NOTE *Surgery*

Laxity of Canine Hip Joint in Two Positions with Computed Tomography

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ABSTRACT. Computed tomographic (CT) examination of 20 canine hip joints was carried out in two positions, normal-standing and weight-bearing. In normal (dorsal acetabular rim angle: DARA < 15 °) or slightly abnormal (DARA, 15° to 20°) hip joints, the values of parameters to laxity were evaluated as more severe in the weight-bearing position. Comparisons of results using various indicators, including the center distance (CD) index, dorsolateral subluxation score, and lateral center edge angle, revealed that the CD index may be a useful marker of functional laxity in the canine hip joint under CT scanning. Further, CT scanning in the weight-bearing position was more sensitive than in the normal-standing position for the detection of laxity in hips with normal or only slightly abnormal DARA.

KEY WORDS: canine, computed tomography, hip joint.

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Hip dysplasia is still a common orthopedic disease of medium- to large-breed dogs [7, 10, 12]. Affected dogs eventually develop osteoarthritis of the hip joints. Hip dysplasia is usually diagnosed by examination of ventrodorsal radiographic projections of the pelvis, obtained with the extended-hip position. However, this test has limited application for diagnosis of hip dysplasia in the early phase, where osteoarthritis has not yet developed, or in juvenile dogs [10, 12]. Other radiographic methods have been proposed for diagnosis of hip dysplasia, including measurement of passive hip joint laxity as represented by the distraction index (DI) and measurement of the degree of dorsolateral subluxation (DLS) of the femoral head during weight bearing, as represented by the DLS score [4, 6–8, 10, 11]. The usefulness of the dorsal acetabular rim angle (DARA) was recently tested in the juvenile pelvis by both radiography and computed tomography (CT) [3, 9, 12].

Joint laxity and dorsolateral subluxation of the femoral head are both important factors in the diagnosis of canine hip dysplasia [4, 5, 7, 8, 10, 11]. Computed tomography in the standing position has been performed in some reports [2–4, 6, 9]. Here, we performed CT examination of the hip joint in a normal-standing position under anesthesia and with the stifles adducted while ‘standing’ under anesthesia in a weight-bearing position, and evaluated the different effects of these two positions on hip joint congruity. All experiments were performed in accordance with the animal experimental guidelines of the University of Kagoshima.

We studied 10 dogs (20 hip joints) that had been bred in our laboratory. There were two Labrador Retrievers, one German Shepherd, one Akita, three Tosas, and three crossbreds (5 males and 5 females). The ages ranged from 7 months to 5 years, and the body weights ranged from 15 to 52 kg (27.8 ± 12.5 kg) at the time of CT examination.

Computed tomography scans were performed in the two positions according to the procedures previously reported [4, 6, 11]. The dogs, under isoflurane anesthesia, were positioned on a platform in ventral recumbency with the vertebrae parallel to the platform. The stifle and hock joint were flexed and the body weight was borne by the femur (Fig. 1).

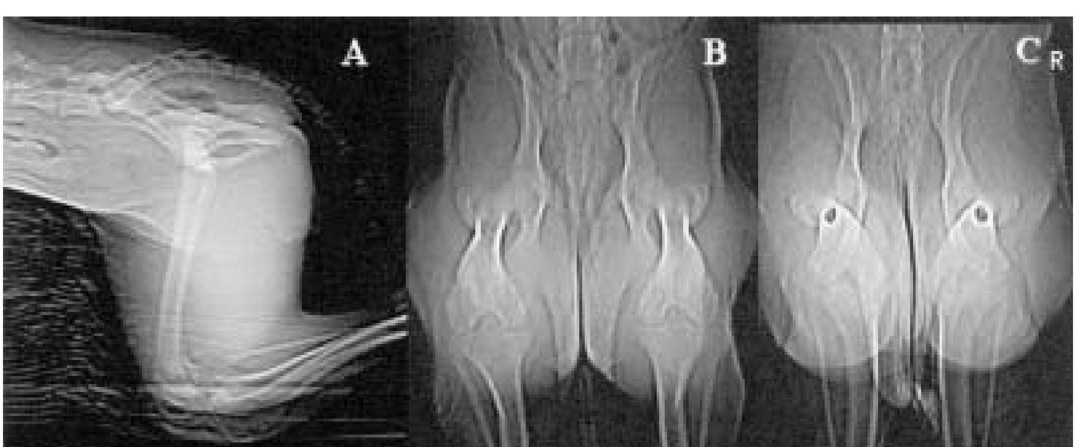

Fig. 1. Positioning for computed tomography (CT) scanning. Lateral view images in normal standing or weight-bearing positions (A). Dorsoventral view in the normal standing position. The stifle joints are placed the same distance apart as the hip joints (B). Dorsoventral view in the weight-bearing position. The stifle joints are taped together in adduction (C).

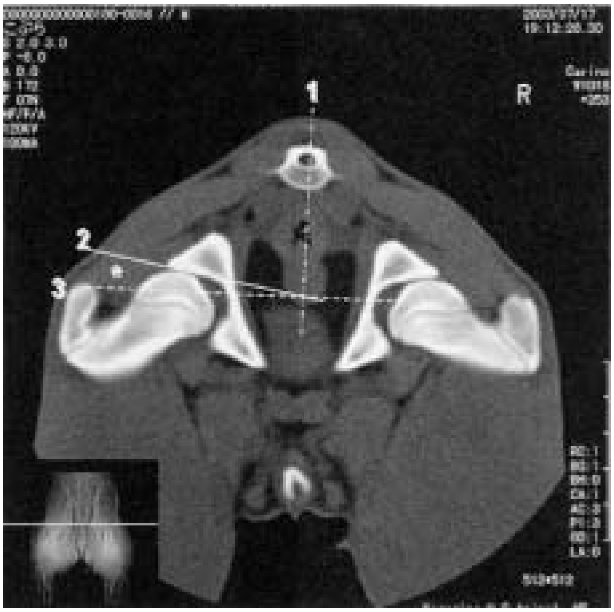

Fig. 2. Transverse pelvic CT image. The dorsal acetabular rim angle (DARA) (*) is formed by three lines: 1, the central pelvic height line; 2, a line superimposed on the plane of each dorsal acetabular subchondral articular surface; and 3, a line drawn at right angles to line 1.

In the normal-standing position, dogs were positioned so that 1) both femoral shafts were perpendicular to the imaging platform on the lateral imaging view; 2) the distance between the stifle joints was equal to that between the hips on the dorsoventral view; and 3) the axes of both femurs were parallel to the imaging platform on CT transverse slices of the sacral region. In the weight-bearing position, dogs were positioned so that 1) both femoral shafts were perpendicular to the imaging platform on the lateral imaging view; and 2) the stifle joints were taped together in an adducted position on the dorsoventral view (Fig. 1). In the above position, a transverse slice at the center of the hip joint was scanned with a width of 2 mm. The dorsal acetabular rim angle as a skeletal parameter and the DLS score and lateral center edge angle (LCEA) as laxity parameters were then measured. The dorsal acetabular rim angle was obtained by drawing three lines: the central pelvic height line, a line drawn 90° to the central pelvic height line, and an intersecting line superimposed on each dorsal acetabular subchondral articular surface (Fig. 2) [3, 9, 12]. The dorsolateral subluxation score was determined in two projections by measuring the percentage of the diameter of the femoral head medial to the lateralmost points of the cranial and dorsal acetabular rims. Two lines were then drawn perpendicular to this line: one at the lateral aspect of the dorsal acetabular rim and one at the medial aspect of the femoral head [4, 8, 11]. The lateral center edge angle was defined as the angle determined by the dorsal edge of the acetabulum, the center of the femoral head, and a horizontal line on CT images [1, 6]. The center distance (CD) index was calculated as the distance between the center of the femoral head and the center of the acetabulum, divided by the measured radius of the femoral head (Fig. 3). All data were expressed as mean ± standard deviation (SD). Statistical differences were analyzed by factorial analysis of variance, and Scheffe's method was used for simultaneous multiple comparisons. A p-value less than 0.05 was considered significant.

In the normal-standing position with normal DARA (< 15°) (n=12 joints), the mean DLS score was 57.5 ± 4.8%

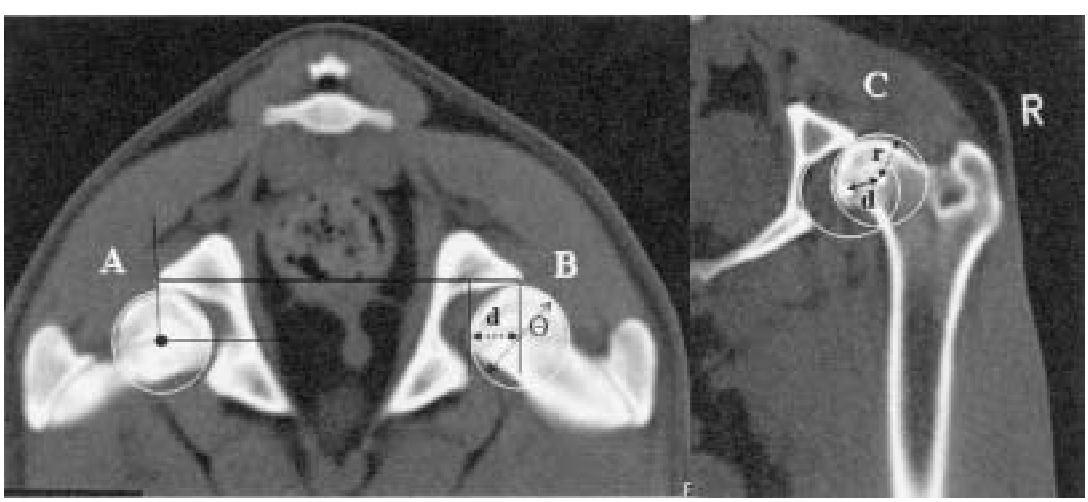

Fig. 3. Transverse pelvic CT image. (A) The lateral center edge angle (LCEA) was defined as the angle determined by the dorsal edge of the acetabulum, the center of the femoral head, and a horizontal line on the CT scan. (B) The dorsolateral subluxation (DLS) score was determined by measuring the distance between these perpendicular lines and dividing that distance by the widest diameter of the femoral head from the same hip (DLS score = $d/\theta \times 100\%$). (C) The center distance (CD) index was calculated as the distance between the femoral head center and acetabular center divided by the measured radius of the femoral head (CD index= d/r).

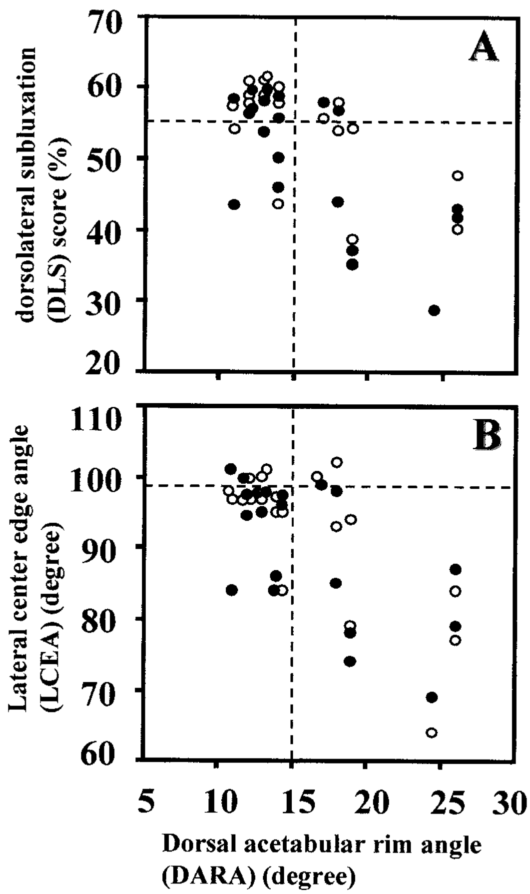

Fig. 4. The relationship between the DLS score (A), LCEA (B), and DARA in the two scanning positions on the CT image. ○; Normal-standing position, ●; weight-bearing position.

and the mean LCEA value was 96.5 ± 4.4°. In the weight-bearing position with normal DARA, the mean DLS score was 54.6 ± 5.4% and the mean LCEA value was 94.2 ± 6.1°. In the normal-standing position with abnormal DARA (> 15°) (n=8), the mean DLS score was 47.0 ± 10.3% and the mean LCEA value was 87.9 ± 12.6°. In the weight-bearing position with abnormal DARA joints, the mean DLS score was 42.9 ± 10.1% and the mean LCEA value was 83.6 ± 10.8°. Figure 4 shows the correlations between DARA and DLS score or LCEA in the two scanning positions. In hips with normal DARA range (under 15°), an abnormal DLS score (under 55%) or an abnormal LCEA (under 99°) [1, 4, 8, 11] occurred in 2 or 9 joints, respectively, in the normal-standing position, and in 4 or 10 joints in the weight-bearing position. In hips with abnormal DARA in the range 15 ° to 20°, the values of these abnormal joints had differences between these values in two positions (Fig. 4). In contrast, in hips with DARA over 20 °, DLS score and LCEA values of two positions were almost closed (Fig. 5).

The center distance index in dogs with abnormal DLS scores (under 55%) and abnormal LCEA (under 99°) in the normal-standing position and weight-bearing position were 0.38 ± 0.2 and 0.54 ± 0.14, respectively. On the other hand, in the normal hip joint with both normal DLS score and LCEA, the CD index in the normal standing-position and the weight-bearing position were 0.17 ± 0.1 and 0.22 ± 0.07, respectively. The mean value of the CD index in the weight-bearing position was therefore higher than in the normal standing position (Fig. 6).

Various radiographic evaluation methods, including measurement of the Norberg angle and the percentage of femoral head covered by the acetabulum in the extended-hip position, have been accepted for quantifying hip integrity [7]. However, they are insufficient for evaluating the absence or presence of hip joint laxity because of twisting of the joint capsule [4, 6, 12]. The relationship between hip laxity and osteoarthritis at the hip joint can be divided into

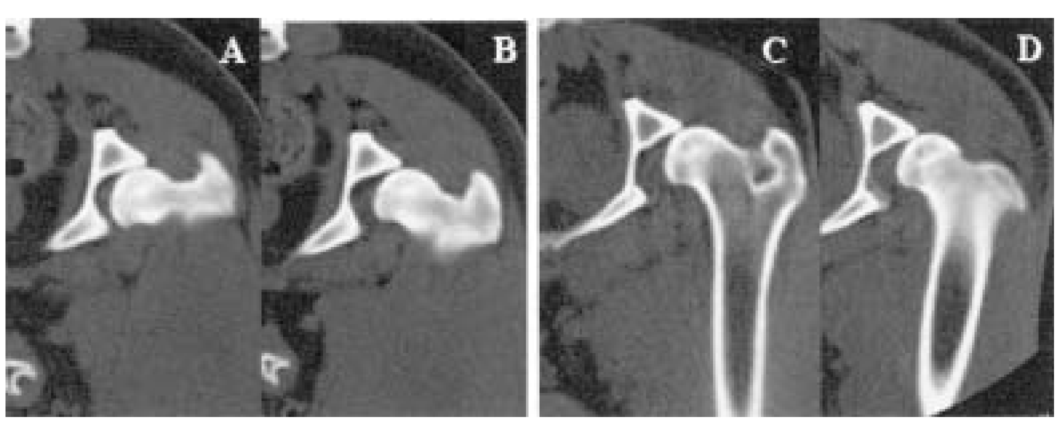

Fig. 5. Comparison of the two scanning positions in the same loose hip joints: a dog with a DARA of 15° to 20° (A, B) and one with a DARA of over 20° (C, D). A and C are taken in the normal-standing position, and B and D are taken in the weight-bearing position. The distance between the acetabulum and the femoral head is greater in the weight-bearing position (B) than in the normal-standing position (A). There was no difference between (C) and (D).

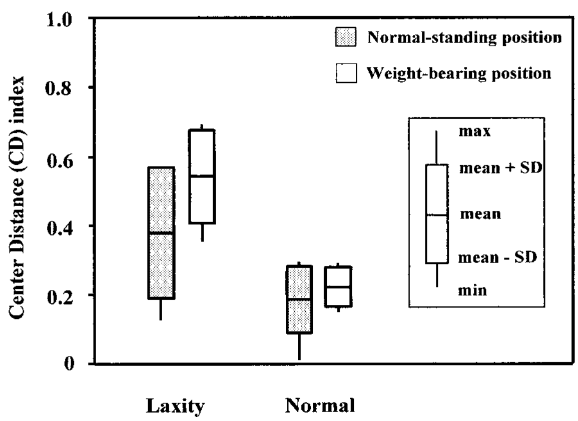

Fig. 6. Difference in the CD indices of normal and lax hips in the two scanning positions on CT image. Normal: joints with normal DLS score and LCEA. Laxity: joints with abnormal DLS score (under 55%) and LCEA (under 99°). SD: standard deviation.

two types in terms of laxity: passive and functional. Passive hip laxity is measured on a hip radiograph of the nonambulating dog under heavy sedation or anesthesia. Functional hip laxity, in contrast, is the pathological form of laxity that occurs when the dog is weight bearing. The standing position with weight loading is a natural position in which we can evaluate functional laxity. It is important and necessary that we evaluate hip joint laxity with CT while subjecting the hip to weight loading.

Here we have described the sensitivity of assessment of hip joint laxity under CT in two scanning positions. In both positions of normal-standing and weight-bearing, we obtained hip joint CT images that could be regarded as weight bearing condition. The direction of the force applied by the body weight to the hip joint is perpendicular to the scanning platform in the normal-standing position. In the weight-bearing position, the direction of the force on the hip joint is changed from perpendicular to oblique by adduction of the stifles. In this way, the femoral head moves easily dorsolaterally along the weight-bearing acetabulum in dogs with hip laxity. Our measured values showed more severe DLS scores and LCEA angles with joint laxity in the weight-bearing position than in the normal-standing position. In addition, the differences between these two positions in the values indicating laxity in the normal (DARA < 15°) or slightly abnormal (DARA 15° to 20°) hip joint tended to increase. This suggests that evaluation of the laxity of the hip joint is dependent upon the direction of force applied to the acetabulum and on the DARA. Some dogs may not show clinical signs of mild laxity because it can be obscured by normal or slightly abnormal DARA in the normal-standing position. In such cases it may be difficult to detect nonambulatory hip dysplasia. In the weight-bearing position the laxity scores were higher than in the normal standing position; this suggests that the weight-bearing position is more sensitive for detecting laxity of the hip joints on CT images.

The central distance of the femoral head is used as a marker of stability after surgical correction, and is defined for this purpose as the distance between the center of the femoral head and that of the acetabulum on CT images [6]. We calculated the CD index for comparison in identical dog. The mean CD index in dogs with abnormal DLS scores or abnormal LCEA was higher in the weight-bearing position than in the normal-standing position. However, in dogs with normal laxity scores the CD index in the two positions was similar. This result was similar to that seen in relation to DLS score or LCEA versus DARA. We suggest, therefore, that the CD index could be used as a marker of functional laxity of the canine hip joint under CT scanning. Although further studies may be needed to understand the phenomena observed here, our results suggest that the weight-bearing position is sensitive for the assessment of canine hip joint laxity on CT images.

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