RADIOGRAPHIC ANATOMY OF THE CANINE COXOFEMORAL JOINT USING THE DORSAL ACETABULAR RIM (DAR) VIEW

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A radiographic study of the anatomy of the canine acetabulum was performed. The relationship between the area of dorsal acetabular rim that is subject to early damage in dogs with coxofemoral joint laxity, and the "DAR point" identified on dorsal acetabular rim (DAR) radiographic views was examined. Radiographs and digital photographs were made of the pelvis harvested from each of six skeletally mature dogs. Through analysis of these images, it was determined that in the standing animal, the DAR point is located 4–6 mm (or approximately 37°) caudal to the dorsal acetabular rim area that is prone to early damage in dogs with coxofemoral joint laxity. This study suggests that the DAR radiographic view may under-represent changes to the dorsal acetabular rim in dogs with coxofemoral laxity. *Veterinary Radiology & Ultrasound, Vol. 44, No. 5, 2003, pp 526–532.*

Key words: dorsal acetabular rim, hip dysplasia, canine, radiography.

Introduction

RADIOGRAPHIC EVALUATION OF the canine coxofemoral joint is an important test for assessing joint laxity and degenerative changes associated with canine hip dysplasia (CHD). The most commonly used method for imaging the hip has been the ventrodorsal (VD) radiographic view with the pelvic limbs extended.[1–4] Subluxation of the femoral head in a lax joint results in stress concentration at the dorsal acetabular rim and subsequent erosion of cartilage in this area.[5–8] Damage to the dorsal acetabular rim in dogs with CHD exacerbates diminished femoral head coverage and is taken into consideration when evaluating patients for triple pelvic osteotomy.[7,9] Although useful in observing gross degenerative changes and as a reference for surgical planning, the value of VD radiographs in evaluating early changes to the dorsal acetabular rim has been questioned.[1–3,9,10]

In 1990, the dorsal acetabular rim (DAR) radiographic view was introduced.[3] The DAR view, as described, provides a radiographic method for unobstructed visualization of the dorsal rim of the acetabulum from a craniocaudal perspective. To achieve this view, the anesthetized patient is placed on the table in sternal recumbency. The pelvic limbs are pulled cranially and held close to the body using a belt or other restraining device. A spacer, placed below the tarsi, may be used to provide additional rotation of the pelvis.[3] If correctly positioned, the x-ray beam will pass through the long axis of the ilial shaft, resulting in the superimposition of the wings of the ilium, body of the ilium, acetabulum, and tuber ischii.[3] A modification of this technique has been reported that allows this view to be obtained in the awake, standing animal. Because this modified view maintains the animal's posture as close as possible to that experienced during normal activity, this technique may have additional value in evaluation of subluxation of the hip joint.[2] The DAR radiographic projection allows for the identification of osteoarthritic changes that may occur along the dorsal rim of the acetabulum, as damage secondary to coxofemoral joint laxity progresses.[3,10] Using the DAR view, when the coxofemoral joint of a dog with normal hips is visualized, the lateral aspect of the dorsal rim appears to be sharply pointed. As the joint is damaged, the shape of this rim progresses from slightly rounded to blunted.[10] It has been stated that the DAR view also allows correlation of palpable joint laxity and crepitation with radiographic findings, assessment of acetabular filling and articular congruence, and measurement of the acetabular slope to help determine appropriate pelvic rotation for a triple pelvic osteotomy (TPO).[1–3,9–11]

Although it has been stated that the DAR view projects the weight-bearing portion of the acetabulum,[3,10,11] the exact location along the dorsal acetabular rim projected by this view has not, to our knowledge, been identified. The purpose of this study was to evaluate the radiographic anatomy of the canine acetabulum using the DAR view and, specifically, to determine the location along the dorsal acetabular rim projected by this technique.

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Materials and Methods

The pelvis was harvested from each of six skeletally mature, medium to large breed, canine cadavers. The dogs had been euthanatized at a local shelter on the same day of harvest. Each pelvis was free from gross degenerative changes based on visual examination. All soft-tissues were removed from each pelvis and sacrum. A 4-mm diameter hole was drilled perpendicular to the sagittal plane of the pelvis, through an ilial wing, the body of the first sacral segment, and the contralateral ilial wing. A wooden dowel was placed through this hole and positioned parallel to the radiographic table using a jig constructed of plexiglass and carbon external fixator rods. Each pelvis was positioned as previously described for evaluating the dorsal acetabular rim, whereby the x-ray beam was able to pass through the long axis of the ilial shaft, resulting in the superimposition of the wings of the ilium, the body of the ilium, the acetabulum, and the tuber ischii.[2,3,10] To ensure correct positioning, an initial radiograph was made and evaluated for rotation and technique. For some pelves, a 5-mm thick transparent bolus pad* was positioned below the pelvis to improve radiographic detail in the area of interest.

A series of 12 DAR radiographs were examined for each of the six pelves (12 acetabula) used in this study. All radiographs were made using a tabletop technique.† The cassette and film‡ were positioned below the jig and pelvis (40-in tabletop height). After correct positioning was obtained, and technique adjusted to maximize detail at the region of the acetabula, the points on the pelvis corresponding to the lateral aspect of the right and left dorsal acetabular rims (DAR) were identified. A single radiopaque marker (#9 lead shot) was glued to each DAR point. Several radiographs with minor cranial–caudal adjustments in the location of the lead shot were necessary to achieve correct identification of this point. After the DAR point was identified, the position of the pellet was photographed and marked on the pelvis. The pellet was then removed and repositioned. A series of radiographs were then made with the pellet positioned at 1-, 2-, 4-, 6-, and 8-mm cranial to and 1-, 2-, and 4-mm caudal to the DAR point. After each radiograph was made, pellet location was photographed and marked on the pelvis, and the pellet was then relocated.

Five radiographs of each pelvis showing the pellet located at the DAR point, or the points 1- and 2-mm cranial and caudal to the DAR point were evaluated by one observer (KGM) who did not know the exact pellet position. This was done to determine which of these potentially overlapping points might be recorded as the DAR point.

DAR radiographs were repeated after highlighting the following structures with barium sulfate paste: dorsal acetabular rim caudal to the DAR point, dorsal acetabular rim cranial to the DAR point, and a horizontal line drawn on the articular surface of the acetabula parallel to the table starting at the DAR point.

DAR radiographs of 27 clinical patients were reviewed to determine if the dorsal acetabular rim cranial and caudal to the DAR point were obscured by overlying soft tissues and the femoral head.

The pelvic tilt in 18 standing dogs, free of orthopedic diseases, was determined by making horizontal beam pelvic radiographs. Cassettes were placed in a stand, and horizontally leveled. Each radiograph was then scanned§ and a line was drawn connecting the dorsal-most points of the ilium and ischium.‖ The angle formed by the intersection of this line and the horizontal line, was defined as the standing angle of the pelvis. This process was repeated three times for each pelvis, and the mean angle for each pelvis was used to determine the mean standing angle for all 18 pelves.

Once the mean standing angle was determined, a lateral digital photograph of each hemipelvis with its associated markers was rotated# until it matched the mean standing angle. A clear acetate sheet was placed over each projected image. Acetate sheets contained a standardized image of a 17-cm diameter circle, with a central crosshair. The projected image was magnified until the dorsal acetabular rim matched the arc of this circle. The acetate sheet was rotated until one crosshair was vertical and the other horizontal. The vertical crosshair was used to approximate the location of the weight-bearing surface in the standing position. The position of the markers on each dorsal acetabular rim was recorded by marking the corresponding point along the circle on the acetate sheet. A line was drawn from each DAR point to the center of the circle, and the angle (degs) between this line and the vertical crosshair was measured and recorded. The distance between the vertical crosshair and DAR point on the acetabular rim was also recorded.

Finally, for illustration purposes, the following radiographs of a canine pelvis was performed: craniocaudal view with the x-ray beam tangential to the weight-bearing portion of the dorsal acetabular rim, and a VD view with markers on the DAR point and at 4 and 6 mm cranial to the DAR point.

Results

For each acetabulum, the relative position of the markers to the DAR point followed a predictable pattern as summarized here. In the first radiograph, the marker was located at the vertex of the sharp angle (DAR point) characteristic of the dorsal acetabular rim as previously described.[1–3,10] The second radiograph in the series was taken with the marker

*Med-Tec, Inc., Orange City, IA.

†Innovet Select radiographic unit, Summit Industries, Inc., Chicago, IL.

‡Kodak 8X10 T-mat Diagnostic film, Eastman Kodak Co., Rochester, NY

§Lumiscan 75, Eastman Kodak Co., Rochester, NY.

‖eFilm Workstation™ 1.8.1, Merge eFilm, Toronto, Ontario, Canada.

#Adobe® Photoshop® 5.0, Adobe Systems Inc., San Jose, CA.

positioned 1-mm cranial to the identified DAR point on each acetabulum. This point also appeared to be at the vertex of the DAR point in 10 of 12 acetabula. The remaining 1-mm cranial markers and all of the markers 2-mm cranial to the DAR point were displaced laterally and toward the bottom of the film in respect to the DAR point. None of the 2-mm markers were incorrectly classified as being at the DAR point. At 4-, 6- (Figs. 1A, 1B, respectively), and 8-mm cranial to the DAR point, this ventrolateral displacement of the marker continued. At 1-mm caudal to the DAR point, the marker seemed to be at the DAR point in 5 of 12 acetabula. The remaining 1-mm caudal markers and all of the markers 2-mm caudal to the DAR point were displaced medially and toward the bottom of the film in relation to the DAR point. Again, none of the 2-mm markers were incorrectly classified as being at the DAR point. The ventromedial shift in position away from the DAR point was continued (Fig. 1C) with the 4-mm caudal marker.

The portions of the dorsal acetabular rim caudal and cranial to the DAR points, and the horizontal line on the articular surface at the location of the DAR point are shown in Fig. 2. In each instance, the horizontal line drawn along the acetabular surface at the level of the DAR point corresponded to the previously described line used to determine acetabular angles.[1–3,9,11] The highlighted caudal acetabular rim formed a shallow arc with its concavity facing medially. The portion of the dorsal acetabular rim caudal to the DAR point was difficult to identify in 25 of 27 radiographs of clinical patients. The highlighted cranial acetabular rim also formed a shallow arc with its concavity facing medially. The arc of the cranial rim was situated lateral to the arc of the caudal rim in each patient. The cranial-most portion of the acetabular rim was consistently located near the ventral margin of the ilial wing. The portion of the dorsal acetabular rim cranial to the DAR point was identifiable in 22 of 27 radiographs of clinical patients (Fig. 3).

The mean standing pelvic angle of the 18 dogs evaluated was 38 deg (±7.1 deg SD; range: 25–51 deg) from horizontal. The mean angle of the DAR point with respect to the vertical cross-hair was determined to be 37 deg (± 5.6 deg SD; range: 30–45 deg) (Fig. 4). The DAR point was between 4 and 6 mm caudal to the intersection between the vertical crosshair and the arc of the dorsal acetabular rim in each case.

In the craniocaudal radiograph performed with the x-ray beam tangential to the weight-bearing portion of the acetabulum, the majority of the acetabular rim is obscured by the ischium (Fig. 5).

In the VD radiograph performed with markers at the DAR point and 4–6 mm cranially, the DAR point is located

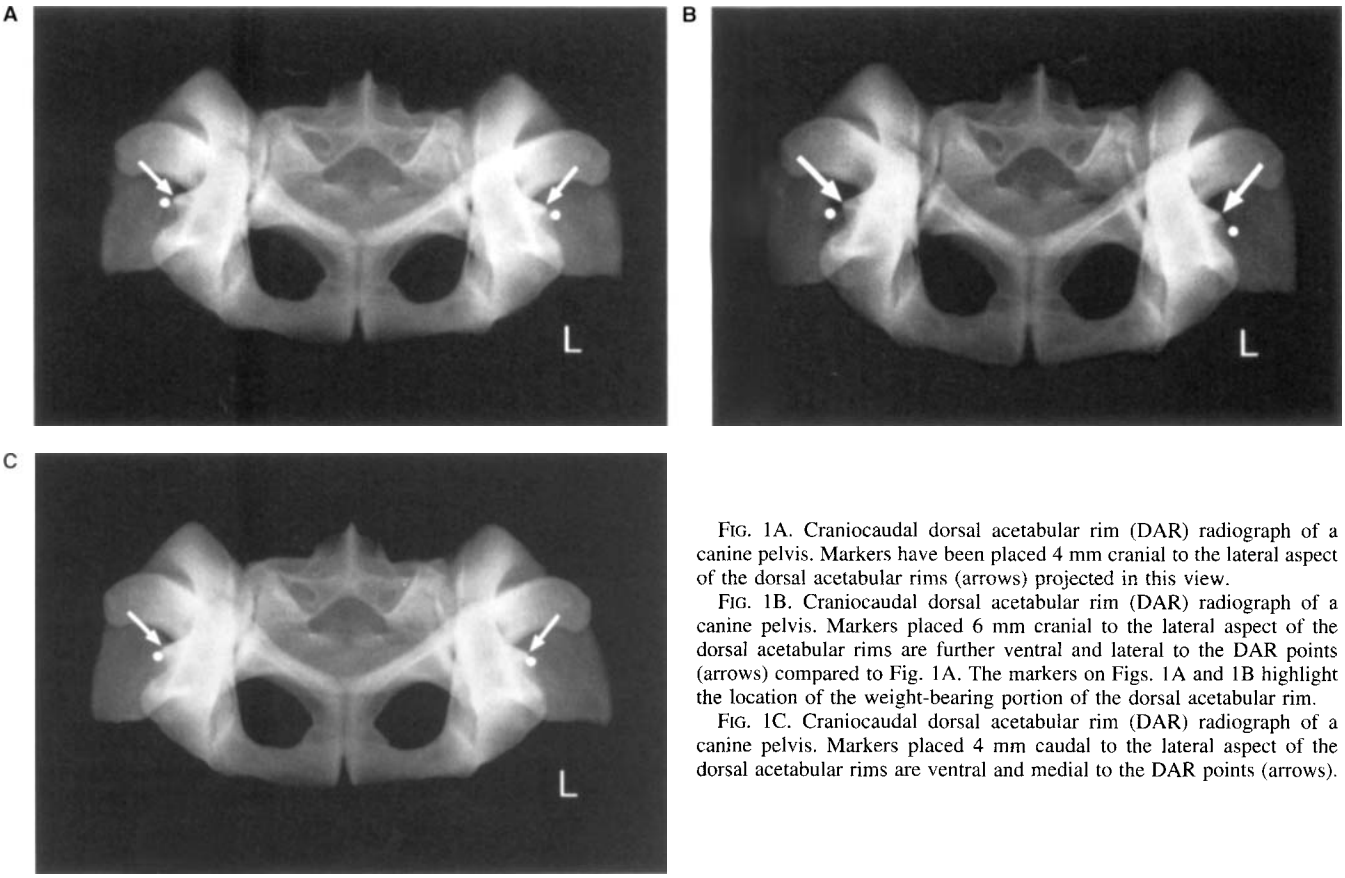

FIG. 1A. Craniocaudal dorsal acetabular rim (DAR) radiograph of a canine pelvis. Markers have been placed 4 mm cranial to the lateral aspect of the dorsal acetabular rims (arrows) projected in this view.

FIG. 1B. Craniocaudal dorsal acetabular rim (DAR) radiograph of a canine pelvis. Markers placed 6 mm cranial to the lateral aspect of the dorsal acetabular rims are further ventral and lateral to the DAR points (arrows) compared to Fig. 1A. The markers on Figs. 1A and 1B highlight the location of the weight-bearing portion of the dorsal acetabular rim.

FIG. 1C. Craniocaudal dorsal acetabular rim (DAR) radiograph of a canine pelvis. Markers placed 4 mm caudal to the lateral aspect of the dorsal acetabular rims are ventral and medial to the DAR points (arrows).

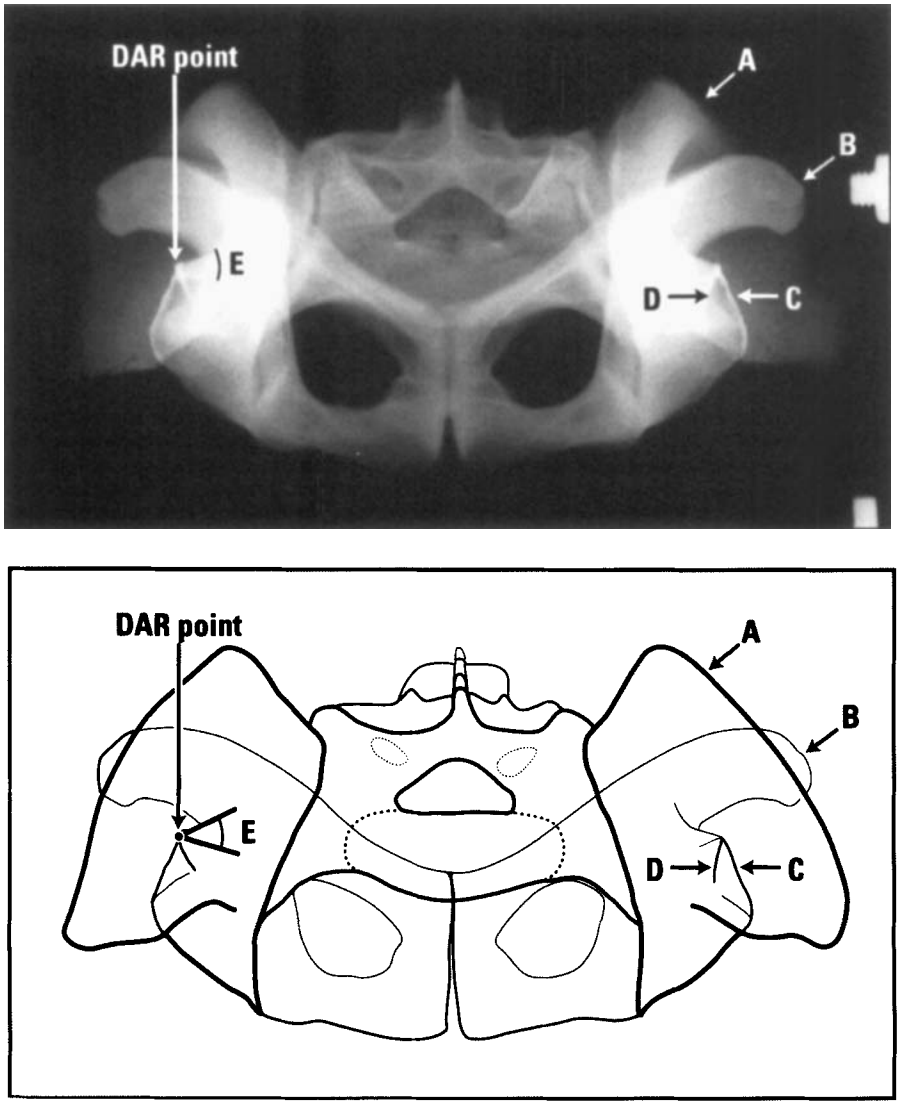

FIG. 2. Craniocaudal dorsal acetabular rim (DAR) radiograph of a canine pelvis with acetabular anatomy highlighted with barium paste, and its associated line drawing. DAR point = the lateral aspect of the dorsal acetabular rim that is projected in this view; A) iliac crest, B) ischiatic tuberosity, C) dorsal acetabular rim cranial to the DAR point, D) dorsal acetabular rim caudal to the DAR point, E) angle formed by the intersection of the dorsal acetabular cortex and the acetabular articular surface at the DAR point.

caudal to the midacetabular rim using this view. The weight-bearing portion of the acetabular rim, between the 4- and 6-mm markers, is located along the cranial third of the acetabulum (Fig. 6).

Discussion

The DAR radiographic view does not project the area of the dorsal acetabular rim most likely to develop early damage in dogs with coxofemoral joint laxity. This has been previously suggested, but not confirmed.[2] The results of this study indicate that the DAR view projects a point between 4 and 6 mm caudal to what we defined as the weight-bearing region of the dorsal acetabular rim (i.e., the point

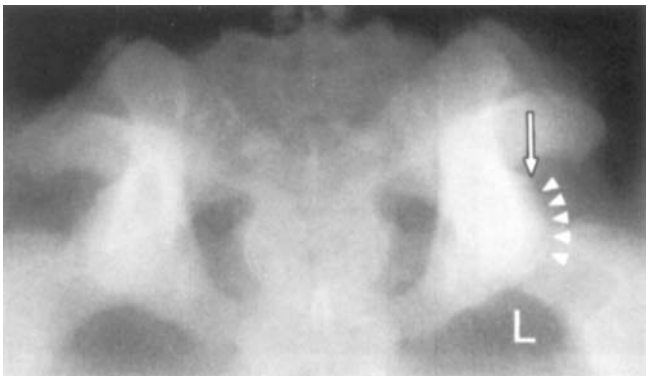

FIG. 3. Craniocaudal dorsal acetabular rim (DAR) radiograph of a 1-year old Labrador Retriever. Note the location of the DAR point (arrow) and the craniodorsal acetabular rim (arrowheads).

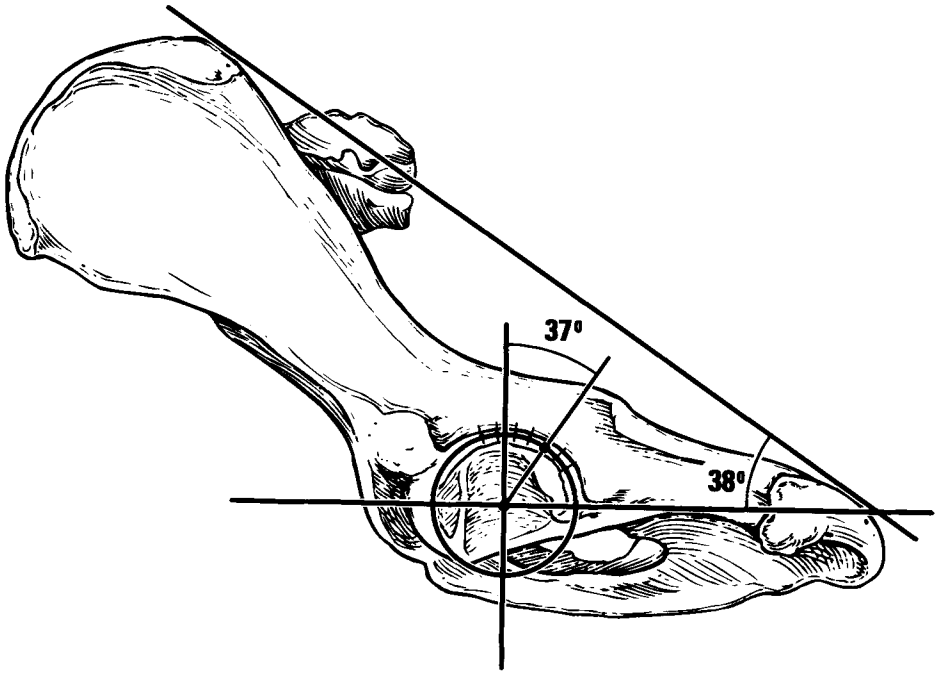

FIG. 4. Lateral line drawing of a canine pelvis. The mean standing angle of the pelves in this study was 38 degrees. Hatch marks along the dorsal acetabular rim indicate the location of the markers 2, 4, 6, and 8 mm cranial to, and 2, and 4 mm caudal to the DAR point (solid circle). A vertical line crosses the weight-bearing region of the dorsal acetabular rim 4–6 mm (37 degrees) cranial to the DAR point.

where a vertical line crosses the dorsal acetabular rim in a standing dog with a pelvic tilt of 38 deg). A similar angle (40 deg) regarding pelvic tilt has been reported previously.[12] During flexion and extension of the coxofemoral joint, the area of the dorsal acetabular rim experiencing the greatest compressive and shearing forces likely changes, depending on the phase of the stride. The coxofemoral joint angle varies from approximately 110 deg in flexion to 128–140 deg in extension in walking dogs.[13,14] However, the area of earliest and greatest acetabular rim damage is along this craniodorsal rim.[4,7,15] Damage to this area has been identified in both anatomic specimens and on VD hip-extended radiographs.[4,7,15,16] Microfractures develop in the cartilage in this area, followed by cartilage fibrillation, erosion, and dorsal osteophytosis.[7,15] The craniodorsal rim becomes slightly convex and worn as early as 2–3 months of age histologically, although these early changes are difficult to identify using the standard VD radiographic technique.[7,15] The craniodorsal rim becomes rounded on gross and ventrodorsal radiographic examination as early as 3–5 months of age.[7,15,16] Radiographic changes to the acetabular rim on the VD view should first appear along the region that corresponds to the markers placed 4–6 mm cranial to the DAR point (Fig. 6). It is not known if this radiographic wear point would shift further cranially in dogs with excessive anteversion of the femoral head and neck.

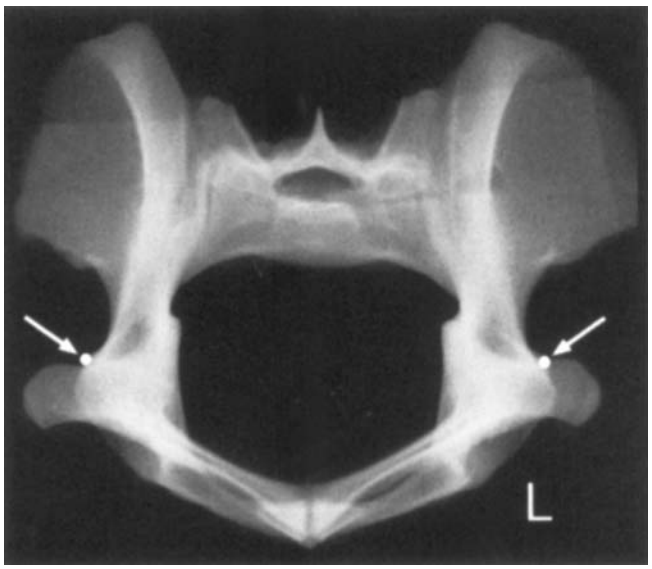

FIG. 5. Craniocaudal pelvic radiograph performed with the x-ray beam tangential to the weight-bearing portion of the acetabulum. Markers (arrows) have been placed 5 mm cranial to the DAR points (weight-bearing area). The majority of the acetabular rim is obscured by the ischium.

In the first radiograph in the series, the marker was positioned at the previously described DAR point. As the marker was moved 1 mm cranial or caudal to this point along the dorsal acetabular rim, it was not possible to distinguish a marker shift in 10/12 and 5/12 radiographs, respectively. This suggests there is a 2-mm-long region along the caudodorsal acetabular rim that may be interpreted as being the DAR point on a correctly positioned DAR radiographic view. As the marker was positioned further cranially along the acetabulum (2–8 mm), the resulting progressive marker displacement was in a ventral and lateral direc-

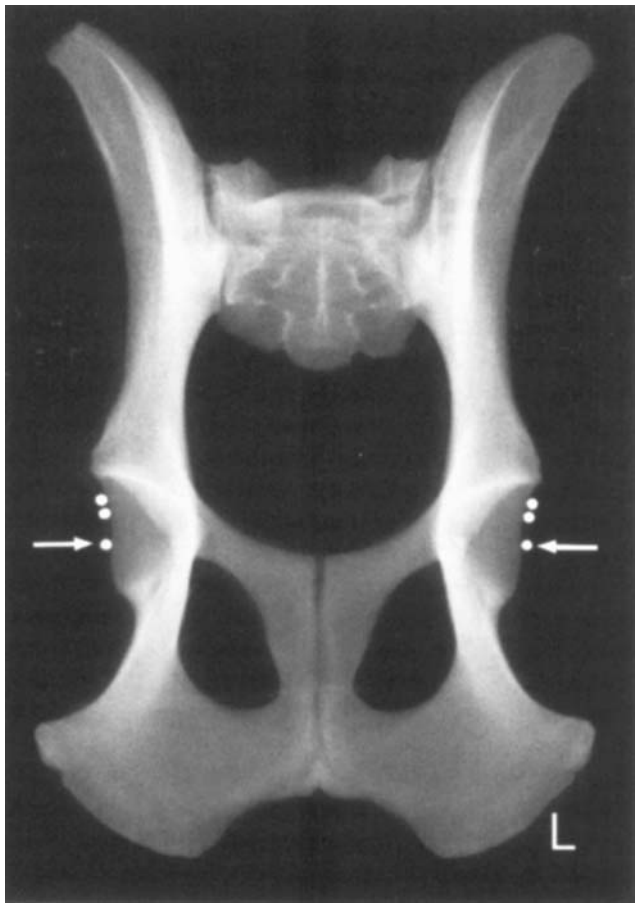

FIG. 6. Ventrodorsal pelvic radiograph performed with markers at the DAR point (arrows), and 4- and 6-mm cranial to this point. The DAR point is located caudal to the midacetabular rim on this view. The weight-bearing portion of the acetabular rim, between the 4- and 6-mm markers, is located along the cranial third of the acetabulum.

tion in relation to the DAR point. Barium paste placed along this portion of the acetabular rim consistently appeared a curvilinear line ending near the ventral margin of the ilial wing. This line was visible in 22 of 27 clinical DAR view radiographs. Evaluation of this line using the DAR view in dogs with coxofemoral joint laxity has not been described. It may be that dorsal acetabular rim wear could be identified at an earlier stage using the DAR view if changes to this line were evaluated. As the markers were moved caudally along the dorsal acetabular rim (2–4 mm), there was progressive marker displacement in a ventral and medial direction in relation to the DAR point. Barium paste placed along this portion of the acetabular rim consistently appeared as a curvilinear line located medial to the cranial acetabular rim. This line was obscured by superimposed tissues in 25 of 27 clinical DAR view radiographs. Even if this line were visible, its evaluation in patients with coxofemoral joint laxity would be of questionable value because the majority of damage to the acetabular rim does not occur in this area.

It is interesting that two independently measured variables, the mean pelvic tilt (38 deg), and the angle between the vertical line and the DAR point (37 deg), are essentially the same. For the DAR radiographic projection, the pelvis is tilted so the x-ray beam is parallel to its long axis. When this is done, the beam must also be tangential to the DAR point for these two angles to be similar, which further supports our finding that the acetabular rim area seen on the DAR view is caudal to the area most likely to experience early damage. It is physically impossible to direct the x-ray beam tangential to the weight-bearing region of the acetabular rim in a live dog, because it would be running through the longitudinal axis of the abdomen and thorax. Even if it were possible to perform this radiograph, the acetabular rim would be obscured by the ischium (Fig. 5).

Because the point along the dorsal acetabular rim highlighted by the DAR view is caudal to the weight-bearing area, blunting of the DAR point on the DAR view likely underestimates the amount of damage to the dorsal acetabular rim. Although the DAR view may allow identification of changes to the dorsal acetabular rim that are not visible on the standard hip-extended ventrodorsal radiographs and may be useful for assessing acetabular filling and for correlating palpation to radiographic findings,[1–3,9–11] early damage to the weight-bearing portion of the dorsal acetabular rim may be missed. Assessment of changes to the dorsal acetabular rim ventrolateral to this point on the DAR radiographic projection deserves further study in dogs with coxofemoral joint laxity.

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