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Comparison of Tibial Plateau Angles in Normal and Cranial Cruciate Deficient Stifles of Labrador Retrievers

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Objective—To investigate tibial plateau angles (TPA) in normal and cranial cruciate ligament (CCL) deficient stifles of Labrador retrievers.
Study Design—Prospective clinical study.
Animals—Eighty-one client-owned purebred Labrador retrievers.
Methods—Lateral radiographs of the tibia were obtained from 2 groups of dogs. Group I (42 dogs) had CCL rupture diagnosed by arthrotomy or arthroscopy. Group II (39 dogs) had no history of orthopedic problems, no radiographic evidence of CCL rupture, and dogs were >8 years of age. The tibial axis and the tibial plateau were determined on the radiographs, and the TPA was measured using image measurement software. The TPA measurement results of groups I and II were compared.
Results—Group I (CCL rupture) had a mean TPA (±SD) of 23.5 (±3.1) degrees, and group II (normal) had a mean TPA (±SD) of 23.6 (±3.5) degrees. With a *P* value of .97, no statistical difference was detected between the 2 groups.
Conclusions—No correlation between the magnitude of TPA and CCL rupture was identified in this group of Labrador retrievers.
Clinical Relevance—In Labrador retrievers, TPA should not be used as a predictor of CCL rupture.

CRANIAL CRUCIATE ligament (CCL) injury is one of the most common orthopedic diseases in dogs.[1] The clinical presentation and the associated degenerative joint disease have been studied extensively.[2-4] Although there is wide agreement about the pathogenesis and morphogenesis of secondary degenerative changes resulting from transection of the CCL, the primary cause leading to CCL rupture in the dog is controversial.[5,6] Ligament degeneration, immune mediated disease, conformational abnormalities, and trauma to the stifle joint have been incriminated.[7-11] An abnormally increased tibial plateau angle (TPA) has also been associated with CCL rupture.[12] Four of 5 dogs with severely increased TPA because of primary growth deformities of the proximal tibia had CCL rupture.[12]

In a normal stifle joint, the intact CCL opposes cranial tibial thrust, a cranially oriented force resulting from tibial compression generated during weight bearing.[13,14] The relationship between the amount of cranial tibial thrust and the magnitude of the TPA has been investigated in cadaver models.[15,16] These studies showed a close relationship between the magnitude of the TPA and the amount of cranial tibial thrust generated. As the TPA decreased, cranial tibial thrust was reduced until cranial tibial thrust was converted into caudal tibial thrust at a TPA of 6.5°.[15]

In a clinical study of dogs admitted for CCL rupture

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and dogs admitted for reasons unrelated to CCL rupture, the mean TPA in the CCL rupture group was 5.7° greater than the mean TPA of the normal group.[17] The authors hypothesized that an abnormally increased TPA magnified cranial tibial thrust and may therefore increase the stress placed on the CCL, ultimately leading to ligament degeneration.

Comparing the TPA of normal dogs with dogs with CCL rupture can be difficult for several reasons. Stifle joint positioning during radiography can influence the TPA determined on radiographs.[18] Imprecise radiographic positioning may lead to overestimation or underestimation relative to the anatomic TPA. Measurement of the TPA may also be influenced by different observers (interobserver variation) and is subjected to repetition or measurement error (intraobserver variation).[19] In addition to this observer-induced variability, the TPA varies between individuals within a breed.[17,19] Because skeletal conformation between various canine breeds differs, it may influence the breed-specific mean TPA.[17,20] Finally, a primary cause for CCL rupture has not been recognized, making it difficult to identify a control group of normal individuals.

The objective of our study was to investigate the correlation between the TPA and the incidence of CCL rupture in Labrador retrievers. Our hypothesis was that dogs with CCL rupture have a significantly greater TPA than dogs with normal stifle joints.

MATERIALS AND METHODS

Preliminary Study

To identify a control group (ie, normal dogs unlikely to develop CCL rupture), we determined the age of onset of clinical signs related to CCL injury for our hospital population. Medical records of all Labrador retrievers that had surgical repair for CCL rupture during the previous 5 years were reviewed. The dog's age at admission was recorded, and their age at the onset of clinical signs was determined from the client history. Only records with the information necessary to collect all the data were included. Complete records including age at admission, duration, and onset of lameness were available for 166 dogs. The duration of lameness before admission ranged from 1 week to 4 years with a mean (±SD) duration of 33 (±37) weeks. Of the 166 dogs, 13 (8%) were 8 years or older at admission and only 10 dogs (6%) had an age of onset of clinical signs after 8 years of age (Fig 1). None of the dogs were older than 10 years of age.

The number of animals necessary to show a significant difference in TPA between normal dogs and dogs with CCL injury was calculated using power analysis. Based on previously published data,[17] a minimum of 15 dogs in each group would be sufficient to show a significant difference in TPA between groups.

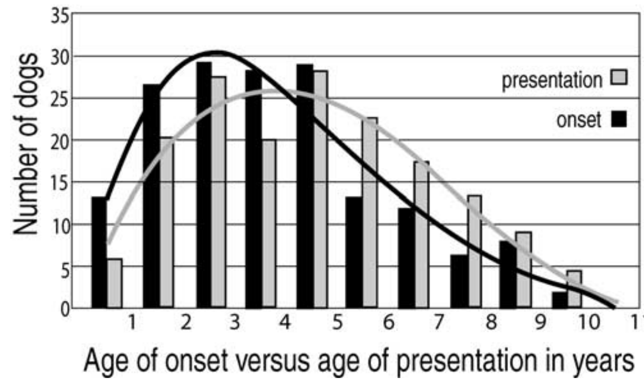

Fig 1. Results of the preliminary study investigating the age at onset and age of admission related to cranial cruciate ligament injury in the Labrador retriever. The distribution of the age at onset is in black and the age at admission in gray. A polynomial trend line was added to each of the 2 groups. Note that only 10 (6%) of the dogs had an age of onset of 8 years or older and that none of the dogs admitted were older than 10 years.

Study Design

Two groups of randomly chosen, client-owned, purebred Labrador retrievers were identified, and permission for radiographic evaluation of the tibia was obtained from the owners. Group I consisted of dogs admitted for CCL injury. All the dogs in this group were purebred Labrador retrievers, were diagnosed with partial or full CCL rupture by arthrotomy or arthroscopy, and had no other orthopedic condition or injury involving the stifle joint. The stifle joint with CCL rupture was used for radiographic evaluation and TPA determination.

Group II consisted of normal dogs admitted for reasons unrelated to orthopedic disease. All dogs were purebred Labrador retrievers, had no current or past history of hind limb orthopedic problems, and were at least 8 years of age. The stifle joint for radiographic evaluation and TPA determination was randomly chosen. Dogs in group II with signs of degenerative joint disease were excluded from the study. The TPA was determined (described below) and the magnitude of the TPA of both groups compared.

Radiography

Dogs were awake, sedated, or anesthetized and positioned in lateral recumbency on a wooden platform containing the radiographic cassette to ensure direct contact of the

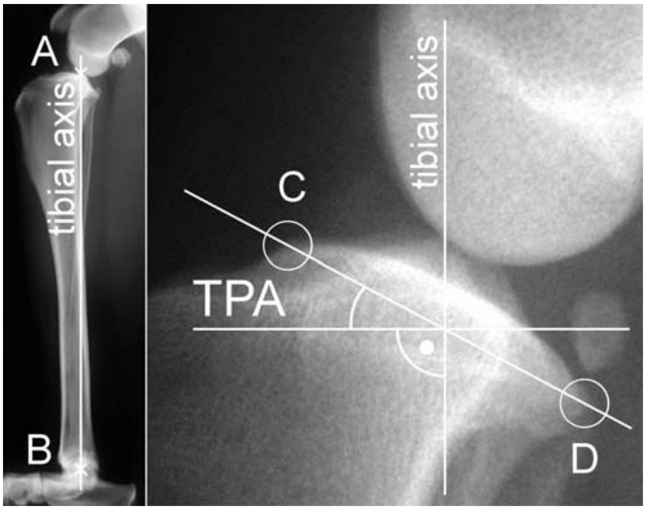

Fig 2. Determination of the tibial plateau angle (TPA) on lateral tibial radiographs. A line connecting the midpoint between the intercondylar eminences (A) and the center of the talus (B) defined the long tibial axis. The medial tibial plateau was determined by its most cranial (C) and most caudal (D) margin. The results were digitally scanned, and the TPA between the tibial plateau slope and the perpendicular to the tibial axis was determined using image measurement software.

entire hind limb with the surface of the cassette. The stifle and the hock joint were kept at approximately 90°. The opposite leg was pulled cranially or abducted in a flexed position. When the prepuce or abdomen overlaid the stifle joint, a plastic paddle was used to free the stifle joint from overlaying soft tissues. Radiographs of the tibia including the stifle and hock joint were taken with the radiographic beam centered on the stifle joint. The radiographs were evaluated for superimposition of the tibial and femoral condyles, and, if necessary, the central beam was repositioned and the radiographs repeated until superimposition of the tibial and femoral condyles was achieved. A maximum of 6 radiographs were taken, and the one closest to complete superimposition of the tibial and femoral condyles was chosen for TPA determination.

Radiographic Determination of TPA

The long axis of the tibia was determined by the midpoint between the 2 apices of the tibial intercondylar eminences and the center of the talus. The medial tibial plateau was determined by its most cranial and most caudal margin (Fig 2). After determination of the tibial axis and the tibial plateau, the results were digitally scanned, and the TPA between the medial tibial plateau and a line perpendicular to the functional axis of the tibia was measured with the help of image measurement software (Sigma Scan Pro 2.0, Jandel Scientific, San Rafael, CA). One observer (U.R.) determined and measured the TPA of both groups. Each TPA determination and measurement was performed 4 times for each dog, and the average of the 4 measurements was used for the final TPA for each dog.

Statistical Analysis

The 2 groups were compared using a paired *t* test. A *P* value $< .05$ was considered significant.

RESULTS

Group I (CCL Rupture)

Mean age at admission for this group of 42 dogs was 5.4 years (range: 10 months to 10 years). Mean (±SD) TPA was 23.5 ± 3.1 degrees (range: 18° to 30°).

Group II (Normal)

Mean age at admission for these 39 dogs was 10 years (range: 8 to 14 years). Dogs were admitted for laryngeal paralysis (6), vaccination (4), cataracts (3), and other medical disease or neoplasia (29). Mean (±SD) TPA was 23.6 ± 3.5 degrees (range: 15° to 29°). Statistical comparison of the TPA revealed no significant difference ($P = .97$) between the 2 groups (Fig 3).

DISCUSSION

Meaningful comparison of the TPA of normal dogs and dogs with CCL rupture can be difficult. Identification of normal dogs unlikely to suffer from CCL rupture is problematic because a predisposing cause for CCL rupture has not been clearly recognized. Multiple studies have reported the epidemiologic fea-

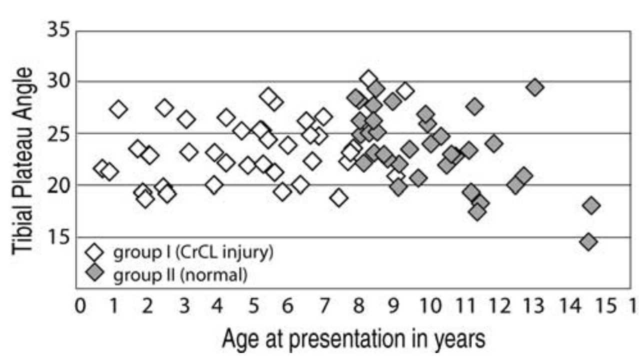

Fig 3. Graph showing the magnitude of the tibial plateau angle and the age at admission of both groups. Group I (CCL injury) is shown in white, and group II (normal) is shown in gray.

tures of CCL rupture in dogs.[2-6] For our study, the age of onset of owner-perceived lameness in the Labrador retriever was reviewed. Based on our preliminary study, most dogs with CCL rupture became lame between 2 and 4 years of age and were admitted for treatment between 3 and 5 years of age. Only 6% of dogs were 8 years of age or older when the owner detected lameness, and none were older than 10 years of age. For our study, we therefore defined Labrador retrievers of at least 8 years of age with no evidence of clinical and radiographic signs of CCL rupture as normal because these dogs can be considered at a low risk to develop CCL disease in the future.

Positioning of the tibia during radiography can influence the TPA determined on radiographs.[18] It has been shown that cranial and proximal positioning of the limb relative to the x-ray beam leads to overestimation of the TPA, whereas caudal and distal positioning leads to underestimation of the TPA. To decrease variation because of radiographic positioning, radiographs were repeated until superimposition of the tibial and femoral condyles was achieved.[18]

The measurement variation introduced by different observers can be divided into measurement error (intraobserver variation) and the variation between individuals (interobserver variation).[18,19] Both can be mainly attributed to the subjective identification of radiographic landmarks for tibial plateau slope and tibial axis determination and to manual measurement of the TPA. One study investigating TPA measurement reported an intraobserver variability of $\pm 3.4°$ and an interobserver variability of $\pm 4.8°$.[19] To exclude measurement variation between observers, only 1 observer determined all the radiographic landmarks. To eliminate variation because of manual TPA measurement, all angles were digitally scanned and determined using computer image measurement software. To decrease measurement error, the average of 4 TPA determinations was used to calculate the final TPA.

Individual TPA variation within breeds has been reported.[17,20] In addition, it has been suggested that skeletal conformation between breeds may influence the overall, breed-specific TPA.[17] To exclude variation because of breed differences, only purebred Labrador retrievers were used for this study. Labrador retrievers were chosen because of their common presentation for CCL rupture.

In our study, no significant difference in the TPA between the 2 groups was found; furthermore, a *P* value of .97 suggests that the TPA of the 2 groups was nearly identical. The magnitude of TPA in our population was not related to CCL injury. Although TPA measurement is essential to determine the amount of tibial plateau rotation during tibial plateau leveling osteotomy,[21,22] the TPA magnitude should not be used as a predictor for CCL disease in Labrador retrievers.

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