Indian J. Vet. Surg. 46(1): 65-67 June 2025

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Avascular necrosis of femoral head secondary to trauma in dogs: a clinical, radiological and computed tomographic evaluation

Ruchi Patwa[1], P. Bishnoi[2†], Sakar Palecha[3], A.K. Bishnoi[3] and Richa Chourasia[4]**

Rajasthan University of Veterinary and Animal Sciences, Bikaner- 334 001 (Rajasthan)

[1]Veterinary officer, Department of Animal Husbandry, Govt. of Rajasthan; [2]Professor and Head, [3]Assistant Professor, Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Science, Bikaner; [4]Assistant Professor, VCC, College of Veterinary and Animal Science, Datia (MP)

DOI: 10.5958/0973-9726.2025.00015.1 *Received: December 2024*

Fracture of hip joint is very common following automobile accident. Hip joint abnormalities can cause hind limb lameness and subsequent muscular atrophy, leading finally to the development of osteoarthritis. The present report describes three clinical cases in client owned dogs with avascular necrosis of femoral head. Clinical examination along with computed radiographic (CR) and computed tomographic (CT) evaluation was done in all three dogs. All the dogs were presented with a history of chronic trauma and lameness of the affected limb with limb adduction. CR and CT images revealed separation of the femoral head from the neck, subcortical sclerotic changes in the femoral head and acetabulum, osteonecrosis and osteophyte formation at the femoral head. Haematological and biochemical evaluations revealed increased alkaline phosphatase levels and altered Ca:P ratio. From this study it was concluded that trauma and femoral head fracture were the common factors that could cause vascular necrosis of the femoral head, which could be diagnosed by CR and CT imaging.

Key words: *Avascular necrosis, Computed Tomography, Dog, Femur*

The conditions associated with the coxofemoral joint include fracture of the acetabulum, luxation of the hip, capital femoral physeal fracture, fracture of the femoral head and neck, hip dysplasia, Legg-Calvé-Perthes disease, degenerative changes that prevent stabilization of the hip and osteoarthritis (Nagaraju *et al*., 2021). Avascular necrosis occurring spontaneously in small breed dogs caused by an interruption of the blood supply is called as Legg-Calvé-Perthes disease (Griffon, 2016), whereas avascular necrosis of femoral head can also occur secondary to fracture and fracture fixation. The earliest radiographic sign is a widened joint space due to the thickened cartilage. This is followed by heterogeneity of the proximal femoral epiphysis with areas of decreased and increased bone opacity. As the disease progresses, the femoral head collapses, and secondary degenerative joint disease and *coxa vara* develop (Puckler *et al*., 2016). The condition can be diagnosed using radiography; however, CT imaging provides sufficient accuracy (Thak *et al*., 2013). The present report describes radiographic and CT evaluation of avascular necrosis of femoral head in three dogs.

Three client-owned dogs presented with signs of avascular necrosis of femoral head made the subject of the study. Signalment data including breed, age, sex, body weight, and history of trauma, were recorded in all the dogs. Limb deformity and lameness evaluation was performed by using a score scale from 0 to 5 (Vassalo *et al*., 2015). Two diagnostic imaging modalities, computed radiography (CR) and computed tomography (CT), were used to conduct imaging studies. CT examination was done under general anaesthesia using standard anaesthetic protocol with atropine sulphate (0.04 mg/kg body wt.), xylazine HCl (1 mg/kg body wt.) and ketamine HCl (5 mg/kg body wt.) administered intramuscularly. The CT examination was performed using a 16 slice CT Scan Machine (Supria, Hitachi Ltd.). CR and CT images were evaluated to assess the morphological changes in the anatomical structures of the hip joint. Haematological and biochemical parameters, *viz.,* complete blood count, AST, ALT, serum urea nitrogen, creatinine, alkaline phosphatase (ALP), total protein (TP), and the calcium–phosphorus ratio (Ca:P) were evaluated.

Legg Calvé Perthes disease is a developmental abnormality that usually affects young small breed dogs, and its pathogenesis is very similar to that described in humans (Aguado and Goyenvalle, 2020). In the present study, two cases presented with a history of trauma, and a chronic femur head fracture was diagnosed on radiography. In all three cases, the duration of lameness was 4-8 months (Table 1), and two were males. The animals aged 72 m, 24 m and 18 m, and body weight was 32 kg, 35 kg and 17 kg, respectively. The cases were presented with lameness of the left limb (scores 3, 5, and 2). Moores *et al*. (2004) reported that avascular necrosis was most commonly found in dogs as a spontaneous disease of the femoral head in young and small-breed dogs. In the present study, in all three cases, thigh muscle atrophy and adduction of the affected limb were observed, and pain on palpation of the hip joint and abduction of the affected limb (left in all three cases) was also present. Piermattei *et al*. (2006), and Aguado and

†Correspondence; E-mail: drpbishnoi29@gmail.com

Table 1: Signalment, history and clinical findings of dogs affected with avascular necrosis of femoral head.

Sl. No.	Signalment (breed, age, sex, body weight)	Etiology	Chronicity of hind Limb limb lameness (months)	Lameness score	Orthopaedic examination	Affected side(right/ left)	Limb deformity
1	German shepherd, 72 m, M, 32 kg	Unknown	6	3	Pain on palpation	Left	Thigh muscle atrophy & adduction
2	Labrador, 24 m, F, 35 kg	Accidental injury	8	5	Pain on palpation	Left	Thigh muscle atrophy & adduction
3	American bully, 18 m, M, 17 kg	Jump	4	2	Pain on palpation	Left	Thigh muscle atrophy & adduction

M- male; F- female; m- month; kg- kilogram

Goyenvalle (2020) also stated that pain can be elicited in the hip, especially on abduction, crepitation with restricted range of motion and shortening of the limb, gluteal, and quadriceps muscle atrophy; some dogs have sudden lameness or a complete absence of leg support; and pain associated with hip mobilization is often present, particularly during abduction.

In the present study, an irregular area of osteolysis at the proximal femoral epiphysis and femoral head, shallow acetabulum, subluxation of the femoral head with diminished femoral head and acetabulum contact area, and subcortical bone sclerosis at the acetabulum margin were found on radiographic images (Fig. 1). Similar radiographic findings were also reported by Cardoso *et al*. (2018). In the present study, CT findings in two cases revealed a flattened and collapsed left femur head, fragmentation and osteonecrosis of the femoral head with osteoproliferation around the head in another case, and subcortical bone sclerosis at the acetabulum margin (Figs. 2 and 3). Radiographic and CT observations of the present study are in agreement with the findings of Singh (2018), who observed radiolucency with necrotic changes at the femur and neck (in radiography), a tree branch pattern of the right femur head, osteolytic changes with increased gap between the femur head and acetabulum, degenerative changes, and bony reaction at the femur head and neck (in CT images). Similarly, Thak *et al*. (2013) reported separation of the right capital femoral epiphysis from the femoral head due to an epiphyseal fracture with mild malalignment in multiplanar reconstructed CT images and mild osteophyte formation in the right hip joint with lower Hounsfield Unit measurement at the right femoral head as compared to the left.

In all the cases, the complete blood count, AST, ALT, urea nitrogen, creatinine, and total protein

Fig. 1: Ventrodorsal radiograph of the hip joint: (a) asphericity of the femoral head and irregular area of osteonecrosis at the proximal femoral epiphysis (white arrow); (b) flattened and collapsed left femur head (arrow), shallow acetabulum, diminished femoral head, and acetabulum contact area with subcortical bone sclerosis at the acetabulum margin (red arrow); and (c) radiolucency of the phytic region (white arrows) (white arrow).

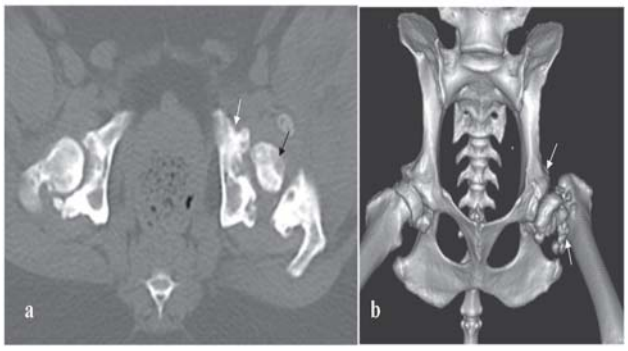

Fig. 2: Reformatted CT image showing osteonecrosis of the femoral head and acetabulum (black arrow), fractured femoral head, and subchondral sclerosis with irregular acetabular margins (white arrow) in the transverse image (a); osteoproliferation at the left femoral head and neck (arrow), femoral head flattening with loss of joint space, and irregular broken displaced head in the 3D image (b).

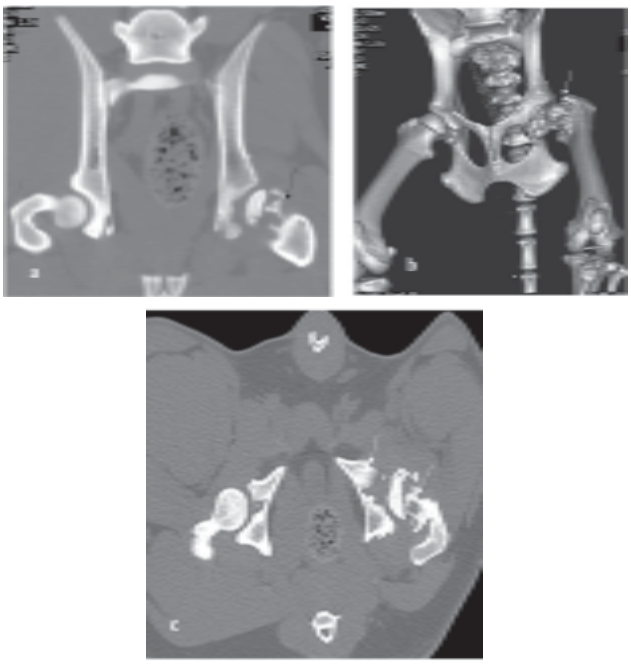

Fig. 3: Reformatted CT image demonstrating (a) fragmentation and osteonecrosis of the femoral head in the dorsal plane (black arrow), (b) femur head flattening with loss of joint space, irregular broken displaced head (white arrow), and presence of osteophytes at the femur head and acetabulum rim in the 3D image; (c) fractured femur head with osteonecrosis and subchondral bone sclerosis with irregular acetabular margin (white arrow) and marked joint surface deformity in the transverse image.

values were within the normal range, whereas an increased value of qlkaline phosphatase (ALP) was revealed (655.9 U/L, 250.47 U/L and 263.99U/L, respectively). ALP is a bone-specific isoenzyme that is elevated as a result of fracture or trauma, increased osteoblastic activity, or osteoproliferation in cases of dysplastic conditions (Singh, 2018). The Ca:P ratio altered from normal ratio with Ca values of 9.47 mg/dL, 8.99 mg/dL and 9.69 mg/dL, respectively, and P values of 5.65 mg/dL, 5.45 mg/dL and 6.25 mg/dL, respectively, in Case 1, 2 and 3. An altered Ca:P ratio might indicate osteolysis (Parzefall *et al*., 2016). Approximately 70% of the extraosseous blood supply to the proximal femur and coxofemoral joint originates from the medial and lateral circumflex femoral arteries. In addition to compromised blood supply, the amount of initial fracture displacement correlates directly with the risk of avascular necrosis (Griffon, 2016).

From this study it was concluded that trauma and fracture were the common factors causing avascular necrosis of the femoral head, which can be accurately diagnosed by CR and CT imaging.

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