SMALL ANIMALS

Evaluation of a radiographic caudolateral curvilinear osteophyte on the femoral neck and its relationship to degenerative joint disease and distraction index in dogs

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Objective—To determine prevalence of a radiographic caudolateral curvilinear osteophyte (CCO) on the femoral neck in various breeds and age groups of dogs and to evaluate its contemporaneous relationship with degenerative joint disease (DJD) and distraction index (DI).

Design—Cross-sectional prevalence study.

Animals—25,968 dogs, including 3,729 German Shepherd Dogs, 4,545 Golden Retrievers, 6,277 Labrador Retrievers, and 1,191 Rottweilers.

Procedure—Data from the University of Pennsylvania Hip Improvement Program database were analyzed, including ventrodorsal hip-extended, compression, and distraction radiographs. The CCO and radiographic signs of DJD were considered independent events and were interpreted as either present or absent. Statistical methods were used to evaluate the CCO as a possible risk factor for DJD and assess its association with DI, as measured by use of distraction radiography.

Results—When all breeds were pooled, DJD was detected in 8.6% of dogs, and the CCO was detected in 21.6% of dogs. Among dogs with a CCO, 25.1% had radiographic evidence of DJD. Among dogs without a CCO, only 4% had DJD. Dogs with a CCO were 7.9 times as likely to have DJD as were those without a CCO. Additionally, DI, weight, and age were significant risk factors for the CCO.

Conclusion and Clinical Relevance—Results confirm the contemporaneous association between the CCO and DJD and that passive hip laxity, as measured by use of the DI, is associated with both the CCO and DJD. (*J Am Vet Med Assoc* 2002;220:472–476)

Radiographic signs of **degenerative joint disease (DJD)** such as subchondral bone sclerosis, periarticular osteophytosis, and joint remodeling have been accepted as criteria for the diagnosis of hip dysplasia for more than 40 years. Programs promoting the eradication of hip dysplasia from the dog population have relied on these phenotypic features to advise breeders of their dogs' hip dysplasia status and, therefore, their suitability for use as breeding animals. As efforts have intensified to find reliable means of diagnosis in younger dogs, so has the level of scrutiny aimed at some of the more subtle observed radiographic signs.

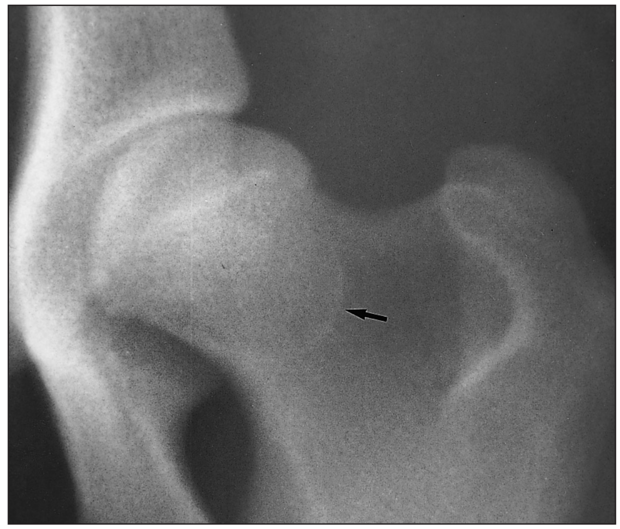

Figure 1—Ventrodorsal radiographic view of a caudolateral curvilinear osteophyte (arrow) on the femoral neck of a dog with otherwise good hip joint conformation.

The radiographic identification of a **caudolateral curvilinear osteophyte (CCO)** at the insertion of the joint capsule on the femoral neck was made for the first time in 1961.[1] Recently, the importance of this osteophyte (sometimes referred to as Morgan's line) has been questioned.[2-6] The presence of the CCO (**Fig 1**), often in the absence of any other evidence of DJD, has prompted questioning of its use as an early sign indicating that definitive DJD will develop later in life.

The hypotheses for the study reported here were that the curvilinear line on the caudal aspect of the femoral neck is a common sign in large-breed dogs that are predisposed to hip dysplasia and that there is an association between this sign and evidence of DJD and joint laxity, as measured by use of the **distraction index (DI)**.

The purpose of the study was to determine the prevalence of the CCO in a large nonrandom popula-

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tion of dogs and subsets of 4 common large breeds, to evaluate the contemporaneous relationship between the CCO and DJD, and to evaluate the relationship between the CCO and DI.

Materials and Methods

The database of the **University of Pennsylvania Hip Improvement Program (PennHIP)** comprising 25,968 dogs of 200 breeds radiographed between 1983 and 2000 was analyzed. All dogs were > 4 months old and had no known history of traumatic or systemic disease. This population included 3,729 German Shepherd Dogs, 4,545 Golden Retrievers, 6,277 Labrador Retrievers, and 1,191 Rottweilers. Age, breed, DI, and evidence of DJD were recorded for each dog. All dogs received a radiographic hip evaluation that included ventrodorsal hip-extended, compression, and distraction radiographs. The hip-extended view was used to assess the presence or absence of the CCO and DJD. Radiographic changes deemed consistent with DJD included acetabular subchondral bone sclerosis, periarticular osteophytosis, and joint remodeling. For the purposes of this study, a CCO was not considered a sign consistent with DJD but was recorded as an independent finding. Hip joint laxity from the distraction radiograph was quantitated by use of the DI, giving a measure of susceptibility to DJD. For statistical purposes, in each dog, the hip with the higher (worse) DI was selected. All radiographs were read by 1 examiner (PJM), consistent with the criteria for DJD of the most commonly used hip dysplasia control scheme, that of the Orthopedic Foundation for Animals.

Statistical analysis—To assess the relationship between CCO and DJD in the overall population and for subpopulations of German Shepherd Dogs, Golden Retrievers, Labrador Retrievers, and Rottweilers within different age groups, the Fisher exact test was used. Odds ratios and 95% **confidence intervals (CI)** were calculated. Additionally, DI, weight, and age were incorporated into a multiple logistic regression model to evaluate the relationship of these factors to CCO. This model was also used to assess breed-specific relationships between DI, the CCO, and DJD in the 4 breeds studied. Significance was defined as values of $P < 0.05$. Analyses were performed by use of statistical software.[a,b]

Results

Mean ± SD age for the population of dogs (n = 25,968) was 19.2 ± 13.7 months, with a range of 4 to 84 months. Mean weight of all dogs was 29 ± 7 kg (63.8 ± 15.4 lb). For German Shepherd Dogs, Golden Retrievers, Labrador Retrievers, and Rottweilers, mean weight was 28.5 kg ± 6.6 kg (62.7 ± 14.5 lb), 27.9 ± 5.9 kg (61.4 ± 13 lb), 28.7 ± 6.4 kg (63.1 ± 14.1 lb), and 36.7 ± 10.2 kg (80.7 ± 22.4 lb), respectively. With all breeds pooled, DJD was detected in 8.6% of hips, and the CCO was detected in 21.6% of hips. Among dogs with a CCO, 25.1% had radiographic signs of DJD. Among dogs without a CCO, only 4.0% had DJD. Among the total population, 16.2% of dogs had a CCO with no evidence of DJD **(Table 1)**.

The CCO was a significant ($P < 0.05$) risk factor for DJD in the pooled sample of dogs as well as for all 4 breeds analyzed individually ($P < 0.001$). With all dogs pooled, those with a CCO were 7.9 (95% CI, 7.2 to 8.7) times as likely to have DJD as were those without a CCO **(Fig 2)**. The CCO was a significant risk factor for DJD in subsets of dogs that were 4 to 11 months old, 12 to 23 months old, and > 24 months old in the overall population as well as in the 4 specific breeds ($P < 0.001$). The odds ratios for the CCO as a risk factor for DJD in each of these age groups within breed were calculated **(Table 2)**. Distraction index, weight, and age were all significant risk factors for the CCO in the pooled sample as well as for all 4 breeds ($P < 0.001$). Distraction index was a significant risk factor for DJD in the overall population as well as in all

Table 1—Distribution (No. [% of total]) of dogs with and without a caudolateral curvilinear osteophyte (CCO) and degenerative joint disease (DJD)

Variable	No DJD	DJD	Total
No CCO	19,537 (75.2%)	824 (3.2%)	20,361 (78.4%)
CCO	4,199 (16.2%)	1,408 (5.4%)	5,607 (21.6%)
Total	23,736 (91.4%)	2,232 (8.6%)	25,968 (100%)

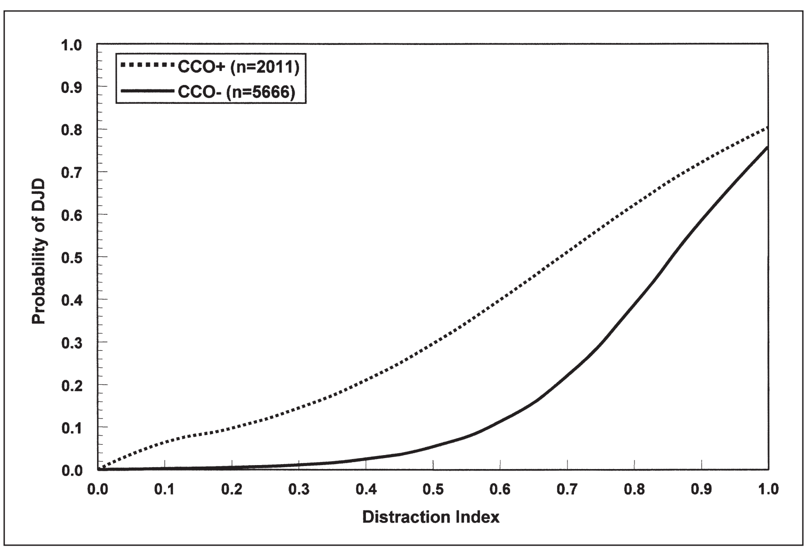

Figure 2—Logistic regression curves of the association between distraction index and probability of having degenerative joint disease (DJD) for dogs ≥ 24 months old with and without a caudolateral curvilinear osteophyte (CCO).

Table 2—Age distributions of dogs with DJD and CCO and risk ratios for CCO as a risk factor for DJD

Breed and age group (n)	Mean age (mo)	Dogs with DJD (No. [%])	Dogs with CCO (No. [%])	Risk ratio	95% CI
German Shepherd Dog					
4–11 mo (1,238)	6.7	67 (5.4)	205 (16.6)	11.2	6.4–19.7
12–23 mo (1,814)	15.7	148 (8.2)	243 (13.4)	28.2	18.6–42.9
≥ 24 mo (677)	38.1	161 (23.8)	228 (33.6)	7.3	4.8–11.0
All ages (3,729)	16.8	376 (10.1)	676 (18.1)	15.6	12.2–20.0
Golden Retriever					
4–11 mo (1,442)	7.0	55 (3.8)	301 (20.9)	8.0	4.4–15.0
12–23 mo (1,854)	16.5	115 (6.2)	517 (27.9)	6.5	4.3–10.0
≥ 24 mo (1,249)	36.7	211 (16.9)	417 (33.4)	9.0	6.3–12.9
All ages (4,545)	19.0	381 (8.4)	1,235 (27.2)	8.4	6.6–10.7
Labrador Retriever					
4–11 mo (2,151)	7.0	65 (3)	355 (16.5)	3.3	1.9–5.7
12–23 mo (2,668)	16.8	149 (5.6)	684 (25.6)	7.2	5.0–10.6
≥ 24 mo (1,459)	37.7	164 (11.2)	375 (25.7)	6.6	4.6–9.4
All ages (6,278)	18.3	378 (6)	1,414 (22.5)	6.3	5.0–7.8
Rottweiler					
4–11 mo (502)	6.8	28 (5.6)	33 (6.6)	7.2	2.5–19.1
12–23 mo (251)	16.4	26 (10.4)	50 (20)	7.4	2.9–19.2
≥ 24 mo (438)	34.6	90 (20.5)	95 (21.7)	6.0	3.5–11.4
All ages (1,191)	19.1	144 (12.1)	178 (14.9)	7.6	5.1–11.4
Total population (all breeds)					
4–11 mo (8,922)	6.9	340 (3.8)	1,388 (15.6)	5.0	4–6.3
12–23 mo (9,369)	16.4	754 (8)	2,208 (23.6)	9.3	7.8–10.9
≥ 24 mo (7,677)	37.0	1,138 (14.8)	2,011 (26.2)	7.4	6.4–8.5
All ages (25,968)	19.2	2,232 (8.6)	5,607 (21.6)	7.9	7.2–8.7

CI = Confidence interval.

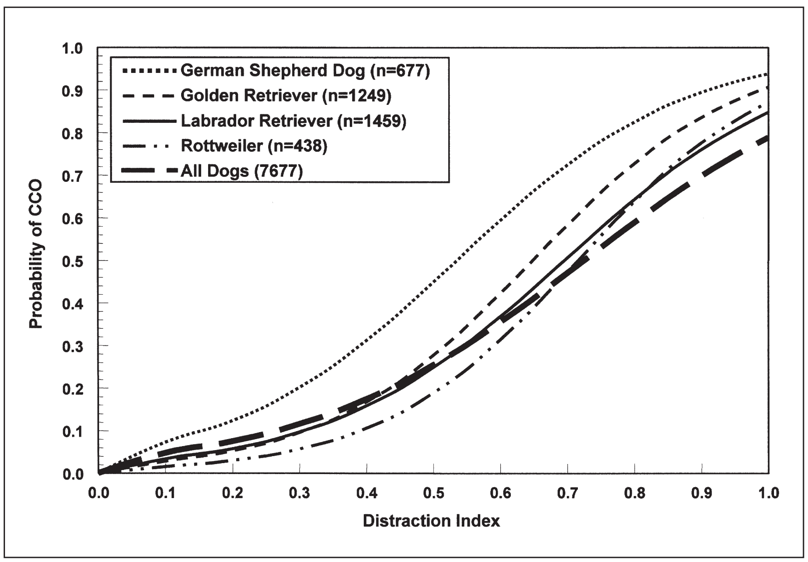

Figure 3—Logistic regression curves of the association between distraction index and probability of having a CCO in dogs that were ≥ 24 months old and of various breeds. Notice the spatial left shift in the German Shepherd Dog curve, which indicates an increased likelihood of a CCO for any given distraction index.

age groups within 4 breeds ($P < 0.001$). With all dogs pooled, for every 0.1 increase in DI, the risk of having a CCO increased by 1.4 times **(Fig 3)**.

Discussion

Presently, the clinical importance of the CCO is unknown. A percentage of dogs that are referred for conventional radiographic evaluation of the hips have no evidence of DJD but have a CCO unilaterally or bilaterally. In our study, only 25.1% of all dogs with a CCO had coexisting radiographic evidence of DJD. If the CCO were accepted to be pathognomonic for hip dysplasia, a large number of dogs would be withheld from the breeding population, perhaps unnecessarily. On the other hand, if dogs with a CCO were judged hypothetically to be phenotypically normal although they were actually genotypically abnormal, a large number of dogs with hip dysplasia potentially could be introduced into the breeding population, thereby weakening the gene pool and slowing genetic progress. In our study, 16.2% of all dogs had a CCO with no other evidence of DJD (Table 1). This finding raises the question as to the clinical relevance of the CCO. To the authors' knowledge, none of the commonly used **canine hip dysplasia (CHD)** screening programs in North America use the CCO as a criterion for the diagnosis of DJD in the absence of other signs of CHD. It is conceivable, therefore, that many dogs presently being used for breeding are, in fact, genotypically dysplastic. As the ultimate aim of all hip evaluation programs is to reduce the prevalence of CHD by appropriate selection of breeding dogs, results of our study suggest that it may be safer to consider all dogs with a CCO as phenotypically dysplastic, unless and until it is possible to prove definitively that the CCO is not an early sign of DJD. Similar logic has resulted in the routine adoption and use of subluxation as a diagnostic criterion, despite absence of scientific evidence that subluxation on the hip-extended view is associated with DJD later in life.

The importance of the CCO on the femoral neck in dogs was first investigated by Morgan.[4] It has been postulated that the etiology of this sign is stress on the insertion of the joint capsule in a hip joint that has excessive laxity. It has been stated that remodeling occurs in an effort to extend the articular surface, and this leads to the formation of osteophytes or enthesiophytes.[4] Others have suggested that the CCO is a sign of DJD and that its presence, often in the absence of other radiographic evidence of DJD, should be taken as an early marker for CHD.[3-5,7,8] This view has empirical support on the basis of the clinical observation that the CCO is more prevalent in dysplastic hip joints than in healthy hip joints.[3,4] However, to the authors' knowledge, statistical associations regarding this relationship have not been reported, and longitudinal studies have not been performed.

If the CCO is to be used as an early marker for the diagnosis of CHD, it is vital that it is shown to be a radiographically repeatable and reliable sign. The CCO is variable in its radiopacity and can be radiographically faint and subtle or more thick and obvious. Radiographic interpretation is, by definition, subjective, and some inaccuracy between and within examiners may occur when interpreting different grades of CCO. It has been shown that changes in the positioning of the hip-extended view, such as external rotation, can obscure the CCO.[4,5] The CCO has been confirmed on cadaver specimens and often appears more prominent than it does on radiographs.[6] Even a faint CCO on a hip-extended radiograph may be clinically important. Conversely, in the presence of marked bone remodeling, the CCO can be obscured.[4] The most sensitive radiographic projection for detecting the CCO is the ventrodorsal hip-extended view, but undoubtedly the sensitivity is < 100%. This study did not attempt to grade radiographic intensity of the CCO or investigate the importance of different intensity grades.

The authors have noticed a radiopaque line in young dogs (< 18 months old) at the same location as the CCO. This "puppy line" appears less distinct, straighter, and often shorter than the CCO and often disappears by 18 months of age. It is different in appearance from the CCO, and we believe that the puppy line may be a nonpathologic entity distinct from the CCO. It was not the purpose of this study to investigate this radiographic sign, but in order to rule out any influence the puppy line may have had on the results, statistical analyses were carried out on subpopulations of dogs 4 to 11 months old, 12 to 23 months old, and > 24 months old, as well as the overall population (Table 2). While uncertainty exists as to the importance of the puppy line, we suggest that no breeding decisions should be made on the basis of its presence or absence until further studies are performed.

The prevalence of the CCO in the large groups of similarly aged German Shepherd Dogs, Golden Retrievers, Labrador Retrievers, and Rottweilers was variable. Prevalence of DJD in Rottweilers was twice as great as that in Labrador Retrievers; however, prevalence of the CCO in Rottweilers was lower than that in Labrador Retrievers. It has been reported that the CCO has low frequency in clinically normal Labrador Retrievers and those with CHD.[4] This was not the case in our study, in which prevalence of CCO was 22.5% in Labrador Retrievers (all ages). Discrepancies between the prevalences of CCO and DJD in these 4 breeds could be explained in several ways. It may indicate that there is no relationship between the CCO and DJD and that many Rottweilers, for example, develop radiographic DJD without the CCO being an early feature. It could also mean that many Rottweilers had a CCO obscured by DJD and were, therefore, not recorded as having a CCO. Another explanation may be that the time at which a CCO develops is breed-specific. The pools of each of the 4 breeds of dog used in this study had similar mean ages. If cohorts of younger or older dogs were used, there could be a significant change in the perceived prevalence of the CCO or DJD. The implications of these findings are that it may be impossible to make statements regarding the importance of the CCO that are relevant to all breeds. In some breeds, it may be an early feature of DJD, whereas in others it may not develop at all or not represent an early sign of a progressive disease.

Results of our study indicated a significant association between the CCO and DJD. It should be noted, however, that this is a contemporaneous relationship and does not confirm that a CCO reliably predicts the ultimate development of DJD in the joint. It may be that, like DI and subluxation, the CCO represents a risk factor in dogs, and its effects may be mitigated or offset by environmental factors. Environmental factors have the potential to influence the phenotype of dogs that are genotypically predisposed to hip dysplasia. For example, in a study[9] involving matched littermate groups of Labrador Retrievers, radiographic signs of hip dysplasia in dogs fed an ad-libitum diet were worse, compared with dogs fed a restricted-intake diet. Excessive exercise in dogs with substantial joint laxity is likely to cause or worsen DJD of the hip, although there is no scientific evidence in the literature to support this empirical impression.

Joint laxity, as measured by distraction radiography, was found in our study to be a significant risk factor for the CCO. This supports (but does not prove) the original hypothesis that the CCO develops secondary to increases in stress on the joint capsule insertion in dogs with excessive hip joint laxity.[4] As DI increases, the probability of having a CCO also increases in a relatively linear fashion (Fig 3). Interestingly, for a given DI, German Shepherd Dogs appear to be at significantly higher risk of having a CCO than Rottweilers. This parallels published evidence that German Shepherd Dogs are at higher risk of developing DJD for any given DI than are Rottweilers.[10]

Joint laxity (DI) has been shown to be the most important risk factor for the development of DJD of the hips in dogs.[11] The association between the CCO and the probability of having DJD, as a function of DI, was apparent (Fig 3). For a given DI, dogs are at significantly higher risk of having DJD if a CCO is present. Interestingly, however, a comparatively small percentage (< 20%) of dogs with low DI, which are unlikely to have radiographic evidence of DJD, are at risk of having a CCO, and similarly, a substantial number of dogs that have a high DI and are, therefore, extremely likely to have DJD, have only a moderately higher risk of having a CCO, compared with the risk of DJD. Otherwise stated, some relatively tight-hipped dogs have a CCO, and conversely, some loose-hipped dogs do not have a CCO but do have DJD. The latter phenomenon may be attributable in part to the observation that in some dogs with severe DJD, the CCO can become radiographically obscured. Why a small number of tight-hipped dogs develop a CCO is unknown. The lack of diagnostic sensitivity of the ventrodorsal hip-extended radiograph may decrease the recognition of the CCO and, therefore, underestimate the true frequency of its occurrence. This may especially be the case in young animals in which the CCO is often less developed and, therefore, may not be detectable on the radiograph.

Results of this study confirmed the contemporaneous relationship between the CCO and DJD, revealed an association between DI and the CCO, and reaffirmed the strong relationship between DI and DJD. It should be stressed that only longitudinal studies, preferably lifelong, will reveal whether there is a consistent relationship between early development of a CCO and subsequent development of DJD. Presently, the available evidence suggests that the gene pool will be improved toward better hips if the CCO is considered a contraindication for breeding. The authors stress that presently a CCO should not be considered an indication for any surgical procedure that purports to delay the onset or decrease the severity of DJD in later years.

[a]Version 8, SAS Institute Inc, Cary, NC.
[b]Version 4.0.1, Cytel Software Corp, Cambridge, Mass.

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