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MORPHOLOGICAL ASSESSMENT AND GRADING OF HIP OSTEO-ARTHRITIS USING DIFFERENT DIAGNOSTIC MODALITIES IN DOGS

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ABSTRACT

Osteoarthritis is a degenerative disease of synovial joints. Hip is the most often afflicted joint in dogs, which makes them reluctant to walk and engage in daily activities. The present study was aimed to assess the morphological changes in osteoarthritic hip joint using radiography and computed tomography. The study was conducted on 30 dogs divided into 3 groups. Group I and II comprised of 6 young (3-5 months) and 6 adult (> 12 months age) indigenous non-lame dogs, respectively, as control. The group III comprised of 18 clinical cases of dog with hip osteoarthritis. Highest distribution of hip osteoarthritis was recorded in Labrador breed of dogs with male dogs being more frequently affected (83.33%) than females. Group II exhibited a significantly reduced joint space (0.09 ± 0.01) as compared to group I (0.19 ± 0.02). Radiographic observation of group III showed coxofemoral luxation and alterations in normal architecture of femoral head, trochanter and acetabulum due to osteophytes formation. Radiographic scoring and categorization of hip osteoarthritis revealed maximum cases (12) of severe osteoarthritis. Computed tomography scan revealed specific lesions of bony changes including presence of minor osteophytes and variation in bone density (Hounsfield unit) in osteoarthritic hip joints compared to normal joints.

Keywords: Computed tomography, diagnostic modalities, dog, hip joint, osteoarthritis

INTRODUCTION

Dogs are excellent companion animal, playing with a dog can help human beings in reducing the stress levels and increase their health and wellbeing, thus healthy joints are essential for quality of life in dogs. Normal hip function may be affected by congenital conditions such as dysplasia, physical injury like trauma and by acquired diseases such as osteoarthritis and rheumatoid arthritis. Osteoarthritis (OA) is a degenerative disease of synovial joints characterized by the formation of various catabolic and pro-inflammatory mediators altering the balance of cartilage matrix degradation and repair. There are aberrant repair and eventual degeneration of articular cartilage as well as formation of new bone at the articular margins (Innes, 2018). Sclerosis of subchondral bone and development of synovial inflammation of variable grade (Yamazaki *et al.*, 2021). The actual cause of osteoarthritis is largely unknown but often associated with injury or dysplasia that result in accelerated turnover of the articular cartilage (McLaughlin and Roush, 2002). Obesity is also one of the factors for development of osteoarthritis as excess weight put unnecessary stress on joints. The prevalence of hip dysplasia is higher in large breeds (Rocha and Torres, 2007), typically manifesting during the rapid growth period of 6-12 month's age (McLaughlin and Roush, 2002; Subramaniyan *et al.,* 2023). The British Veterinary Association/Kennel Club Hip Scoring System evaluated nine radiographic criteria with zero being the best score and six the worst (Gibbs, 1997). The nine criteria include the Norberg angle, subluxation, dorsal and cranial acetabular edge, cranial effective acetabular rim, acetabular fossa, femoral head recontouring, and femoral head and neck exostosis. An average score for each dog breed is published (Gibbs, 1997), and used to guide in selection for breeding to reduce dysplasia prevalence.

Accurate detection and successful characterization of early OA events might lead to better treatment options. Computed tomography (CT) scan allows the evaluation of periarticular and articular tissues without superimposition on joint radiography. Although sporadic studies on hip OA have been reported, there remains a paucity of literature on radio-morphological data and computed tomographic (CT) observations. Therefore, the present study was aimed to characterize clinical and radiographic changes in hip osteoarthritis using radiography and CT as well as to document the distribution of hip osteoarthritis in different breeds and age groups and to establish baseline radio-morphological data from clinically normal hip joint.

MATERIALS AND METHODS

The study was conducted on hip joints of 30 dogs, divided into three groups; in group I and II, comprised of 6 young (3-5 months) and 6 adult (> 12 months) indigenous non-lame dogs, respectively, as control and group III comprised of 18 clinical cases of hip osteoarthritis. The 6-12 month's age was ignored as after 6 months of age, the growth plates begin to close, and no significant differences in joint measurements are expected beyond this age. The selection of dogs for group III was done by screening of 120 cases which showed hind limb lameness irrespective of age, breed and sex brought to Veterinary Clinical Complex, Jabalpur (India). Screening was carried out on the basis of history, clinical examination and radiography. The duration of study was two years, i.e., from September 2021 to August 2023. The study protocol was approved by the Institutional Animal Ethical Committee of NDVSU, Jabalpur (53/IAEC/Vety/2021 dated 26.10.2021) and comply with the CPCSEA guidelines (registration No. 2071/GO/Re/S/ 19/CPCSEA).

Clinical examination

Clinical lameness scoring for assessment of osteoarthritis in dogs was carried out using an ordinal scoring system described by McCarthy *et al.* (2007). Clinical evaluation was based on several criteria. Lameness was scored on a five-point scale: a score of 1 indicated that the dog walked normally; 2 indicated slight lameness during walking; 3 indicated moderate lameness during walking; 4 indicated severe lameness during walking; and 5 indicated reluctance to rise, with the dog unwilling to walk more than five paces. Joint mobility was also graded from 1 to 5. A score of 1 represented a full range of motion. Score 2 indicated a mild limitation (10-20%) in range of motion without crepitus, while score 3 indicated a similar mild limitation (10-20%) but with crepitus present. A score of 4 reflected a moderate limitation (20-50%) in range of motion with or without crepitus, and score 5 indicated a severe limitation (>50%) in range of motion, with or without crepitus. Pain on palpation was assessed using a five-point scale, where a score of 1 indicated no pain. A score of 2 reflected mild signs, such as the dog turning its head in recognition. Score 3 indicated moderate pain, with dog pulling the limb away. A score of 4 represented severe pain, demonstrated by vocalisation or aggressive behaviour, while a score of 5 indicated that the dog would not allow palpation. Weight-bearing ability was scored from 1 to 5. A score of 1 indicated equal weight-bearing on all limbs during standing and walking. Score 2 described normal weight-bearing when standing but favouring the affected limb while walking. A score of 3 indicated partial weight-bearing during both standing and walking. Score 4 reflected partial weight-bearing when standing and non-weight-bearing during walking, while score 5 indicated non-weight-bearing during both standing and walking. Finally, the overall clinical condition was graded on a five-point scale, where 1 indicated the dog was not affected, 2 mildly affected, 3 moderately affected, 4 severely affected, and 5 very severely affected (McCarthy *et al.*, 2007).

Radiographic examination

Standard ventro-dorsal radiographic view of pelvis with extended hind limb were taken with portable X-ray unit (Ultimax-50) assembled with CR system (Carestream). The X-ray machine was set on 8 mAs, while kilovoltage was determined following Sante's rule (2 x thickness + 40), according to the dog's size and age. Radiographic evaluation of hip arthritis was graded on a four-point scale of Areshkumar *et al*. (2018). Grade 1 (slight) was characterized by the presence of periarticular osteophytes only. Grade 2 (mild) included periarticular osteophytes along with remodelling of the femoral head. Grade 3 (moderate) was defined by periarticular osteophytes accompanied by remodelling of the femoral head and neck as well as acetabular remodelling. Grade 4 (severe) showed periarticular osteophytes, remodelling of the femoral head and neck, acetabular remodelling, and sclerosis of the subchondral bone of both the femoral head and the acetabulum.

Computed tomography

Computed tomography (CT) scan of hip joint was performed in dorsal recumbency with extended hind legs. The dogs were given atropine @ 0.02 mg kg^{-1} BW, intramuscular followed by inj. Xylazine @ 1 mg kg^{-1} i.m. and inj. Ketamine HCl @ 5 mg kg^{-1} i.m. Transpelvis view perpendicular to the long axis of the body was taken for imaging of hip joints and 5 mm thick contiguous CT slices were generated having reconstruction index of 0.5 mm using Fujifilm, supria 16ch/32 slice CT. Images were rotated by 180° during reconstruction for convenient visualization in bony window. The acetabular rim, coxofemoral joint space and femoral head margins were evaluated for irregularities including sclerosis, osteophytes, altered morphology and bone density (Hounsfield unit).

Statistical analysis

Statistical analysis was done with the help of R software (R team 2013) using independent 't' test and applied descriptive statistics ($p < 0.05$).

RESULTS AND DISCUSSION

Occurrence of hip osteoarthritis

A total of 120 dogs with lameness were screened on the basis of history, clinical examination and radiography. Out of which 18 dogs revealed osteoarthritic changes in hip joint(s). The occurrence of hip osteoarthritis was 15% (18/120). The distribution of hip osteoarthritis was recorded and classified on the basis of age, breed, and gender. Maximum distribution of OA was observed in the dogs between 4-8 years age (Table 1). The breed-wise study revealed higher distribution i.e. 72.22% in Labrador. Male dogs were more affected (83.33%) than female counterparts. High occurrence of hip osteoarthritis in Labrador breed may be attributed to heavy body weight and obesity (Mclaughlin and Roush, 2002; Simon *et al.*, 2010; Areshkumar *et al.*, 2018; Roitner *et al.*, 2024). Higher hip OA occurrence in males aligns with the findings of Simon *et al.* (2010) but contrasts with Areshkumar *et al.* (2018). Sex related differences in hormone levels, activity patterns, and higher body weight in males may contribute to their increased susceptibility to hip OA (Anderson *et al.,* 2018).

Clinical assessment

Clinical scoring of affected hip joint was performed and found that the majority of dogs (12) exhibited severe clinical signs, with mean scores of 4 for lameness, pain on palpation, and weight-bearing, and 5 for joint mobility, resulting in an overall clinical score of 4. Moderate clinical signs were reported in four dogs, with an overall score of 3, while two dogs showed mild to moderate involvement, reflected by an overall score of 2. These findings indicate that most affected dogs were presented with moderate to severe functional impairment associated with hip joint (Table 2).

Radiographic assessment

In group I, the acetabular section of the ilium, ischium and pubis have not yet fused, and a radiolucent V-shaped gap was observed on the femoral head (Fig. 1a).

Table 1: Age-, breed- and gender-wise distribution of hip osteoarthritis (n = 18)

Description	No. of dogs	Per cent (%)
Age wise distribution		
- < 4 years	03	16.67
- 4-8 years	13	72.22
- > 8 years	02	11.11
Breed wise distribution		
- Labrador	13	72.22
- Great Dane	02	11.11
- German Shepherd	02	11.11
- Non-descript	01	05.55
Gender wise distribution		
- Male	15	83.33
- Female	03	16.67

Table 2: Clinical and radiographic scoring of hip

Overall clinical score	Lameness	Joint mobility	Pain on palpation	Weight-bearing	Clinical severity	Radiographic classification	Grade	No. of dogs
4	4	5	4	4	Severe	Severe	4	12
3	3	4	3	3	Moderate	Moderate	3	4
2	2	3	3	3	Mild	Mild	2	2
1	–	–	–	–	Slight	Slight	1	0

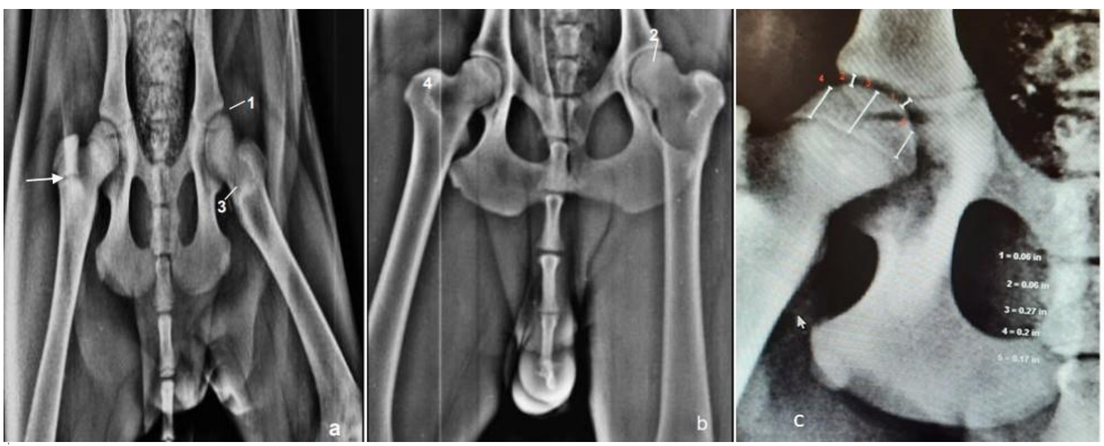

Fig. 1: Ventrodorsal radiograph of hip joint: a) Group I, b) Group II, showing 1. Acetabulum, 2. Femoral head, 3. Neck of femur, 4. Greater trochanter, physis (↑); c) showing measurement (inches) of joint space and proximal femoral epiphysis

There were two proximal physes (growth plate) one for head and another for trochanter of femur. These physes were distinct and relatively the same width from the time of their appearance when ossification of the head is first visible, until 80% of growth is completed at 5 months of age. Then the width of physes narrows gradually and in group II closure of growth plate was observed in radiographs (Fig. 1b). Radiolucent V shaped gap on hip radiograph of group I (young dog) was due to the cartilaginous physis between ilium and ischium. Riser (1973) observed that the union of these bones was masked by the head of the femur and could not be distinguished until 12th week when the acetabular cavity had ossified sufficiently to give an adequate radiographic image. He stated that a Y-shaped strip of endochondral cartilage united the ilium and ischium at the dorsal rim of the acetabulum, and was the last area to ossify. In group II, femoral head was present medial to dorsal effective acetabular margin. Fovea capitis was represented as flattened portion in middle of femoral head (Fig. 1b). Joint space (radiolucent line separating margin of femoral head with adjacent acetabulum) was measured radiographically (Fig. 1c), and found that group II had less joint space than group 1, proximal femoral epiphysis was found significantly larger in group II (Table 3). In group III, among 18 cases of hip osteoarthritis; 12 cases had bilateral and 6 had unilateral osteoarthritis. The osteoarthritis of hip was severe in 12 dogs, moderate in 4 dogs and mild in 2 dogs (Table 2). The radiographic changes varied among different case of hip osteoarthritis but in majority of cases reduction in joint space, increased subchondral bone opacity and variable degree of coxofemoral subluxation was observed. Radiographic and clinical evidence of hip osteoarthritis is a common sequela of canine hip dysplasia, especially in older dogs (Smith *et al.*, 2006; Allan and Davies, 2018). The development of osteophytes, shallow sclerotic acetabulum, and the ragged look caused a modification in the normal architecture of femoral neck and trochanter. Acetabular margin was rounded; cavity lost its cup-like shape and became shallow (Fig. 2B-D). At the site of acetabulum perichondral osteophytes were observed (Fig. 2D). Circum-ferential femoral head osteo-phytes (CFHO) formation was observed in a few cases (Fig. 2A). Presence of CFHO is considered as an early indicator

Table 3: Radiographic measurements of normal hip joint

Parameters	Group I	Group II
Joint space at middle (cm)	$0.19^* \pm 0.02$	0.09 ± 0.01
Thickness of proximal femoral epiphysis (cm)		
- Cranial	0.51 ± 0.01	$0.84^* \pm 0.02$
- Middle	0.68 ± 0.01	$1.11^* \pm 0.02$
- Caudal	0.41 ± 0.01	$0.77^* \pm 0.01$

All values are expressed as mean ± SEM, n = 6, $^*p<0.05$

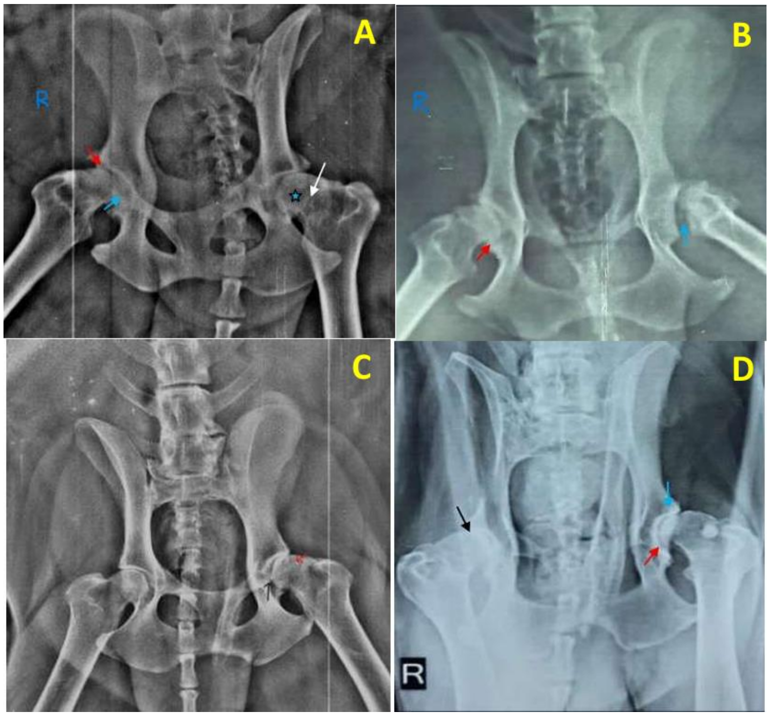

Fig. 2: Ventrodorsal radiographs A. 3-year Labrador dog showing bilateral hip arthritis; left hip has decreased subchondral bone opacity of femoral head (star) and presence of circumferential femoral head osteophytes (white arrow); right hip has irregular acetabular rim (↑), advanced remodelling in femoral head and acetabulum and new bone formation filling the acetabular fossa (↑) B. 4 year Labrador dog showing bilateral hip arthritis; degenerative changes in left femoral head with loss of its rounded appearance and increased joint space at ventromedial part of hip joint (↑); right hip showed moderate sclerotic changes with caudolateral curvilinear osteophyte (↑) C. 6 year Labrador dog showing bilateral hip arthritis; left hip has ragged surface of femoral head (↑), osteophyte formation on acetabulum (↑) right hip has mild changes. D. 14 year Labrador dog showing bilateral hip arthritis; laxity in left hip joint, decreased bone opacity of femoral head, increased subchondral bone opacity at acetabular margin (↑), perichondral osteophyte at acetabulum and enthesophyte at upper margin (↑); changes in right acetabular rim (↑)

of hip osteoarthritis in dogs (Risler *et al.*, 2009; Szabo *et al.*, 2007). Limbs with CFHO had significantly larger joint flexion angle (Alves *et al.*, 2021). circumferential femoral head osteophytes considered the radiographic predictors of future OA development. Dogs presenting with these radiographic signs had a significantly worse clinical presentation (Puckler *et al.*, 2016). Increased bone opacity of subchondral articular surfaces denotes sclerosis of bone, a response to cartilage thinning (Allan and Davies, 2018). Age showed a significant correlation with the presence of several osteoarthritis radiographic findings.

Computed tomography scan observation

In normal hip CT scan of group, I and II, head of the femur is seated deeply within the acetabulum, indicating excellent hip joint congruity (Fig. 3a & b). Fujiki *et al.* (2004) and Schachner and Lopez (2015) performed pelvic CT scans of dogs at various time points and positions and observed similar

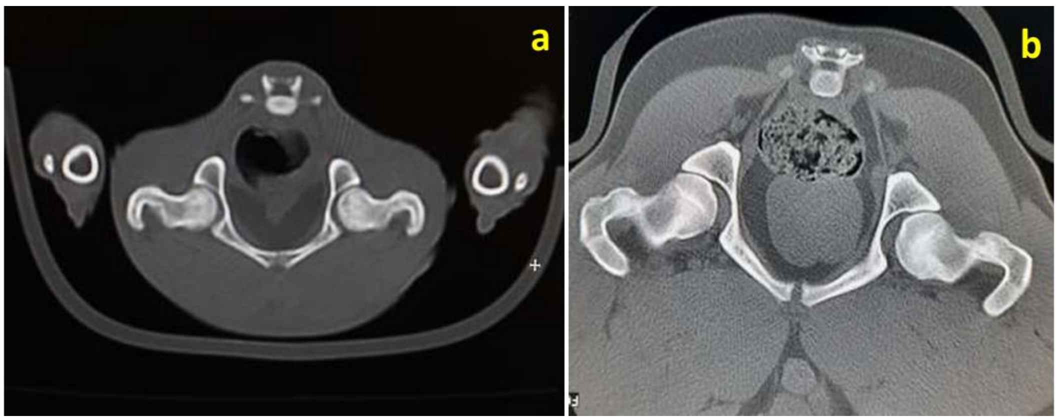

Fig. 3: Transverse CT scan image of pelvis showing normal hip joint congruity a) group I, and b) group II

report. In group III, identification and quantitative assessment of presence of even a single osteophyte was done. The CT scan findings of severe cases of hip osteoarthritis are presented in Table 4 and Fig. 4. There was decrease in joint space and sclerosis of bony margins with increased attenuation at acetabular margins. In one case, marked cavitation was present in acetabulum due to articular erosion. There were changes in Hounsfield unit (HU) around margins of bone and sub-chondral region in osteoarthritic hip joint. Osteophytes showed radiodensity between 410-915 HU depending upon extent of calcification; whereas at areas of erosion the radiodensity was reduced to as low as 216 HU. Subchondral bone was more radiodense with 1350-1450 HU due to sclerosis, in comparison to radiodensity of normal femoral head which was between 900-1000 HU. Variations in Hounsfield unit in normal and osteoarthritic hip occur because bone undergoes remodelling in response to degenerative osteoarthritic changes leading to formation of osteophytes typically around margins of the bone and sclerosis, which makes bones brittle in nature and narrowing of joint space, Chalmers *et al.* (2006) recorded similar findings in dogs.

Table 4: CT scan findings of severe hip osteoarthritis in dogs

Observations	Description of appearance
Osteophytosis	Extensive, mature bone spurs (new bone formation) visible around the entire joint margin, femoral neck, and acetabular rim.
Subchondral sclerosis	Opacity of acetabular and femoral head subchondral bone increased
Joint remodelling	Marked reshaping of the acetabulum and flattened deformation of femoral head
Luxation	Dislocation of femoral head from acetabulum
Narrowing of joint space	Loss of articular cartilage leading to bone to bone contact
Cavitation/bone lysis	Marked cavitation and bone resorption of acetabulum

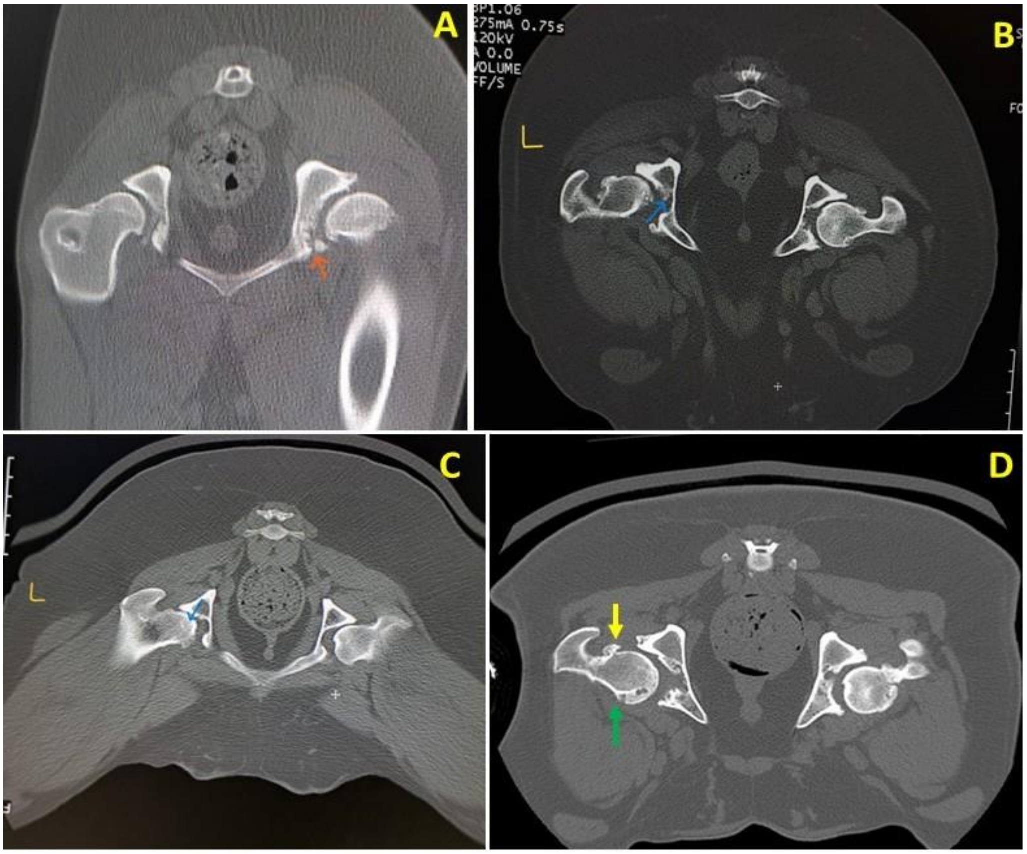

Fig. 4: Transverse CT scan image of pelvis A) showing osteophyte in right acetabular rim (red arrow) along with roughening of femoral head on medial articular surface; B) showing lytic changes in left cotyloid cavity (blue arrow) and formation of osteophytes on femoral head; C) showing irregular contouring of femoral head; D) Periarticular osteophytes along the femoral neck (yellow arrow), sclerosis and remodelling of femoral head (green arrow)

Hip osteoarthritis is a primary complication after hip dysplasia (Simon *et al.,* 2010). Hip laxity causes stretching of the supporting ligaments, joint capsule, and muscles around the hip joint, leading to joint instability, pain, and permanent damage to the anatomy of the affected hip joint. Hip dysplasia can be a genetically inherited condition.

Conclusion: Detailed information obtained from diagnostic imaging modalities is essential for the development of customized treatment of hip osteoarthritis. CT scans allowed the identification of precise extent of bony proliferation and remodelling before surgical planning of femoral head and neck osteotomy or total hip replacement. Conscientious breeding and weight management is vital to decrease the occurrence of this devastating disease. Dogs that suffer from inherited hip dysplasia, show signs within the first year and should be spayed or neutered to avoid passing this genetic tendency of malformation to offspring.

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Ethical statement: The study protocol was approved by the institutional animal ethical committee of NDVSU, Jabalpur (53/IAEC/Vety/2021, dated 26.10.2021) and complied with CPCSEA guidelines (registration No. 2071/GO/Re/S/ 19/CPCSEA).

Conflict of interest: All the authors declare to have no conflict of interest.

Data sharing and accessibility: The data presented in this study are available from the corresponding author [NG], upon reasonable request.

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