as % b.w.·s. Right hindlimb weight distribution was calculated as the PVF of the right hindlimb divided by the sum of PVFs of all four limbs ×100. The pelvic limb symmetry index (SI) was calculated from PVF as $[(X_L - X_R)/(0.5 \times (X_R + X_L))] \times 100$, where X_L and X_R represent the left and right hindlimb PVF values, respectively. In this case, a hindlimb SI value <6% was considered compatible with physiological gait symmetry based on previous canine gait studies (Budsberg et al. 1993; Boddeker et al. 2012; Lorke et al. 2017). Right hindlimb PVF increased from 35.38 ± 1.31 %b.w. at 2 weeks to 72.32 ± 6.60 %b.w. at 4 weeks and 79.08 ± 5.06 %b.w. at 8 weeks. Right hindlimb VI increased from 3.26 ± 0.38 to 4.00 ± 0.82 and 4.96 ± 0.27 % b.w.·s, whereas right hindlimb weight distribution increased from 14.71 ± 1.14% to 17.01 ± 1.04% and 18.83 ± 0.61%. The PVF-based SI decreased from 32.88 ± 9.54% to 17.97 ± 8.02% and 5.89 ± 2.23%, indicating progressive restoration of limb loading and gait symmetry (Figure 5).

DISCUSSION

Complex pelvic fractures in dogs may involve the ilium, pubis, and ischium, and treatment commonly focuses on the reduction and stabilisation of the ilium to restore pelvic alignment and stability. Fractures of the pubis and ischium are often managed without fixation unless pelvic canal compromise, hip instability, or marked displacement are present (DeCamp et al. 2015; Bouabdallah et al. 2020). To the best of our knowledge, femoral impingement caused by a displaced ischial fracture fragment has not been previously reported in dogs. In the present case, persistent and worsening pain and lameness were associated with contact between a displaced ischial bone fragment and the proximal femur during hip motion, as demonstrated by follow-up CT with three-dimensional reconstruction (Figure 3A,B). This case indicates that femoral impingement should be considered when pain and lameness persist or worsen after a pelvic fracture.

Persistent pelvic limb lameness and gait asymmetry have been reported in some dogs after pelvic fractures despite apparent fracture healing (Vassalo et al. 2015; Bouabdallah et al. 2020). However, the structural basis for these signs has not yet been elucidated. In the present case, repeated clinical examinations and follow-up imaging supported direct

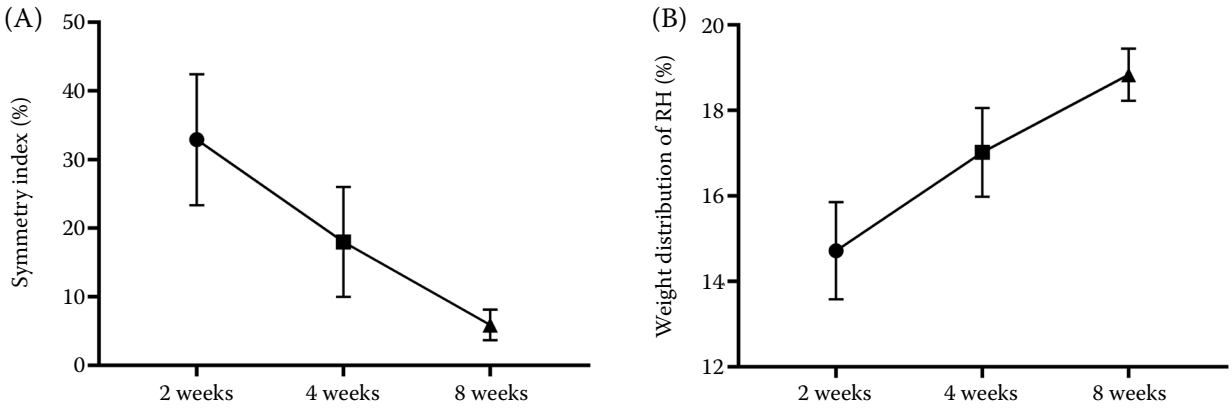


Figure 5. Pressure-sensing walkway gait parameters at 2, 4, and 8 weeks after revision surgery
(A) Symmetry index (%). (B) Weight distribution of the right hindlimb (RH, %). Data are presented as mean ± SD

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mechanical contact between the displaced ischial fragment and the proximal femur as the source of pain. Displaced pelvic fragments cause complications such as pelvic canal narrowing and obstruction (Costa et al. 2018). This case suggests that they may also cause morbidity through extrapelvic mechanical interference with femoral motion.

The fracture configuration likely contributed to the impingement. Bilateral pubic fractures combined with a right ischial table fracture permitted translation of the ventral pelvic segment, orienting the ischial fracture margin toward the proximal femur (Figure 1). This altered three-dimensional relationship placed the fracture edge within the hip's excursion envelope and predisposed the dog to repetitive contact during hip motion. Delayed worsening may have become more evident as post-traumatic swelling and muscle guarding subsided and an early callus formed, reducing clearance between the displaced fragment and the proximal femur in certain hip positions. A similar delayed mechanical problem has been described in dogs with distal femoral malunion, in which ostectomy of the offending osseous prominence relieved the lameness (Jones et al. 2021).

Pelvic canal narrowing after pelvic fracture repair has been described previously, and severe narrowing may be associated with recurrent constipation in cats (Hamilton et al. 2009). Potential complications of pelvic canal narrowing include constipation, tenesmus, obstipation, and, in breeding females, dystocia during parturition, which may pose serious risks to both the dam and offspring. However, in dogs, radiographic narrowing of the pelvic canal does not necessarily correlate with clinically relevant constipation, and postoperative pelvic canal narrowing after ilial fracture repair may occur in association with implant failure and loss of reduction, particularly screw loosening or pullout and plate bending (Averill et al. 1997; Petrovsky et al. 2021). In the present case, the sacral index, calculated on ventrodorsal pelvic radiographs as the ratio between the width of the sacrum at the cranial border and the width of the pelvic canal at the narrowest point, between the medial cortices of the acetabulae, increased from 1.288 preoperatively to 1.375 immediately before revision surgery, 1.513 immediately after revision surgery, and 1.66 at 4 weeks after revision, indicating progressive radiographic narrowing over time. This change may have been influenced by several factors, including a complex fracture configuration with concurrent pubic fractures, femoral impingement before revision surgery, implant stiffness, intraoperative manipulation during revision, and minor variations in serial radiographic positioning. Despite this radiographic progression, the dog did not develop constipation, tenesmus, or other clinical signs attributable to pelvic canal narrowing during follow-up.

Continuous monitoring is warranted, as progressive pelvic canal narrowing may become clinically relevant over time. Long-term management should include owner education and periodic clinical and radiographic reassessment, particularly for constipation, tenesmus, obstipation, dyschezia, changes in faecal size or shape, or recurrent pelvic discomfort. If clinical signs develop, initial management may include dietary modification, stool softeners or laxatives, and repeat imaging to reassess the pelvic canal diameter, colonic distension, fracture alignment, and implant stability. Severe or recurrent obstipation should prompt patient stabilisation, evacuation of retained faeces when necessary, and evaluation of structural obstruction. If clinical signs persist despite medical management, surgical options to relieve pelvic canal narrowing, such as removal of the obstructing bone, corrective osteotomy, pelvic canal widening procedures, or partial internal hemipelvectomy in selected cases, may be considered based on the underlying cause and severity of the clinical signs. In chronic cases with irreversible colonic dysfunction or megacolon, subtotal colectomy may be required.

Follow-up imaging is important for localising the source of pain. Previous studies have compared computed tomography and conventional radiography for evaluating pelvic fractures in dogs (Crawford et al. 2003; Stieger-Vanegas et al. 2015). Survey radiography suggested abnormal contact between the displaced caudal pelvic fragment and proximal femur, but repeat CT with multiplanar assessment and three-dimensional reconstruction allowed more direct characterisation of the mechanical impingement and clarified its precise spatial relationship. This additional information helped plan revision surgery.

Revision surgery was directed at eliminating focal osseous contact while preserving pelvic stability. Although internal fixation of the caudal pelvic fragment could have been considered, the initial surgical priority was the stabilisation of the iliac body

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as the main component of the pelvic weight-bearing axis, whereas revision was directed at relieving focal mechanical impingement. In addition, revision was performed approximately 4 weeks after the initial procedure, when early callus formation and mild muscle contracture had already developed, and additional implant placement in the caudal pelvic region would have required further dissection in the limited anatomical space in this relatively small dog (8.9 kg). After intraoperative confirmation of impingement, osteoplasty was performed to remove and smooth the prominent ischial margins. In human orthopaedics, femoroacetabular impingement is recognised as a source of hip pain caused by abnormal osseous contact during joint motion, and surgical treatment aims to improve clearance when structural conflict persists (Ganz et al. 2003; Pierannunzii 2019). Although the lesion in this dog was post-traumatic rather than developmental, the same mechanical principle supported osteoplasty. Greater trochanteric osteotomy was performed to improve exposure, as described for canine hip surgery (Silveira and Saunders 2022). Because sciatic nerve injury is a recognised concern in pelvic trauma and pelvic-region surgery, the nerve was identified and protected throughout the procedure, and no postoperative neurologic deficits were observed (Jacobson and Schrader 1987; Harasen 2007; Dell'Apa et al. 2024). Therefore, in selected cases, targeted osteoplasty may be considered when a focal bony prominence causes mechanical interference and pelvic stability is maintained.

The objective gait assessment supported the clinical improvement observed in this case. Pressure-sensing walkway studies have shown that gait asymmetry may persist after sustaining pelvic fractures despite apparent healing (Vassalo et al. 2015). In previous canine gait studies, hindlimb SI values <6% have been considered compatible with physiological gait symmetry (Budsberg et al. 1993; Boddeker et al. 2012; Lorke et al. 2017). In this dog, serial kinetic assessment demonstrated progressive improvement after osteoplasty, and the mean PVF-based SI at 8 weeks (5.89 ± 2.23%) approached this previously reported range, supporting the clinical relevance of the identified bony contact (Figure 5).

This study had some limitations. This report describes a single case; therefore, the frequency of this complication and its associated risk factors cannot be determined. Although gait analysis has documented functional improvements after osteoplasty, follow-up remains limited for assessing long-term outcomes and recurrence.

This case report describes femoral impingement caused by a displaced ischial bone fragment as a source of pain after a pelvic fracture. Cross-sectional imaging was useful for defining the relationship between the pelvic fragment and proximal femur and for guiding interventions. In this dog, osteoplasty of the impinging ischial margin resulted in clinical and objective functional improvements, suggesting that targeted osteoplasty may be considered in selected cases in which pelvic stability is maintained and focal bony contact is identified. Additional cases are required to better define the indications and outcomes.

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Conflict of interest

The authors declare no conflict of interest.

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