Relationship Between Age and Tibial Plateau Angle in Dogs With Cranial Cruciate Rupture

The pathogenesis of cranial cruciate ligament (CCL) rupture remains controversial, and its relationship to tibial plateau angle is unknown. In this study, the tibial plateau angle was measured in 200 large-breed dogs diagnosed with CCL rupture. Correlation analyses were performed to determine whether the age at the time of CCL rupture and the tibial plateau angle were related. While these two values were inversely correlated, the relationship was not strong enough to explain the frequency of CCL rupture in young, large-breed dogs. There was no statistically significant correlation between age at the time of CCL rupture and tibial plateau angle. **J Am Anim Hosp Assoc 2005;41:117-120.**

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Introduction

Despite the numerous publications devoted to rupture of the cranial cruciate ligament (CCL) in the dog, its exact pathogenesis remains poorly understood.[1] Multiple explanations have been offered to explain this common orthopedic condition, including trauma (e.g., acute stifle hyperextension, excessive tibial internal rotation), degenerative processes, obesity, anatomical features, immune-mediated diseases, and conformation.[1-10] These etiologies are not mutually exclusive, and the pathogenesis may be multifactorial in some cases.[11,12] Although CCL rupture may occur as a single acute traumatic event, it most often follows a degenerative process in dogs.[2,13,14] Two studies have shown that by 5 years of age, the CCL of dogs weighing >15 kg or an average of 35 kg have microscopic evidence of degenerative disease involving fibroblast populations and collagen fibers.[1,2] These changes appear to follow chronic mechanical loading and microinjury.[1]

Other studies have documented a prevalence of CCL rupture in young (≤2 years of age), large-breed dogs.[3,15] Several studies suggest that dogs with CCL rupture have a greater tibial plateau angle than dogs without CCL disease, although these papers have recently been challenged.[8,10,16] The tibial plateau angle is measured before performing a tibial plateau leveling osteotomy (TPLO). This angle determines how much rotation of the tibial plateau is necessary to correct the excessive slope by leveling the tibial plateau.[a]

As yet, a consensus has not been reached to explain why some young, large-breed dogs are prone to CCL rupture. The question remains as to when and why the CCL of some young, large-breed dogs undergoes degeneration. The purpose of this study was to test the hypothesis that young, large-breed dogs with CCL rupture have a steeper tibial plateau than older, large-breed dogs with CCL rupture.

Materials and Methods

Case Material

Two hundred dogs consecutively diagnosed with CCL rupture between February 2001 and March 2002 were entered into the study. A presumptive diagnosis of CCL rupture was based on lameness examination, a positive cranial drawer test and/or tibial compression test, joint effusion, pain on flexion and extension, presence of a medial joint buttress, and/or meniscal click.[11,17,18] Radiography, arthrocentesis, arthroscopy, and/or surgical exploration were also performed to evaluate the lameness in some cases. Criteria for inclusion in the study included surgical confirmation of CCL rupture and identification of the nature of the CCL tear (partial versus complete). Other data recorded included signalment (e.g., age, gender, breed), weight, and tibial plateau angle.

Tibial plateau angle was measured by one of three Slocum-licensed, board-certified surgeons (Paré, Robinson, Gendreau) from a lateral plain radiograph of the affected stifle.[a] A line was initially drawn parallel to the tibial plateau [Figure 1]. A second line was drawn along the long axis of the tibia between the intercondylar eminences of the tibial condyle and the center of the talus. A third line was drawn perpendicular to the long axis of the tibia. The tibial plateau angle [Figure 1] is the angle between the first and third lines.[a]

Several sources of variation in tibial plateau angle measurement have been described, including intra- and interobserver measurement variability, anatomical or pathological specificities, and stifle positioning during radiography.[19,20] Angles were rounded up to the nearest whole number.

Dogs had their tibial plateau angle measured if the surgeon thought the dog might be a candidate for TPLO. Because the authors only performed TPLO and only measured the tibial plateau angle in large dogs at the time of this study, only large-breed dogs were included in the study population.

Data Analysis

The relationship between classes of categorical variables was tested using chi-square test for homogeneity in cases where the variable had two classes (e.g., gender). When the categorical variable had more than two classes (e.g., breeds), analysis of variance was used, with tibial plateau angle as the dependent variable and breed as the independent variable.[b] For all analyses, a value of $P<0.05$ was considered significant.

The relationship between two continuous variables (i.e., tibial plateau angle, age at the time of CCL rupture) was determined using correlation analysis.[b] A correlation coefficient (r) ranges from -1.00 to +1.00. Correlation coefficient r = -1.00 represents a perfect negative correlation, while r = +1.00 represents a perfect positive correlation. A value of 0.00 represents a lack of correlation. The coefficient of determination (r^2) was used to determine the proportion of variation in the two variables (in other words, the "strength" of the relationship).

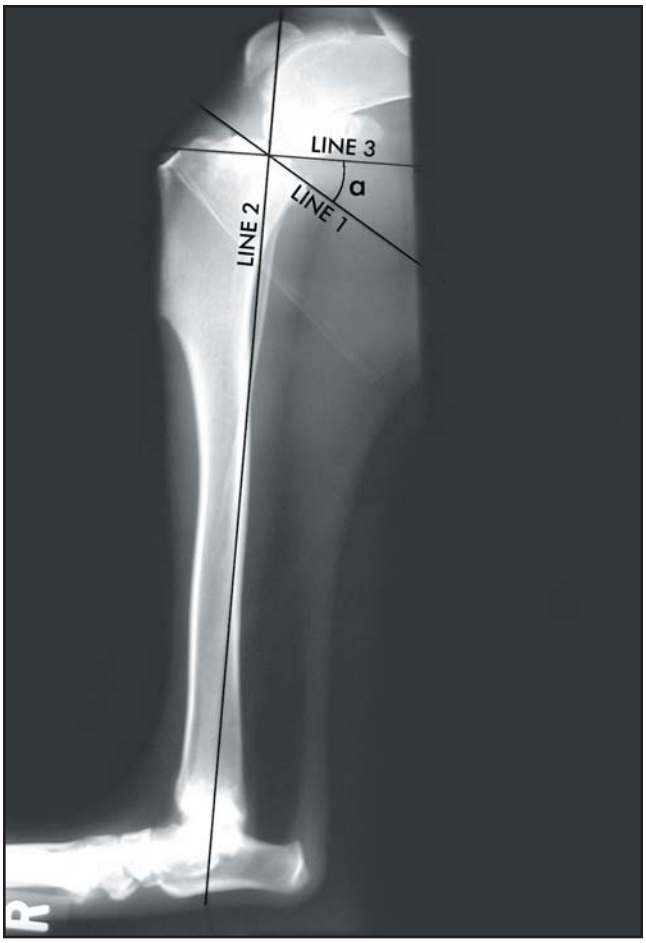

Figure 1—Lateral radiograph of the right stifle of a 2.5-year-old, spayed female Great Dane, showing a tibial plateau angle (a) measurement of 33°.

Results

Case Data

Two hundred dogs met the criteria for inclusion in the study. The mean ± standard deviation (SD) age was 5.4±2.7 years (range 1.2 to 13.5 years). One hundred and twenty-four (62%) dogs were females (112 spayed, 12 intact). Seventy-six (38%) dogs were males (63 castrated, 13 intact). There was a significant difference in the proportion of males versus females (P=0.0007). The mean ± SD body weight was 40.9±11.8 kg (range 17.7 to 81.8 kg).

Forty-one breeds were represented, including the Labrador retriever (n=56, 28%), rottweiler (n=36, 18%), golden retriever (n=20, 10%), and German shepherd dog (n=9, 4.5%). Thirty (15%) dogs were mixed-breed dogs. Overall, 70% of the cases were composed from four breeds or were mixed-breed dogs. Thirty-six breeds had less than four representatives in the study.

One hundred and sixty-one (80.5%) dogs had a complete tear of the CCL, and 35 (17.5%) had a partial tear. In four dogs, the CCL was not observed because the remnants had been removed by another surgeon. In those dogs, the stifle remained unstable despite the initial surgery.

The mean ± SD tibial plateau angle for all breeds was 25.3˚±4.4˚ (range 14˚ to 38˚). The mean tibial plateau angle was 25.2˚±4.9˚ in rottweilers, 24.9˚±3.7˚ in Labrador retrievers, 24.6˚±5˚ in German shepherd dogs, and 24.3˚±2˚ in golden retrievers. There was no statistical difference in tibial plateau angles between the various breeds (P=0.2285).

Data Analysis

The correlation coefficient "r" for all breeds in the study was -0.25, indicating the correlation between the age at the time of the CCL rupture and the tibial plateau angle was low. The negative correlation coefficient is represented by the downward slope of the line in the scatterplot of 200 data points in Figure 2. The linear regression equation representing this line is tibial plateau angle = 27.5 – 0.4 × [age at the time of rupture].[b] The coefficient of determination for tibial plateau angle and age was 0.063, indicating that the "age at the time of rupture" variable represented only 6.3% of the variation of the tibial plateau angle.

Individual breeds were also analyzed alone. In the German shepherd dog, golden retriever, and Labrador retriever, there was no statistical correlation between age at the time of CCL rupture and the tibial plateau angle (r of 0.16, -0.36, and -0.20, respectively).

Among the 36 rottweilers, the correlation coeffiecient was -0.61, which indicated a low correlation. The linear equation representing the fitted line in Figure 3 is tibial plateau angle = 31.2 – 1.5 × [age at the time of rupture].[b] Since r = -0.61, then r^2 = 0.37, which indicated that age at the time of the CCL rupture explained 37% of the variation of the tibial plateau angle.

Discussion

A universally accepted pathogenesis for CCL rupture has not been identified. The fact that CCL rupture is common in young, large-breed dogs is well established.[3,4,9,15] Results of the study reported here showed that in large-breed dogs with CCL tear, there was no statistically significant correlation between age at the time of CCL rupture and tibial plateau angle. It is important to note that the study did not imply that the tibial plateau angle changes as a dog grows older. To the authors' knowledge, the concept of whether tibial plateau angle changes as a dog grows older has not been investigated in any long-term studies. Tibial plateau angle was measured only once in each dog, at the time of diagnosis.

In general, affected breeds, age, weight, gender, and average tibial plateau angle of the dogs in this study were consistent with those previously described in the literature.[3,4,8,11,14,18]

The data presented here showed that 6.3% of the variation in age at the time of CCL rupture accounted for the variation in tibial plateau angle in all breeds. Among rottweilers, this variation was 37%. For all breeds, 93.7% of the relationship was secondary to another factor or several other factors; among rottweilers, 63% of this relationship arose from one or more factors. Although not statistically significant, the correlation in rottweilers between age and plateau angle was stronger than in all other breeds, as shown by a steeper downward slope and an array of data points closer to the line of slope [Figure 3].

To the authors' knowledge, no study has quantified the relative importance of other factors explaining the incidence of CCL rupture. Whitehair *et al.* noted that age at the time of CCL rupture decreased as body weight increased.[4] Bennett *et al.* hypothesized that some of these large dogs had activity restricted during puppyhood.[15] The age and tibial plateau angle relationship found in some dogs may be partially explained by a theory proposed by Read *et al.* These authors hypothesized that compression of the caudal aspect of the proximal tibial physeal plate may trigger premature closure localized to the caudal, proximal tibia.[9] This closure may eventually cause an excessive tibial plateau angle at an early age and subsequently an excessive cranial tibial thrust and rupture of the CCL early in the dog's life.

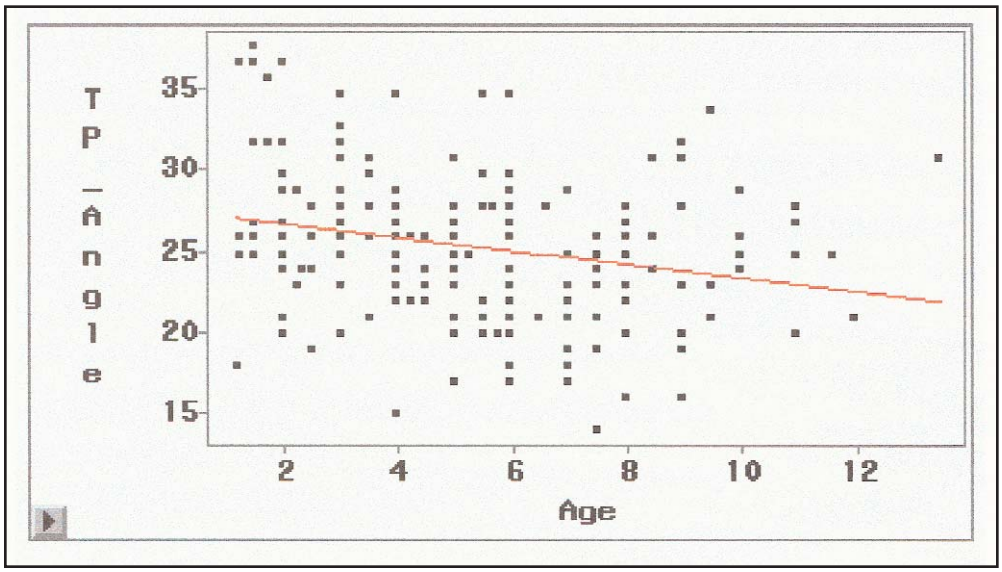

Figure 2—Tibial plateau (TP) angle (in degrees) versus age (in years) for 200 dogs with a cranial cruciate ligament rupture.

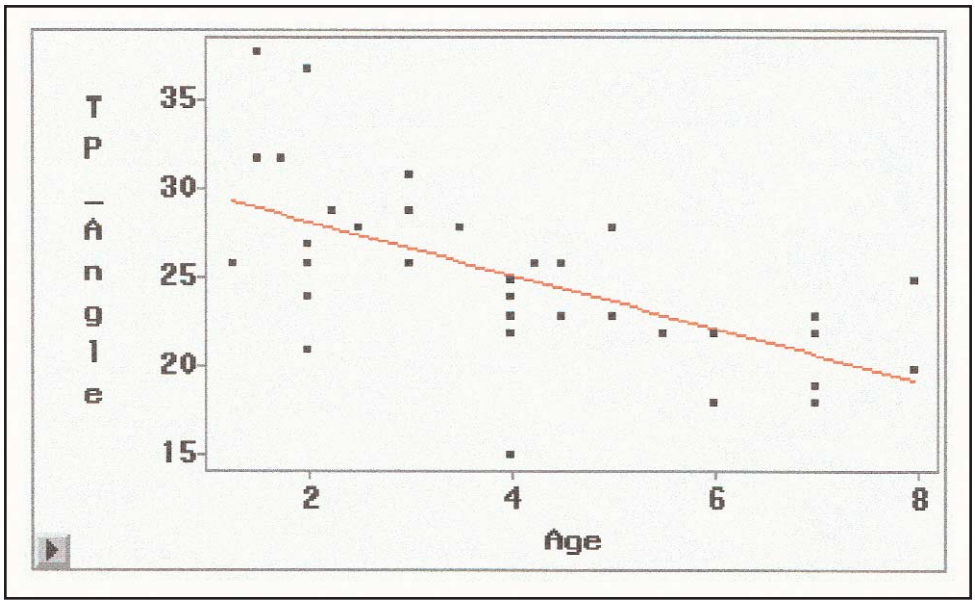

Figure 3—Tibial plateau (TP) angle (in degrees) versus age (in years) for 36 rottweilers affected with a cranial cruciate ligament rupture.

Conclusion

The study reported here showed that among 200 large-breed dogs with CCL rupture, there was no statistically significant correlation between age at the time of CCL rupture and tibial plateau angle. Attributing a CCL rupture solely to a steep tibial plateau angle may be an oversimplification of the problem, as other factors are clearly involved. The relative importance of other factors compared to the tibial plateau angle requires further study and quantification to better understand the pathogenesis of CCL rupture.

[a] Slocum B. Personal communication, 2001. Tibial plateau measurement. Slocum Enterprises, Inc., Eugene, OR 97404

[b] SAS Institute, Inc., Cary, NC 27513

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