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Radiological evaluation of the relationship between caudolateral curvilinear osteophyte and joint laxity and degenerative joint disease associated with Canine Hip Dysplasia

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ABSTRACT

The aim of the present study was to investigate the relationship between the caudolateral curvilinear osteophyte (CCO) and canine hip dysplasia (CHD), degenerative joint disease (DJD) and joint laxity as measured using the subluxation index (SI) and Norberg Angle (NA). Three hundred and fifty-three dogs belonging to 8 breeds were evaluated. Following sedation, the hips were evaluated radiographically using the ventro-dorsal hip-extended view and the subluxation view. Radiographic changes examined whether DJD was seen or not. CCO was not considered a sign consistent with DJD but was recorded as an independent finding. The overall prevalence of CHD was detected as 36.11%. DJD and CCO were detected in 16.0% and 34.70% hip joints, respectively. Among hips with CCO, 33.9% had radiographic signs of DJD, however, only 6.5% hips without CCO had DJD. A significantly ($P<0.01$) positive correlation was determined between CCO and DJD. The mean NA was significantly ($P<0.001$) higher and the mean SI was significantly lower in dogs without CCO than in dogs with CCO. A significantly ($P<0.01$) positive correlation was observed between CCO and DJD and CCO and SI, and also a significantly ($P<0.01$) negative correlation was detected between CCO and NA. This study confirmed the relationship between the CCO and DJD, and reaffirmed the relationship between the SI and DJD. Presently the evidence from this study suggests that by evaluating both CCO and DJD together, the gene pool will be improved to produce better hips if dogs with CCO and greater SI than 0.5 are withheld from the breeding population.

Key words: dog, hip dysplasia, Morgan line, caudolateral curvilinear osteophyte, subluxation index, degenerative joint disease

Introduction

Canine hip dysplasia (CHD) has been studied widely since it first was reported in 1935 (SMITH et al., 1990; SCHNELLE, 1935). Success in reducing CHD incidence is

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limited by the insensitivity and timing of detection methods, which result in failure to remove affected animals from the breeding pool. However, CHD is still common, despite radiographic screening of breeding dogs (HAAS, 2006). Most researchers have focused on early diagnosis and treatment of CHD (BADERTSCHER, 1977; BARDENS and HARDWICK, 1968; CULP et al., 2006; FLUCKIGER et al., 1999; HAAS, 2006; HENRY and PARK, 1972; LUST et al., 1993; MADSEN and SVALASTOGA, 1995; PRIEUR, 1978; SMITH et al., 1990; VEZZONI, 2006). Radiography is the only accepted tool for large-scale screening of dogs for CHD (CHALMERS et al., 2006; FLUCKIGER et al., 1999). As efforts have intensified to find a reliable means of diagnosis in younger dogs, so has the level of scrutiny aimed at some of the more subtle radiographic signs observed (MAYHEW et al., 2002). Femoral head subluxation (joint laxity) has been described as the first radiographic sign of hip dysplasia that can be detected as early as at 30-60 days of age (BELKOFF et al., 1989; FLUCKIGER et al., 1999; RISER, 1975). In dogs as young as 16 weeks of age, the degree of hip joint laxity is a risk factor for osteoarthritis (SMITH et al., 2001).

The radiographic identification of a caudolateral curvilinear osteophyte (CCO), sometimes referred to as Morgan's line at the insertion of the joint capsule on the femoral neck, was made for the first time in 1961 (WHITTINGTON et al., 1961). Laxity of the coxofemoral joint during weight bearing places tension on the joint capsule, leading to trauma and thickening of the joint capsule and osteophyte formation in the capsule along the capsular border (RISER et al., 1985). There are a few articles about CCO, and also the importance of this osteophyte has been questioned (ACKERMAN, 1982; KLIMT et al., 1992; MAYHEW et al., 2002; MORGAN, 1987; RISER, 1975; TORRES et al., 1999). The presence of CCO, 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 purpose of this study was to investigate the relationship between CCO and CHD, DJD and joint laxity as measured by the subluxation index (SI).

Materials and methods

In this study, 706 coxofemoral joints of 353 dogs belonging to eight breeds were evaluated (Table 1). None of the dogs had any known history of a traumatic or systemic disease. Age, breed, Subluxation index (SI), Norberg angle (NA) and evidence of DJD were recorded for each dog. Before the radiographic examination, all the dogs were heavily sedated to achieve full muscle relaxation by an intramuscular injection of 1-2 mg/kg/BW Xylazine HCL (Rompun, Bayer, İstanbul, Turkey) and 2 mg/kg/BW ketamine HCL (Ketalar, Eczacibasi, Istanbul, Turkey) combination following the subcutaneous administration of 0.02 mg/kg/body weight (BW) atropine sulphate (Vetas Atropin, Vetas, Kocaeli, Turkey). After this, radiographs were taken in hip-extended and subluxation position.

Table 1. Breed and sex distribution of dogs

Breed	Male	Female	Total
German Shepherd	53	65	118
Labrador Retrievers	23	22	45
Golden Retrievers	15	5	20
Pointer	33	29	62
Doberman Pincher	14	15	29
Irish Setter	13	18	31
Anatolian Karabash	15	13	28
Belgian Malinois	9	11	20
Total	175	178	353

The subluxation method applied was identical to the one described by FLUCKIGER et al. (1999) because this technique does not require any specific requirements. For this technique, the dogs were placed in dorsal recumbency on the X-ray table. Femurs were positioned at a 60° angle to the table top; the stifles were adducted and manually pushed craniodorsally by a tester during exposure; the tibia served as a lever, the degree of instability was quantified by a dimensionless subluxation index (SI = d/r), defined as the ratio of the distance from the center of the acetabulum (d) and the radius of the femoral head (r). For evaluation of hip dysplasia with NA, radiographs were taken in the standard ventro-dorsal hip-extended position. The hip-extended view was used to assess the presence or absence of CCO and DJD. Radiographic changes deemed consistent with DJD included acetabular subchondral bone sclerosis, change in shape or depth of acetabulum, periarticular osteophytosis, remodeling of the femoral head and joint remodeling. All radiographs were evaluated by the first author. For the purposes of this study, CCO was not considered a sign consistent with DJD, but was recorded as an independent finding. Hip joint laxity from the subluxation radiograph was quantitated by use of the SI, giving a measure of susceptibility for DJD. All the radiographs were read carefully, consistent with the criteria for DJD of the most commonly used hip dysplasia control scheme of the Orthopedic Foundation for Animals.

Statistical analyses were performed using the SPSS statistical package program (SPSS for Windows, version 10.0). The mean values and standard deviations (SD) were calculated as descriptive statistics. The relationship between CCO and DJD was evaluated by the chi-square test. The NA and SI results were evaluated by the Student's *t* test, according to whether CCO and DJD were seen or not. The relationship between CCO and breed, age and sex were evaluated by the chi-square test. The correlation between NA, SI, CCO and DJD were evaluated by Pearson's correlation coefficient. Also for evaluation of NA and SI results according to age groups, data were subjected to Kruskal-Wallis one-way analysis of variance (ANOVA). P values <0.05 were considered significant for all analyses.

Results

A total of 353 dogs were evaluated radiographically for hip dysplasia. The distribution of the studied dogs by sex was 50.4% females and 49.6% males. The overall prevalence of canine hip dysplasia was 36.11%, and 18.28% of dogs were scored as borderline (when it could not be completely ruled out that it is dysplastic or not) according to the Orthopedic Foundation for Animals' hip score scheme. When all breeds were pooled, DJD was detected in 16.0% of hips and CCO was detected in 34.70% of hips. Among the hips with CCO, 33.9% had radiographic signs of DJD. Among hips without CCO, only 6.5% had DJD. Among the total population, 22.9% of hips had CCO without evidence of DJD (Table 2). SI and NA of dogs in relation to CCO and DJD are shown in Table 2. When all the dogs are pooled into the same group, the mean NA of dogs without CCO was 103.46° and 100.79° in dogs with CCO. If DJD status is ignored, the mean SI of dogs without CCO was 0.37 and 0.46 in dogs with CCO. A significant difference (P<0.001) was also observed in NA and SI according to whether CCO was seen or not. The results of Pearson's correlation of CCO with DJD, breed, sex, age, NA and SI are shown in Table 3. A significant (P<0.01) positive correlation was determined between CCO and DJD and CCO and SI, and a significant (P<0.01) negative correlation was determined between CCO and NA.

Table 2. Distribution (No. [% of total] of dogs with and without CCO and DJD and descriptive results of SI and NA in relation with CCO and DJD)

CCO	DJD	N (%)	SI Mean (SD)	NA Mean (SD)
CCO (Negative)	DJD (Negative)	431 (61.0%)	0.36 (0.15)	104.04 (3.70)
	DJD (Positive)	30 (4.2%)	0.48 (0.17)	95.10 (10.09)
CCO (Positive)	DJD (Negative)	162 (22.9%)	0.38 (0.16)	104.50 (3.43)
	DJD (Positive)	83 (11.8%)	0.62 (0.14)	93.51 (7.97)
Significance			***	***

CCO: caudolateral curvilinear osteophyte, DJD: degenerative joint disease, SI: Subluxation Index, NA: Norberg Angle, SD: Standard deviation. ***: P<0.001

Table 3. Pearson's correlation results of CCO with DJD, breed, sex, age, NA and SI

	CCO	DJD	Breed	Sex	Age	NA	SI
CCO	1	0.355**	-0.044	0.030	-0.005	-0.210**	0.255**

** P<0.01

For evaluation of the relationship between CCO and age, all the dogs were divided into three groups according to their ages (group 1: between 4-11 months, group 2: between 12-23 months, and group 3: 24 months and older). CCO was observed in 34.3%, 35.8%, and 34.0% respectively. However, no significant difference was observed between age groups.

The prevalence of CCO was higher in male dogs (37.1%), than females (32.3%), however, this difference was not statistically significant. Moreover no significant difference was observed between breeds according to whether CCO was seen or not.

Discussion

This study attempted to determine the relationship between CCO and joint laxity, and DJD associated with CHD. Hip joint laxity was measured by NA and the subluxation method described by FLUCKIGER et al. (1999), because this technique does not require any special equipment and can be learned quickly. Significant differences (P<0.001) were observed in SI and NA according to whether CCO was observed or not. There was a significant negative correlation between CCO and NA, and a positive correlation between SI and CCO. In dogs which had both CCO and DJD, the mean SI was significantly higher (P<0.001), and the mean NA was significantly lower (P<0.001) than in dogs without CCO and DJD. The present results support the previous hypothesis that CCO is a result of excessive laxity of the hip joint (POWERS et al., 2004; RISER et al., 1985), which causes osteophytes to form within the insertion lines of the joint capsule.

Previous studies noticed a radiopaque line in young dogs at the same location as the CCO, called the "puppy line". They also reported that this line appears less distinct, straighter, and often shorter than the CCO observed in dogs ≤ 18 months of age, and it then disappeared or transformed into a CCO, so it is thought to be nonpathologic and should not be confused with CCO (MORGAN, 1987; MAYHEW et al., 2002; POWERS et al., 2004; RISLER et al. 2009). For evaluation of the relationship of CCO with age, statistical analyses were carried out on subpopulations of dogs 4-11 months old, 12-23 months old and ≥24 months old as well as the overall population. It was observed that the prevalence of CCO was not statistically different between the age groups or sexes. Morgan (BARDENS and HARDWICK, 1968) reported that CCO has a low frequency in clinically normal Labrador Retrievers and those with CCO, it was reported that the prevalence of CCO was 22.5% in Labrador Retrievers (MAYHEW et al., 2002). In the present study, the prevalence of

CCO in Anatolian Karabash was twice as great as that in Setters. If the breeds are sorted according to prevalence of CCO, Anatolian Karabash (50.0%) has the highest prevalence, followed by Labrador Retrievers (43.3%), Golden Retrievers (40.0%), Doberman Pinchers (34.5%), German Shepherd Dogs (32.2%), Pointers (31.5%) and Malinois (30.0%). Setters (24.2%) had the lowest prevalence of CCO. However, these differences were not statistically significant. Therefore, it may be suggested that these factors change in relation tothe population on which the studies were carried out.

There are a large number of studies about hip joint laxity (BELKOFF et al., 1989; FLUCKIGER et al., 1999; HENRICSON et al., 1966; LUST et al., 1993; RISER, 1975) and a few studies about CCO, separately, (ACKERMAN, 1982; KLIMT et al., 1992; MAYHEW et al., 2002; MORGAN, 1987; POWERS et al., 2004; RISER, 1975; SMITH et al., 1998; TORRES et al., 1999). There is general agreement that hip joint laxity is a risk factor for osteoarthritis (SMITH et al., 2001), however not every dog with subluxation of the hips will develop significant osteoarthritis (LUST et al. 1993). In addition, it was reported that CCO is an important early radiographic indication of osteoarthritis (POWERS et al., 2004) or a risk factor (MAYHEW et al., 2002) for secondary DJD caused by joint laxity. KARBE et al. (2012), stated that the CCO in Pembroke Welsh Corgis had similar clinical relevance to that in large-breed dogs as a marker of hip dysplasia and a predictor for OA. It was reported that some dogs have no evidence of DJD, but have a CCO unilaterally or bilaterally, and were referred for conventional radiographic evaluation of the hips (MAYHEW et al., 2002). Also, in a study comparing radiographic and computed tomographic images, it was stated that x-rays could not always determine the presence of CCO (KISHIMOTO et al., 2010). In the present study, among the hips with CCO, 33.9% had radiographic signs of DJD, however, only 6.5% of hips without CCO had DJD, and, among the total population, 22.9% of hips had CCO without evidence of DJD. A statistically significant correlation ($P<0.01$) between CCO and DJD was observed in this study, supporting the previous suggestion that CCO is early evidence (POWERS et al., 2004) or a risk factor (MAYHEW et al., 2002) for secondary degenerative joint disease caused by joint laxity. However, if CCO were accepted to be pathognomonic for hip dysplasia, a large number of dogs would be withheld from the breeding population, perhaps unnecessarily (in the present study, only 33.9% of dogs with CCO had DJD). On the other hand, if dogs with CCO were judged hypothetically to be phenotypically normal, although they were actually genotypically abnormal, a large number of dogs with hip dysplasia could potentially be introduced into the breeding population. Previous studies reported that increased laxity is a risk factor and a condition for development of hip dysplasia, but not sufficient in itself, (LUST et al., 1993), however, in young puppies, assessment and measurement of increased early laxity may not be an accurate predictor for CHD, because of the smaller size of puppies relative to the strength of the examiner, and the pliability of the musculoskeletal system in puppies (ADAMS et al., 2000; LUST et al., 1993; SARIERLER, 2003; SMITH et al., 1990). However, if CCO and SI were evaluated together, more significant results may be gathered. In the present study, in the group of dogs which had SI≥0.5, 50.6% (n = 119) had CCO, and 48.1% (n = 113) dogs had DJD, and 35.3% (n = 83) dogs had both CCO and DJD. In addition, in the group of dogs, with CCO and SI≥0.5, 69.7% dogs had DJD, and dogs without CCO and SI≥0.5, only 25.9% had DJD.

The results of this study confirm the relationship between CCO and DJD and reaffirmed the relationship between SI and CCO, and SI and DJD. Presently the evidence from this study suggests that by evaluating both CCO and SI together, the gene pool will be improved, leading toward better hips if the dogs which have CCO and greater SI than 0.5 are withheld from the breeding population.

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SAŽETAK

Svrha je ovog rada istražiti odnos između osteofita na kaudolateralnom rubu (engl. caudolateral curvilinear osteophyte, CCO) i displazije kuka u pasa te degenerativne bolesti zglobova (engl. degenerative joint disease, DJD) i labavosti zgloba mjerene subluksacijskim indeksom (SI) i Norbergovim kutom (Norberg Angle, NA). Istraživanje je bilo provedeno na 353 psa iz osam pasmina. Nakon sedacije kukovi su bili procjenjivani radiološki u ventro-dorzalnoj projekciji s ekstendiranim nogama i u subluksaciji zgloba kuka. Radiografske promjene bile su istražene bez obzira je li degenerativna bolest zgloba bila vidljiva ili ne. Nalaz CCO ne smatra se postojanim znakom degenerativne bolesti zgloba, ali je uočen kao samostalan nalaz. Cjelokupna prevalencija displazije kuka pasa iznosila je 36,1 %. Degenerativna bolest zgloba zabilježena je u 16,0 %, a CCO u 34,7 % zglobova kuka. U 33,9 % zglobova s CCO zabilježeni su radiografski znakovi DJD, dok je u samo 6,5 % zglobova bez CCO zabilježen DJD. Utvrđena je značajno (P<0,01) pozitivna korelacija između CCO i DJD. Srednja vrijednost NA bila je značajno (P<0,001) veća, a srednja vrijednost SI značajno manja u pasa bez CCO nego u pasa s CCO. Značajno (P<0,01) pozitivna korelacija zabilježena je između CCO i DJD, CCO i SI, dok je signifikantno negativna korelacija (P<0,01) bila utvrđena između CCO i NA. Ovo je istraživanje potvrdilo vezu između CCO i DJD te ponovno utvrdilo odnos između SI i DJD. Rezultati ovog istraživanja pokazuju da vrednovanje CCO i DJD zajedno s genetskim nalazima može pridonijeti genetskom poboljšanju zglobova, ako se psi koji imaju CCO i SI veći od 0,5 isključe iz uzgojne populacije.

Ključne riječi: pas, displazija kuka, Morganova linija, osteofiti kaudolateralnog ruba, subluksacijski indeks, degenerativna bolest zglobova

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