Case Report

An Undetermined Osteoporotic Disease Managed with IM Rod in a Dog

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Abstract

Osteoporosis is a systemic bone disorder characterized by decreased bone density, which can weaken bone strength and increase the risk of fractures. Osteogenesis imperfecta (OI), one of the main causes of osteoporosis in children, results in fragile bones and multiple fractures. The present study documented the case of a dog with an undetermined osteoporotic disease managed with intramedullary rod fixation. A 3-month-old intact male Alaskan Malamute dog, weighing 11.6 kg, was presented with lameness in the left pelvic limb. Radiography revealed left pelvic and femoral fractures, and the cortex of the long bones was thin. On CT scanning, a significant decrease in trabecular bone mineral density (BMD) was observed compared with normal dogs. Hyperparathyroidism was ruled out on the basis of blood tests and ultrasonography. Histopathological examination of the fragmented bone revealed remodeling with no evidence of neoplasia. Genetic testing could not differentiate OI in the dog, therefore an undetermined osteoporotic disease was tentatively diagnosed. Fractures were managed using multiple intramedullary rods. Although the trabecular BMD further decreased and additional surgery was required due to the migration of inserted rod and additional fracture, body weight of the dog was increased from 11.6 kg to 28.6 kg during the follow-up. The clinical symptoms, including pain and lameness, improved. Taken together, rodding surgery might be a viable option for dogs with pathological fractures due to osteoporotic disease by distributing weight and preventing bending force.

Keywords: osteoporosis, osteogenesis imperfecta, fracture, intramedullary rod, dog

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Introduction

Osteoporosis is characterized by a systemic decline in bone mass and microarchitecture, leading to an increased susceptibility to fragile fractures (Rancher *et al*., 2011). Osteoporosis in children can occur because of diverse conditions, including metabolic disorders and nutritional deficiencies (Krassas, 2006). Osteogenesis imperfecta (OI), also known as brittle bone disease, is one of the main causes of primary osteoporosis in children owing to mutations in genes encoding type Ⅰ collagen (Gold *et al*., 2019; Campbell *et al*., 2000). It is characterized by bone fragility, skeletal deformities, and short stature (Kang *et al*., 2017). The clinical management of undetermined osteoporotic diseases, such as OI, includes physical rehabilitation, orthopedic surgery, and pharmacological therapies, such as bisphosphonates (Forlino *et al*., 2011). The placement of intramedullary rods can be performed to correct deformities and manage fracture recurrence (Forlino *et al*., 2011). Although the surgical stabilization of osteoporotic bone disease has been documented in veterinary medicine (Evason *et al*., 2007; Kim *et al*., 2020), OI-affected individuals are often euthanized because of their poor quality of life (Gold *et al*., 2019; Tse *et al*., 2021). From this point of view, this study reports an undetermined osteoporotic disease managed with multiple intramedullary rods for 10 months in an Alaskan Malamute dog.

Case description

A 3-month-old intact male Alaskan Malamute dog, weighing 11.6 kg, presented to the Veterinary Teaching Hospital with a fracture in the left pelvic limb of unknown cause. Upon physical examination, the dog exhibited toe-touching lameness in the left pelvic limb and showed signs of pain upon manipulation. Radiography confirmed fractures in the left ilium and femur. The cortex of long bones was thin (Fig. 1A and B). To facilitate surgical reduction of these fractures, the dog was pre-medicated with midazolam (0.2 mg/kg, i.v.; Midazolam Inj., BUKWANG, Korea), ensuring a smoother induction of anesthesia. Anesthesia was subsequently induced using propofol (6 mg/kg, i.v.; Provive Inj. 1%, Pharmbio Korea, Korea) and maintained with isoflurane (Ifran, Hana Pharm. Co., Korea). Reduction of the femoral fracture was performed using an intramedullary rod (5.0 mm diameter; Solco Biomedical, Seoul, Korea) (Fig. 1C). Fragile femoral bone was observed during surgery. Additional fractures occurred around the fracture sites. As multiple fractures also occurred in the proximal femur during fracture reduction, the dog underwent femoral head and neck ostectomy. Reduction of the fractured left ilium could not be performed because of the fragility of the iliac bone. Postoperative recovery of the dog was uneventful. Peri- and post-operative pain was managed with a buprenorphine transdermal patch (10 μg/h; Norspan Patch, Mundipharma Y.H., Korea) and/or meloxicam (0.1 mg/kg, s.c.; METACAM, Boehringer Ingelheim, Korea). The dog was managed with strict rest for two weeks. The inserted rods were removed after bone healing. Histopathological examination (IDEXX Laboratories, USA) through bone biopsy revealed lamellar bone and regions of woven bone with evidence of remodeling. The marrow spaces contained loose spindle cell proliferation or hematopoietic tissue, and there was no evidence of neoplasia (Fig. 2). Blood tests were performed to identify diseases that might cause pathological fractures. Complete blood count revealed no abnormalities. Ionized calcium, serum total calcium, and serum total phosphorus levels were within reference ranges. Renal ultrasonography confirmed no specific findings with blood urea nitrogen (BUN) and creatinine levels within normal ranges (Table 1). Trabecular bone mineral density (BMD) was measured using CT (Hi Speed Qx/I, GE Healthcare, USA). The BMD measured at the 7th lumbar vertebra was 153 Hounsfield unit (HU), indicating relatively lower BMD than that in normal dogs (350 HU) (Fig. 3A). Genetic testing was performed to differentiate suspected hereditary OI. As there was no matching breed available (Korea Genome Information Institute), the mutation sites of the Beagle and Dachshund with OI were alternatively compared. Although the mutated gene in the dog was not revealed by genetic testing, OI could not be ruled out in the present study. Taken together, the dog was tentatively diagnosed with undetermined osteoporotic bone disease. During the follow-up period of three months, the dog required two additional surgeries for fractures of the right and left humerus and the right femur (Fig. 4A and C). Fractures occurred due to the slipping of the dog or an unknown cause. Multiple intramedullary rods (2.0 - 2.3 mm diameter) were used to reduce the number of fracture sites (Fig. 4B and D). Loosening of inserted rods with irritation of adjacent soft tissues often occurs, requiring cutting or reinsertion of the loosened rods. During the postoperative follow-up period, bone regeneration responses, including periosteal reaction, callus formation, and bone remodeling, were observed. Approximately 3 months after the surgery, bone fusion was confirmed on radiography (Fig. 5). No additional fractures were not observed after the final surgery. Approximately six months later, the dog was readmitted to the clinic because of lameness and pain of its left pelvic limb with unknown reason. Body weight of the dog was increased from 11.6 kg to 28.6 kg in the latest follow-up. Radiography revealed left femoral fracture. Trabecular BMD was 63 HU, confirming a further decrease compared to that 9 months prior (Fig. 3B). Surgical reduction was performed using intramedullary rods (3.0 mm diameter) (Fig. 6). The dog was discharged from the hospital two days after surgery. The inserted rods were not removed to support the bones and reduce the risk of fracture (Fig. 7). Although the dog often exhibited lameness and required pain management, it could walk throughout the follow-up period.

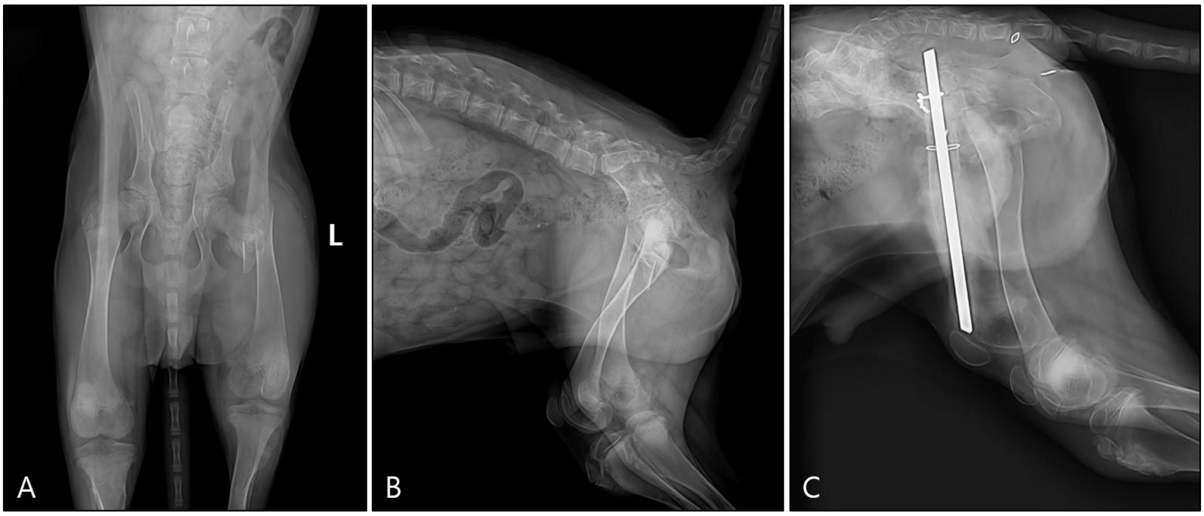

Figure 1 Plain radiograph showing left pelvic and femoral fractures of a dog and intramedullary rod was inserted for fracture reduction. (A) Ventrodorsal view. (B) Lateral view. (C) Postoperative view.

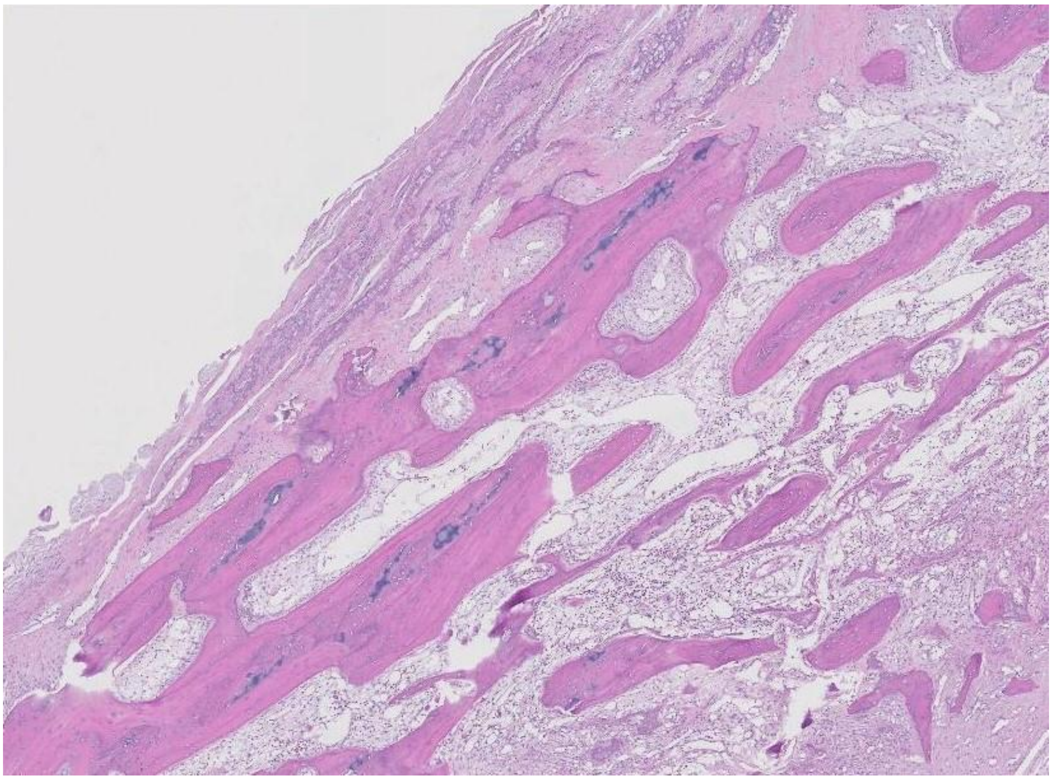

Figure 2 Photomicrographs of histological section of fractured femur bone fragment. There are lamellar and woven bones in the regions of bony remodeling.

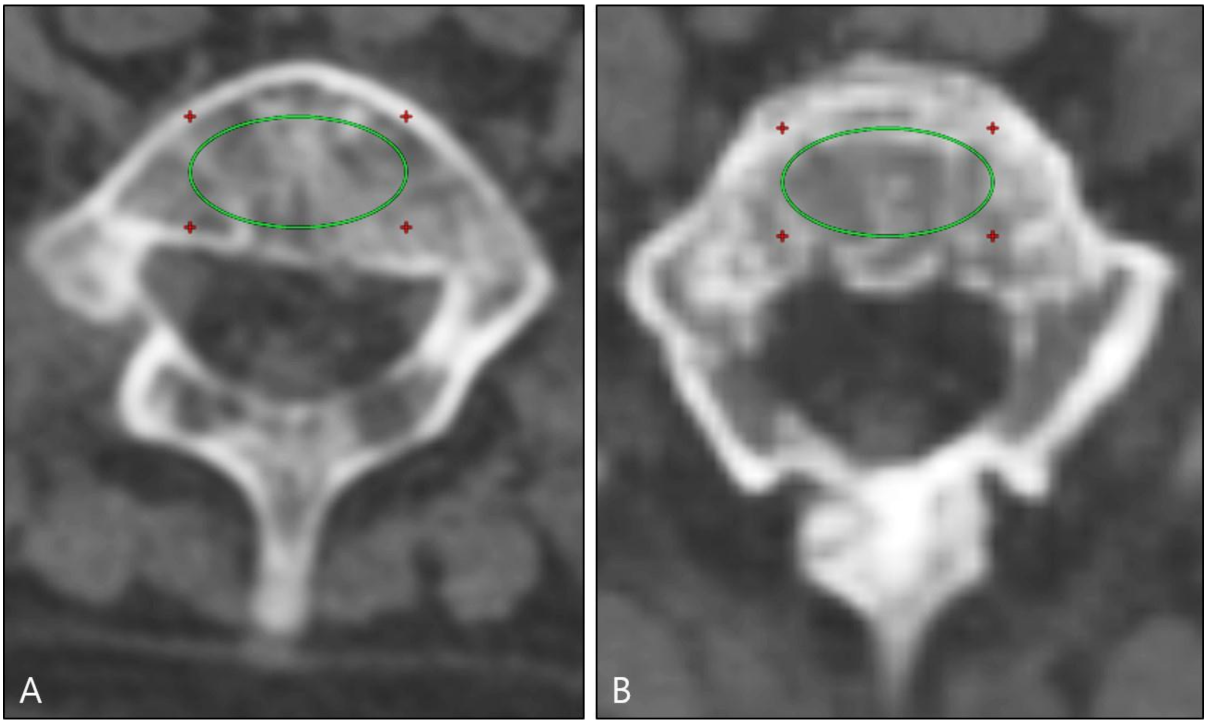

Figure 3 Measurement of mean Hounsfield unit (HU) for the region of interest (circled) to assess trabecular bone mineral density using CT scan. Mean HU value at the level of the 7th lumbar vertebra (153 HU) was lower than that in normal dogs (350 HU) and further decreased 9 months later (63 HU). (A) First CT scan, when the fracture was first confirmed. (B) Second CT scan, 9 months after first scan.

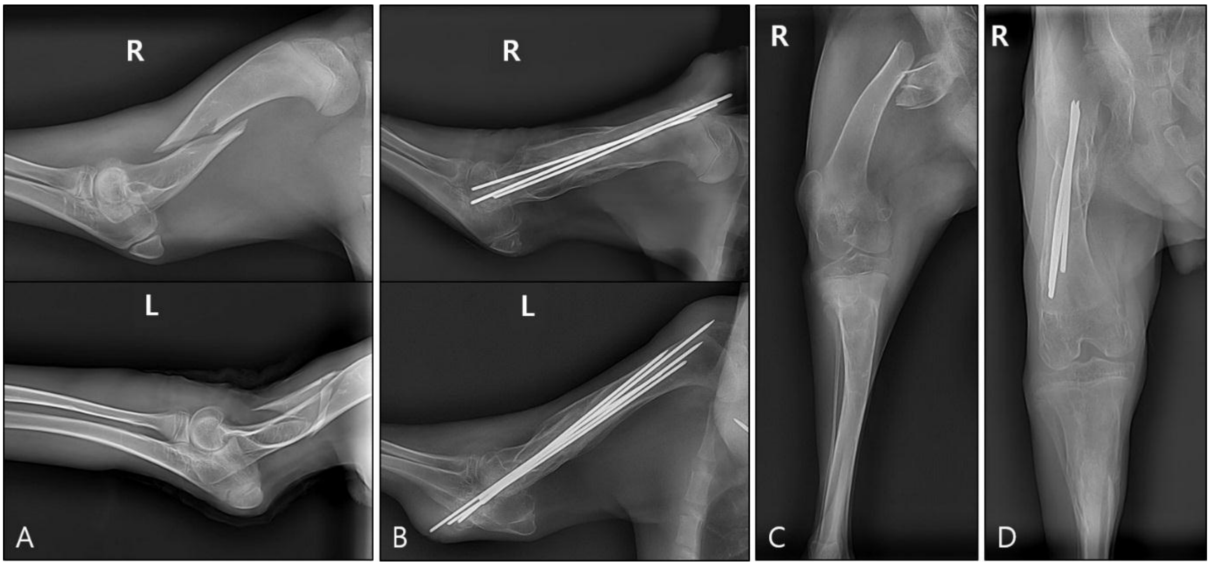

Figure 4 Plain radiograph showing right and left humerus and right femur fractures and radiograph of surgical correction with multiple intramedullary rods. (A) Preoperative view of right and left humerus. (B) Postoperative view of right and left humerus. (C) Preoperative view of right femur. (D) Postoperative view of right femur.

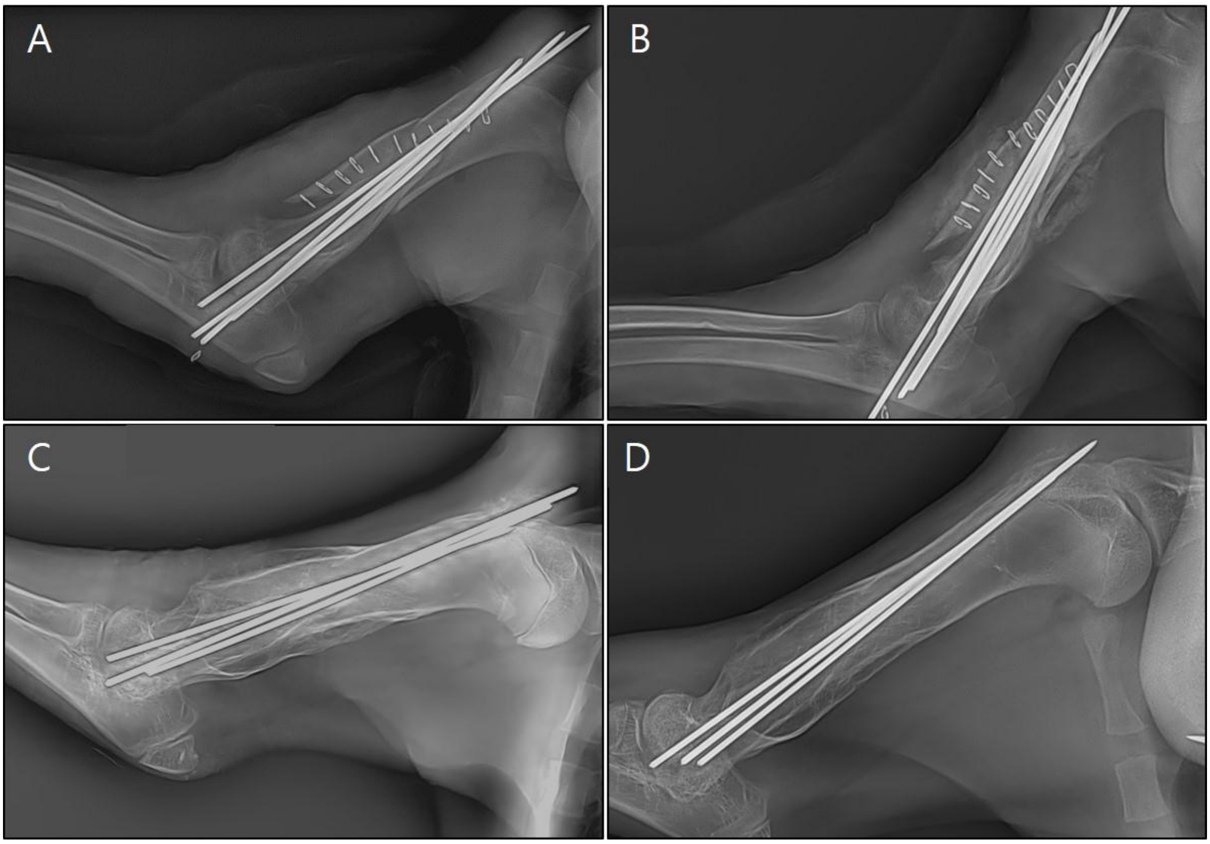

Figure 5 Radiograph showing the healing progress of the right humerus bone after operation. Periosteal reaction and callus formation were observed from 11 days postoperative, followed by evidence of bone remodeling approximately 3 months after operation. (A) 3 days postoperative. (B) 11 days postoperative. (C) 53 days postoperative. (D) 95 days postoperative.

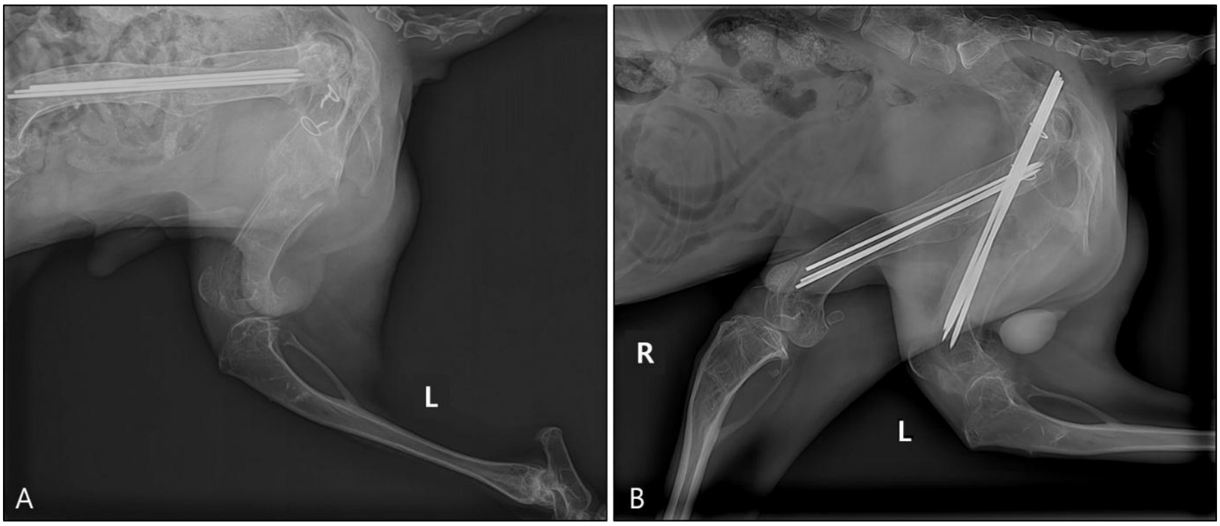

Figure 6 Radiograph showing left femoral fracture and surgical reduction with intramedullary rod. (A) Preoperative view. (B) Postoperative view.

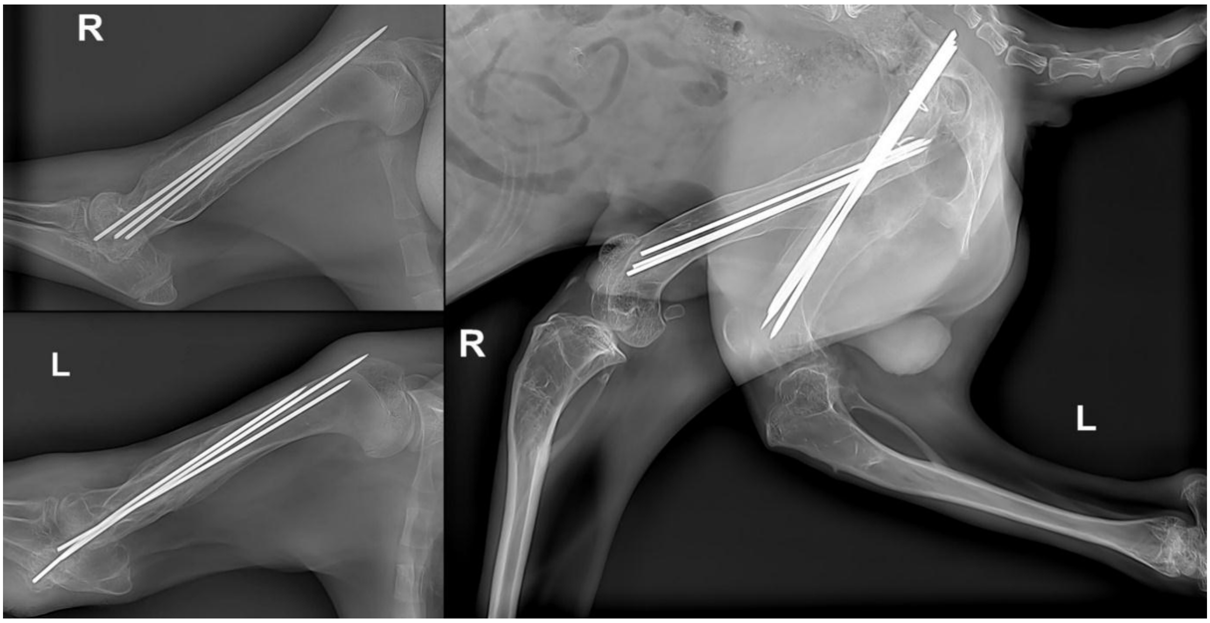

Figure 7 Multiple intramedullary rods were maintained to support bones and reduce fracture risk.

Table 1 Results of serum chemistry and ionized calcium level.

Measurement	Patient value	Reference interval
Ionized calcium (mmol/l)	1.39	1.16–1.40
Calcium (mg/dl)	9.7	9.0–11.3
Phosphorus (mg/dl)	5.2	2.6–6.2
Blood urea nitrogen (mg/dl)	14.0	7–25
Creatinine (mg/dl)	0.8	0.5–1.5

Discussion

Osteoporosis is characterized by a systemic decline in bone mass and microarchitecture, leading to an increased susceptibility to fragile fractures (Rancher *et al.*, 2011). Osteoporosis in children can occur because of diverse conditions, including metabolic disorders and nutritional deficiencies (Krassas, 2006). Osteogenesis imperfecta (OI), an inherited bone disorder, is one of the main causes of primary osteoporosis in children (Gold *et al.*, 2019).

Measurement of bone mineral density (BMD) is an available method for the diagnosis of suspected osteoporosis patients (Kalender and Fischer, 1993). The cortical bone of the femur was thin on radiography, and low BMD was confirmed on CT. Although variations were based on the measured regions of interest and the age of the patients, the dog was tentatively diagnosed with osteoporotic disease because of further decreased BMD after 9 months.

Osteoporosis in young patients is uncommon, and differential diagnoses that may cause pathological fractures, such as trauma, primary hyperparathyroidism, renal or nutritional secondary hyperparathyroidism, or neoplasia have been evaluated (Rancher *et al.*, 2011; Campbell *et al.*, 1997). According to the serum biochemistry analysis, most serum markers, such as ionized calcium, total calcium, and phosphorus were within their reference ranges. Primary renal disorders were ruled out using abdominal ultrasonography and serum BUN and creatinine levels. The dog was fed a standard canine commercial diet. Thus, primary or secondary hyperparathyroidism was considered improbable. Neoplasia was unlikely, considering the young age of the dog and the histopathological results of the bony samples. Although genetic testing for several suspected mutation sites related to OI (Campbell *et al.*, 2001; Drögemüller *et al.*, 2009) was conducted, no genetic mutations were identified in this dog. Considering the lack of information on OI in this breed, it is presumed that other mutation sites may exist in dogs. Taken together, it is reasonable to suspect that the dog had an undetermined osteoporotic disease or OI.

Although most dogs with OI were euthanized due to a poor long-term prognosis (Lazar *et al.*, 2000), surgical reduction of the fracture was performed following the owner's request in the present study. Unlike veterinary medicine, rodding surgery (supporting a weak bone, maintaining the bone straight, and reducing the fracture rate) and operative indications (recurrent fractures and severe bowing deformities) for patients with OI are well documented in the human literature (Esposito and Plotkin, 2008; Fassier, 2021). The use of plate and screws is not recommended in patients with OI because they can increase stress around a weak bone (Fassier, 2021). Rodding surgery is performed using static or telescopic rods depending on the patient's status (Esposito and Plotkin, 2008).

Fracture reduction was performed using multiple static rods in the present study, and the inserted rods were maintained with the intention of supporting the bones and reducing fracture risk. When performing rodding surgery, rod migration is a commonly reported complication in patients with OI (Luhmann *et al.*, 1998). The dog in the present study also experienced the migration of the inserted rods, which required operative revision. With surgical management and owner's effort to support the dog, its body weight was finally increased from 11.6 kg to 28.6 kg during the follow-up period. It was impossible to conduct follow-up observations on the disease due to the patient's relocation abroad nine months after the first surgery. If a histopathological examination is conducted when BMD decrease further, we could obtain more information about the patient's condition.

In conclusion, although most animals diagnosed with OI are euthanized owing to poor prognosis (Agerholm *et al*., 1994; Evason *et al*., 2007; Drögemüller *et al*., 2009), rodding surgery can be an alternative option for undetermined osteoporotic disease in veterinary medicine.

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