Comparison of tibial plateau angle between clinically normal Greyhounds and Labrador Retrievers with and without rupture of the cranial cruciate ligament

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Objective—To compare tibial plateau angle (TPA) between Greyhounds without damage to the cranial cruciate ligaments and Labrador Retrievers with and without damage to the cranial cruciate ligaments.

Design—Clinical study.

Animals—87 client-owned dogs and 15 research colony Greyhounds.

Procedure—Standing position, horizontal-beam radiography was performed on Greyhounds and unaffected Labrador Retrievers to determine standing TPA. Lateral radiography of the stifle joint was performed on all dogs to determine traditional TPA. Age and body weight were recorded for unaffected and affected Labrador Retrievers.

Results—Greyhounds had mean standing TPA of 1.56° and mean traditional TPA of 22.50°. Unaffected Labrador Retrievers had mean standing TPA of 3.52° and traditional TPA of 27.97°. Affected Labrador Retrievers had mean traditional TPA of 25.55°. No significant difference was found in mean standing TPA between Greyhounds and unaffected Labrador Retrievers. Standing TPAs in Greyhounds and unaffected Labrador Retrievers were not significantly different from a plane drawn parallel to the ground. Significant differences in traditional TPAs were detected among all 3 groups.

Conclusions and Clinical Relevance—Greyhounds had mean traditional TPA of 22.50°; similar angles should be considered normal for dogs. Although affected Labrador Retrievers had mean traditional TPA that was significantly greater than that of Greyhounds, the steepest TPA was found in unaffected Labrador Retrievers. Because Greyhounds and unaffected Labrador Retrievers had similar standing TPAs, we conclude that although TPA may be associated with damage to the cruciate ligaments, many dogs with a steep TPA do not develop cruciate ligament disease. (*J Am Vet Med Assoc* 2002;221:1426–1429)

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Disease of the **cranial cruciate ligament (CCL)** in dogs has been reported to be associated with trauma, immune-mediated mechanisms,[1-3] age-related degeneration of the CCL,[4] obesity,[5] and conformational abnormalities such as a patellar luxation[6] and narrowed intercondylar notch.[7,8] In addition, in a number of reports it is suggested that the slope of the tibial plateau, or **tibial plateau angle (TPA)**, may predispose dogs to disease of the CCL. Read and Robins[9] were the first to describe the proximal TPA and report its association with disease of the CCL in 5 dogs. Slocum reported the slope to be 22.6° in dogs and suggested that this angle was excessive and predisposed dogs to tearing of the CCL.[10] These data, however, were derived from a study population that was not defined regarding dog's age, weight, breed, or CCL status. Morris et al[11] reported that the TPA in dogs with rupture of the CCL was 23.76°, whereas it was 18.1° in dogs without injuries of the CCL. Dogs were considered to be without rupture of the CCL if they had no cranial drawer sign, no evidence of a medial buttress, and no radiographic abnormalities of the stifle joint. In contrast, Caylor et al[12] reported mean TPA in dogs without disease of the CCL to be 23.5°, and Reif et al[a] reported it to be 25.0°. However, neither of these studies considered a breed effect, although it is reported that some breeds (eg, Labrador Retriever, Newfoundland, Rottweiler) are predisposed to and some breeds (eg, Greyhound) are not predisposed to disease of the CCL.[13]

We hypothesized that if the TPA increases the in vivo forces on the CCL and predisposes dogs to rupture of the CCL, the TPA in standing dogs would be greater in dogs of a breed predisposed to rupture of the CCL, compared with dogs of a breed considered protected from or not predisposed to rupture of the CCL. In addition, we hypothesized that if the TPA predisposes dogs to rupture of the CCL, the traditional TPA would be significantly greater in dogs of a breed predisposed to rupture of the CCL, compared with dogs of a breed not predisposed to rupture of the CCL. The objectives of this study were to determine the relationship of the TPA to a plane parallel to the ground (standing TPA) in healthy standing Greyhounds and Labrador Retrievers with intact CCLs (unaffected Labrador Retrievers), and determine the TPA as measured by the long axis of the tibia (traditional TPA) in Greyhounds, unaffected Labrador Retrievers, and Labrador Retrievers with surgically confirmed rupture of the CCL (affected Labrador Retrievers).

Materials and Methods

Dogs—Fifteen adult Greyhounds from a research colony at Iowa State University Veterinary Teaching Hospital were used; the Labrador Retrievers were either client- or student-owned dogs. All owners gave permission for their dog to be radiographed. Dogs were considered free of disease of the CCL if they were not lame, had no cranial drawer sign, no effusion, no signs of pain with hyperextension of the stifle joint, no thickening of the medial joint capsule, and no radiographic abnormalities in the stifle joint. If dogs had bilateral disease of the CCL (n = 6), only the stifle joint for which surgery was planned was evaluated.

Standing TPA—Greyhounds and unaffected Labrador Retrievers were allowed to assume a comfortable standing position on the radiographic table. The film cassette was positioned between the dog's hind limbs, parallel to the limb of interest in the sagittal plane and adjacent to the limb to be evaluated, with 1 edge of the cassette placed flat on the radiographic table. A lateral to medial horizontal-beam radiograph was taken of the stifle joint. The radiographic beam was centered on the diaphysis of the tibia and included the hock joint and a gravitational-dependent marker that identified a plane parallel to the ground.[11] No sedation was used. From the exposed radiographic film, the standing TPA was measured from the articular surface of the medial tibial plateau. The cranial-most edge of the tibial plateau was identified by a discreet point at the insertion of the CCL in the cranial intercondylar region.[11,13,14,a] The caudal edge of the tibial plateau was identified by the insertion of the caudal cruciate ligament at the dorsal and most caudal aspect of the medial tibial plateau.[11-13,a] A second line that intersected the first was drawn parallel to the plane of the ground **(Fig 1)**. This established the standing TPA. The same evaluator measured all radiographs.

Traditional TPA—All dogs received general anesthesia or were heavily sedated. The limb to be evaluated was positioned directly on a film cassette with the hip, stifle, and hock joints placed in 90° of flexion and the greater trochanter, head of the fibula, and lateral malleolus in contact with the film cassette.[11,b] A mediolateral radiograph of the stifle joint was taken. The radiographic beam was centered on the diaphysis of the tibia and included the hock joint.[11] From the exposed radiographic film the TPA was measured from the articular surface of the medial tibial plateau, as described.[11,13,14,a] The long axis of the tibia was determined by drawing a line between the center of rotation of the stifle joint, defined as the point centered between the intercondylar eminences of the tibial condyle and the center of the talus. A line was drawn perpendicular to the long axis of the tibia. The traditional TPA was defined as the difference between the angle of tibial plateau and the line drawn perpendicular to the long axis of the tibia **(Fig 2)**.[11,13,14,a] The same evaluator measured all radiographs.

Statistical analyses—Descriptive statistics were used to evaluate the basic properties and quality of the data. Results are given as mean ± SEM. Standing TPA was compared between 18 Greyhounds and 40 unaffected Labrador Retrievers by use of a Student *t* test for equivalence of means. Traditional TPAs were compared among 18 Greyhounds, 40 unaffected Labrador Retrievers, and 44 affected Labrador Retrievers by use of an ANOVA to detect a difference among group means and post-hoc Tukey-adjusted *t* tests to determine pair-wise differences in group means. Significance was set at $P < 0.05$.

Figure 1—Lateral radiographic view of the stifle joint of a dog in a standing position. Line A corresponds to the tibial plateau and line C corresponds to a line drawn parallel to the ground; θ′ is the standing tibial plateau angle (TPA) measured between lines A and C.

Results

Greyhounds were skeletally mature and included 11 females and 7 neutered males; body weights were not determined. The unaffected Labrador Retrievers included 18 females (4 sexually intact, 14 spayed) and 22 males (7 sexually intact, 15 castrated). Their mean body weight was 32.4 ± 0.8 kg (71.3 ± 1.8 lb), and their mean age was 43.8 ± 5.0 months. The affected Labrador Retrievers included 25 females (4 sexually intact, 21 spayed) and 19 males (3 sexually intact, 16

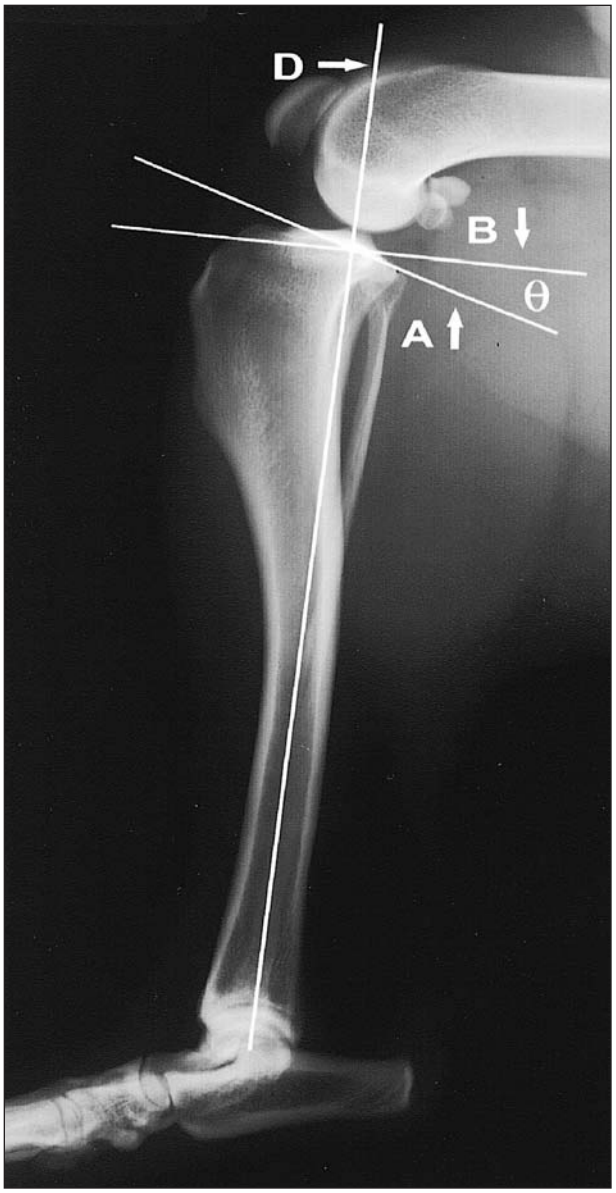

Figure 2—Lateral radiographic view of the stifle joint of a dog in lateral recumbency. Line A corresponds to the tibial plateau, line D corresponds to the long axis of the tibia, and line B corresponds to a line drawn perpendicular to line D; θ is the traditional TPA measured between lines A and B.

castrated). Their mean body weight was 39.0 ± 1.0 kg (85.8 ± 2.2 lb), and their mean age was 51.3 ± 4.3 months. No significant differences were found between the Labrador Retriever groups for weight or age.

Greyhounds had a standing TPA (1.56 ± 1.91°) that was closer to 0° than that of unaffected Labrador Retrievers (3.52 ± 1.31°). However, there was no significant difference between these groups, and the standing TPA was not significantly different from a plane parallel to the ground (ie, TPA = 0°). The Greyhounds had the smallest traditional TPA (22.50 ± 0.84°), followed by affected Labrador Retrievers (25.55 ± 0.55°) and unaffected Labrador Retrievers (27.97 ± 0.66°) A significant difference was found among all 3 groups.

Discussion

The traditional TPA in dogs with intact CCLs have been reported from 16.9 to 25.0°.[10-12,b] However, the breeds of dogs either varied or were not reported, or the number of dogs studied was small (eg, 16.90° was the mean TPA of 4 Rottweilers). We found a significant difference (5.47°) in the traditional TPA between Greyhounds and unaffected Labrador Retrievers. Because Greyhounds are statistically less likely to have ruptured CCLs and Labrador Retreivers are predisposed to this disease,[13] this finding suggests that abnormal, traditional TPAs could be associated with disease of the CCL. In addition, we found that affected Labrador Retrievers had significantly greater traditional TPA (3.05°), compared with Greyhounds. However, one must be cautious when interpreting this finding because unaffected Labrador Retrievers had traditional TPAs that were larger than that of affected Labrador Retrievers. This might suggest that although differences were significant, they may not be clinically relevant. Only a rigorous, large-scale, prospective clinical study will be able to confirm an association between traditional TPA and prevalence of damaged CCLs and determine the strength of the association.

In a previous publication, it was reported that dogs with injured CCLs had significantly greater traditional TPA (by 5.66°), compared with dogs with intact CCLs.[11] In fact, it was suggested that prophylactic rotational osteotomy of the proximal tibia be considered in an effort to protect dogs from injury to the CCL.[11] In our investigation of Labrador Retrievers, we found the opposite; unaffected Labrador Retrievers had significantly greater traditional TPA (2.42°), compared with affected Labrador Retrievers. Our findings are supported by a recent scientific abstract in which it was stated that unaffected Labrador Retrievers older than 8 years also had a TPA that was slightly greater than affected Labrador Retrievers.[c] The difference in the findings could be explained by the fact that our data are reported for a single breed, whereas the other study[11] reported data for several breeds. Regardless, we can only suggest that for Labrador Retrievers, suggesting prophylactic rotational osteotomy to prevent rupture of the CCL seems premature. Although we found that the traditional TPA was greater in Labrador Retrievers (predisposed to CCL disease), compared with Greyhounds (not predisposed to CCL disease), it seems that Labrador Retrievers can have high traditional TPAs and not have injured CCLs.

After anatomic and radiographic inspection of canine hind limbs, Slocum and Devine[10] reported that the tibial plateau is inclined relative to the functional axis of the tibia. During their study, they positioned the stifle joint in a normal standing angle of approximately 140°. They concluded that this inclination results in the point of contact of the articular surfaces being cranial to this axis, thus generating a cranial tibial thrust force during tibial compression. They also stated that if the tibial plateau were perpendicular to the functional long axis, and that if the point of contact were on this axis, compressive forces alone would be generated during tibial compression.[10] Morris et al[11] went one step further with these conclusions and suggested that the

force generated by cranial tibial thrust is one mechanism of injury to the CCL. In essence, as the traditional TPA increases, the cranial tibial thrust force increases, and the likelihood of injury to the CCL increases.

In an effort to determine the position of the tibial plateau relative to the functional axis of the tibia, we measured the TPA in standing dogs. We decided to study standing dogs with intact CCLs because it is well recognized that there is a large variation in the standing confirmation of various breeds, and we believed that determination of the TPA in a standing dog would better reflect how the TPA affects the forces associated with the stifle joint. Dogs with preexisting injury to the CCL would not reliably assume a normal standing position and, therefore, were not studied. We found no significant difference in the standing TPA between Greyhounds and unaffected Labrador Retrievers. In fact, the standing TPA for dogs of both breeds was not significantly different from a plane parallel to the ground. Thus, mean standing TPA is not inclined, which is relative to the functional axis of the tibia. We are not suggesting that these findings mean that the TPA has no relationship with the forces associated with the stifle joint, or that the TPA doesn't predispose some dogs to injury of the CCL. It is possible that dogs in the unaffected Labrador Retriever group that were determined to be clinically normal prior to this study may develop injuries to the CCL in the future.

In an effort to limit the effect of radiographic and measurement variability in our study, we made every attempt to superimpose the condyles on all radiographs. The effect of rotation on TPA measurement, however, is limited, as reported by Reif et al.[a] They found that internal and external rotation of the tibia only accounted for ± 1° of variation in the TPA. The largest source of measurement error has been found to be interobserver variation.[12,a] Intraobserver variation has been reported to have a mean difference between measurements as high as 1.1°.[12] We used a single observer who was trained to recognize published, specific sites that defined the medial tibial plateau.[11,13,14,a] These points are readily defined radiographically. These potential sources of error could account for only a few degrees of variation in the values. The difference we found among groups, although significant, was small and suggested that at least in Labrador Retrievers there is limited association between the TPA and injury to the CCL.

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[b]Slocum B. Slocum Enterprises Inc, Eugene, Ore: Personal communication, 1996.

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