The stifle joint is one of the primary joints that supports the hind limbs and allows femorotibial articulation between the femoral condyle and proximal portion of the tibia. The portion of the stifle joint involved in femorotibial articulation does not effectively match the shape between the femoral condyle and the proximal tibial articular surface; therefore, its bone lacks stability, compared with that in the hip joint. Additionally, the tibial plateau of dogs slopes caudally, so a cranial force (referred to as the CrTT) develops on the tibial plateau surface when the tibia is pressed along its long axis by the femoral condyle. The magnitude of the CrTT is dependent on the amount of compression as well as the slope of the tibial plateau. This force always forms during weight bearing.

The forces that oppose the CrTT are both active and passive. The active force is created by the biceps femoris, semimembranosus, and semitendinosus muscles, and the passive force is created by the CrCL and meniscus. The primary restraining component for the CrTT is the CrCL, which is a static stabilizer. There are numerous reports of the anatomic and biomechanical features of the CrCL. Despite consideration that the biceps femoris, semimembranosus, and semitendinosus muscles act as a dynamic stabilizer, which theoretically opposes the CrTT, the authors are not aware of reports of such an effect in dogs. Additionally, in biomechanical studies that involved the use of canine stifle joints, the tensile force of the biceps femoris, semimembranosus, and semitendinosus muscles has not been reproduced. Furthermore, we were unable to find any reports that provided a description of the tensile force of the periarticular muscles, namely the quadriceps and gastrocnemius muscles, which appear to be related to the stability of the stifle joint with respect to the biceps femoris, semimembranosus, and semitendinosus muscle.

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**Abbreviations**

CrCL Cranial cruciate ligament  
CrTT Cranial tibial thrust  
kgf kilogram•force

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**Objective**—To evaluate the role of the semitendinosus muscle in stabilization of the canine stifle joint.

**Sample**—Left stifle joints collected from cadavers of 8 healthy Beagles.

**Procedures**—Left hind limbs, including the pelvis, were collected. To mimic the tensile force of the quadriceps, gastrocnemius, and semitendinosus muscles, wires were placed under strain between the ends of each muscle. A sensor was used to measure the tensile force in each wire. Specimens were tested in the following sequence: cranial cruciate ligament (CrCL) intact, CrCL transected, released (tensile force of semitendinosus muscle was released in the CrCL-transected stifle joint), and readjusted (tensile force of semitendinosus muscle was reapplied in the CrCL-transected stifle joint). Specimens were loaded at 65.3% of body weight, and tensile force in the wires as well as the cranial tibial displacement were measured.

**Results**—Tensile force for the CrCL-transected condition increased significantly, compared with that for the CrCL-intact condition. Mean ± SD cranial tibial displacement for the CrCL-intact condition was 2.1 ± 1.3 mm, which increased to 7.2 ± 2.3 mm after release of the tensile force in the semitendinosus muscle.

**Conclusions and Clinical Relevance**—Results supported the contention that the semitendinosus muscle is an agonist of the CrCL in the stifle joint of dogs. Moreover, the quadriceps and gastrocnemius muscles may be antagonists of the CrCL. These findings suggested that the risk of CrCL rupture may be increased by diseases (such as cauda equina syndrome) associated with a decrease in activity of the semitendinosus muscle. (Am J Vet Res 2012;73:672–680)}
cles. However, in human medicine, the relationship between functions of the periarticular muscles (especially the quadriceps and gastrocnemius muscles and biceps femoris, semimembranosus, and semitendinosus muscles) and the CrCL, or recovery of knee joint function after CrCL rupture, has been extensively studied.7–26

The purpose of the study reported here was to evaluate the effect of tensile force on the periarticular muscles in a CrCL-deficient stifle joint. We hypothesized that the tensile force of the semitendinosus muscle would increase after CrCL transection.

Materials and Methods

Sample—Left hind limbs, including the pelvis, were collected by disarticulation of the sacroiliac joint in cadavers of 8 healthy Beagles. The dogs had no clinical or radiographic evidence of problems in the hip, stifle, or tarsal joints. All dogs used were euthanized for reasons unrelated to the study reported here. The dogs were euthanized by injection of an overdose of pentobarbital sodium. The study was approved by the Bioethics Committee at Nippon Veterinary and Life Science University.

Specimen preparation—The collected hind limbs were stripped of all muscular tissues, except for the quadriceps muscle (an extensor muscle of the stifle joint), semitendinosus muscle (one of the flexor muscles of the stifle joint), and gastrocnemius muscle (an extensor muscle of the tarsal joint). All soft tissues of the distal talocrural joint, including the skin, were preserved.

Origin and termination of each muscular group—The tensions of the extensor muscle (quadriceps muscle) and flexor muscle (semitendinosus muscle) of the stifle joint and the extensor muscles (gastrocnemius muscle) of the tarsal joint were mimicked. To preserve muscular origin and insertion and to mimic muscular tension, holes were drilled in the insertion (termination) sites of the muscles. First, a hole was drilled in the patella, which is the insertion site of the quadriceps muscle. The hole was drilled by use of a 1.1-mm drill bit and was perpendicular to the patellar ligament. Next, a hole was drilled by use of a 2.0-mm drill bit in the ischiatic tuber, which is the insertion site of the quadriceps muscle. Then, a hole was drilled by use of a 1.5-mm drill bit in the ischiatic tuber at the origin of the semitendinosus muscle. Then, a hole was drilled by use of a 1.5-mm drill bit in the insertion of the medial collateral ligament as part of the insertion of the semitendinosus muscle. This latter hole was drilled parallel to the articular surface of the stifle joint. A hole was drilled by use of a 1.5-mm drill bit in each fabellar facet in the femoral epicondyles, which are the origin of the gastrocnemius muscles. Finally, a 0.8-mm drill bit was used to drill holes in the calcaneal tuber, which is the insertion of the medial and lateral head of the gastrocnemius muscle. After the holes were drilled, a 0.8-mm stainless steel wire was inserted into the hole in the patella and a 1.0-mm stainless steel wire was inserted in each of the other holes.

Intra-articular preparation of stifle joints—An incision was made in the medial and the lateral articular capsule of each stifle joint to enable us to introduce a 0.6-mm stainless steel wire for the CrCL transection. A 3.0-mm stainless steel globe was implanted in each specimen at the femoral medial epicondyle and the proximal insertion of the medial collateral ligament to enable us to evaluate the femoro-bi- tibial relationship in the sagittal plane. Additionally, a 1.5-mm Kirschner wire was inserted into the extensor fossa, and a 3.0-mm stainless steel globe was implanted in the top of the greater trochanter to enable us to determine the abduction angle of the femur.

Determination of the angle of the pelvis and hip joint—To determine the pelvic angle, 3 Steinmann pins (3.0 mm) were inserted into the sacroiliac joint. The pelvic and Steinmann pins were fixed with acrylic resin at a pelvic angle of 32°. The pelvic angle is defined as the angle between the ground and the line connecting the cranial iliac spine and the ischiatric tuber.b,c To radiographically identify the pelvic angle, the cranial dorsal iliac spine was highlighted by use of a 1.5-mm Kirschner wire. Additionally, to maintain the abduction angle at 102° and flexion angle at 115°, the hip joint and proximal portion of the femur were fixed in acrylic resin with 2.7-mm Steinmann pins. Because the origin of the quadriceps muscle was defined as the trochanteric fossa in the present study, the hole in the resin-fixed hip joint was drilled to resemble this origin. Each specimen was wrapped in towels soaked in saline (0.9% NaCl) solution, frozen at –30°C until the day before testing, and then thawed in a refrigerator (5°C) for 12 hours prior to analysis. After confirming that the limbs were fully thawed, each specimen was mounted on an acrylic testing frame and attached to a force plate by use of 3.0-mm screws.

Joint angle—The pelvis, hip joint, stifle joint, tarsal joint, and hip abduction angles were configured at (mean ± SD) 32 ± 5°, 115 ± 5°, 137 ± 5°, 120 ± 5°, and 102 ± 5°, respectively.b–d (Figure 1). The hip abduction angle was determined in 10 standing Beagles (20 hind limbs). Circular markers were placed on the femoral lateral epicondyle and greater trochanter, and an image (caudal view) was recorded. The center of each marker was connected with lines, and the intersection of the lines was measured as the hip abduction angle.

Angles for the pelvis and hip, stifle, and tarsal joints corresponded to the form of the peak vertical force detected for 65 steps in 8 Beagles walking at a mean ± SD velocity of 1.2 ± 0.1 m/s. These angles were collected by use of a force plate and video camera. Data were collected at 200 U/s and 1,000 frames/s. The force plate and video camera were synchronized by a light-emitting diode. Each angle was measured with reference to a report in which the pelvic angle was described. The hip joint angle was defined as the angle connecting the cranial dorsal iliac spine–greater trochanter–head of the fibula. The stifle joint angle was defined as the angle connecting the greater trochanter–head of the fibula–center of the tarsal joint, and the tarsal joint angle was defined as the angle connecting the head of the fibula–center of the tarsal joint–distal aspect of the third metatarsal bone. The abduction angle of the hip joint was defined as the angle between the line connecting the left and right dorsal edges of the acetabulum and the line connecting the greater trochanter and extensor fossa (Figure 1). The angle of the stifle joint and
tarsal joint were adjusted by use of a wire lock and turnbuckle.

Muscular tensile force—Tension of the wires that mimicked the quadriceps, gastrocnemius, and semitendinosus muscles was measured. Muscle tension was measured by use of a tension gauge, which was mounted between the wire and turnbuckle. The rated capacity and resolution of the sensor were 30 kgf and \(3 \times 10^{-3}\) kgf, respectively. Wires that mimicked the quadriceps and gastrocnemius muscles were adjusted to a tension that constantly maintained the stifle joint and tarsal joint angles throughout the experiment. Then, the wire that mimicked the semitendinosus muscle was adjusted to a tension of 22.8% of body weight. Tension in the wire that mimicked the quadriceps muscle was dependent on the stifle joint angle, and tension in the wire that mimicked the gastrocnemius muscle was dependent on the tarsal joint angle. None of the muscle forces involved in the stifle joint was mimicked.

Specimen loads—To reproduce in vivo conditions, a static axial load was applied until 65.3% of body weight was loaded on a specimen paw. This value corresponded to the peak vertical force detected in Beagles walking at a velocity of 1.2 m/s. The vertical force on the paw was measured by use of a force gauge, which was located under the paw. The rated capacity and resolution of the sensor were 20 kgf and \(2 \times 10^{-3}\) kgf, respectively.

Cranio-caudal displacement force of the paw—Each paw was mounted on a custom-made moveable platform, which allowed a craniocaudal displacement force to be achieved (Figure 2). After the position of the paw in the CrCL-intact specimen was determined, a digital force gauge was attached to the moveable platform, and the digital force gauge connected to the custom-made moveable platform was secured to the table with adhesive tape. Additionally, the positions of the digital force gauge, frame, and table did not change during the experiment. The frame was also secured to the table with adhesive tape.

The cranial displacement force was measured as the pulsed force. The rated capacity and resolution of the sensor were 50.00 N and \(1 \times 10^{-2}\) N, respectively.

Testing procedure—Each specimen was fixed to the testing frame, then a default load (65.3% of body weight) was introduced to the paw. The turnbuckles and cable lock were then adjusted to attain the pertinent angle of the stifle and tarsal joints.

The loading of each specimen was performed in the following test sequence: CrCL intact, CrCL transected, released (tensile force of the semitendinosus muscle was released in the CrCL-transected stifle joint), and readjusted (tensile force of the semitendinosus muscle was reapplied in the CrCL-transected stifle joint). Transection of the CrCL was performed arthroscopically. Adjustment of the wire locks and turnbuckles was not performed until the test measurements for the CrCL-transected condition were completed. The same load was applied for the CrCL-intact and CrCL-transected conditions. After the test for the CrCL-transected condition was completed, the load for each specimen was removed. Additionally, the tensile force in the semitendinosus muscle was released and the specimen was reloaded, but we continued to adjust the tension in
the quadriceps and the gastrocnemius muscles. After the test for the released condition was completed, the load for each specimen was removed and the force for the semitendinous muscle was reapplied at a tensile load of 22.8% of body weight; the specimens then were readjusted. The test for the readjusted condition was performed because we wanted to evaluate the effect of the semitendinous muscle tensile force (22.8% of body weight) in a CrCL-transected stifle joint.

Data acquisition—Lateral and dorsoventral radiographic views were obtained for each condition to measure the cranial tibial displacement and internal rotation of the tibia. The joint angles were measured on the lateral radiographic views by use of image analysis software. Cranial tibial displacement was measured on the lateral radiographic views (Figure 3). Displacement was referenced on the lateral radiographic views by use of a 100-mm marker. The CrCL-intact condition was assigned a value of zero for the cranio-caudal displacement of the tibia. Cranial tibial displacement was calculated as the difference from the CrCL-intact stifle joint position. To standardize each cranial displacement force, the values of the force obtained for each test condition were calculated as the percentage of the vertical force.

Internal rotation of the tibia was measured on the dorsoventral radiographic views by use of the connection between the 1.5-mm Kirschner wire inserted into the tibia and the Steinmann pin inserted into the pelvis. Internal rotation of the tibia was calculated as the difference in rotation from the CrCL-intact stifle joints by use of the image analysis software. Tensile forces measured from the wires that were used to mimic the quadriceps, semitendinosus, and gastrocnemius muscles and the vertical force in the paw were collected continuously for 5 seconds after a specimen was subjected to the described test conditions. Data collection rate was 1,000 Hz. The data were collected from each sensor via a sensor interface and were analyzed on a personal computer by use of dynamic data acquisition software. Tensile forces for the quadriceps, semitendinosus, and gastrocnemius muscles were divided by the vertical force, and the ratios were used for the study.

Statistical analysis—A 1-way repeated-measures ANOVA was used to evaluate differences in the tensile force of the quadriceps and gastrocnemius muscles for the 4 test conditions (CrCL intact, CrCL transected, released, and readjusted). A 1-way repeated-measures ANOVA was used to evaluate differences in the tensile force of the semitendinosus muscle for 3 test conditions (CrCL intact, CrCL transected, and readjusted). A 1-way repeated-measures ANOVA was used to evaluate differences in the vertical force in the paw for the 4 conditions (CrCL intact, CrCL transected, released, and readjusted). A 1-way repeated-measures ANOVA also was used to evaluate differences in cranial tibial displacement, internal rotation of the tibia, and cranial displacement force of the paw for 3 test conditions (CrCL transected, released, and readjusted). When significant differences were detected, paired comparisons were performed by use of the Tukey honestly significant difference method. For all statistical analyses, values of P < 0.05 were considered significant. A statistical analysis software package was used to perform all statistical analyses.

Results

Sample—The mean ± SD body weight of the dogs was 9.8 ± 1.1 kg. The mean tibial plateau angle was 31.1 ± 3.5°. The actual mean angle of the pelvis, hip joint, stifle joint, and tarsal joint was 31.9 ± 5.6°, 114.9 ± 11.1°, 137.0 ± 11.8°, and 128.7 ± 9.4°, respectively. Actual mean hip abduction angle was 101.5 ± 3.3°. Actual mean peak vertical force was 65.3 ± 6.8% of body weight.

Joint angle and vertical force—Angles of the pelvis, hip joint, and stifle joint did not differ significantly...
between the CrCL intact, CrCL transected, released, and readjusted conditions. The tarsal joint in the CrCL transected condition was significantly flexed, compared with the CrCL-intact (P = 0.010), released (P = 0.030), and readjusted (P = 0.013) conditions. The vertical force on the paw did not differ significantly among the test conditions (Table 1).

Muscular tensile force—Mean ± SD tensile force of the quadriceps muscle in the CrCL-intact condition (ratio of tensile force to vertical force, 3.3 ± 0.5) did not differ significantly, compared with that for the CrCL transected (4.0 ± 0.6; P = 0.057), released (3.1 ± 0.5; P = 0.899), or readjusted (3.2 ± 0.5; P = 0.991) conditions (Figure 4). In contrast, tensile forces were significantly decreased for the released (P = 0.011) and readjusted (P = 0.029) conditions, compared with the tensile force for the CrCL-transected condition. There were no significant (P = 0.979) differences in tensile force between the released and readjusted conditions for the quadriceps muscle.

Mean ± SD tensile force of the semitendinosus muscle in the CrCL-transected condition (ratio of tensile force to vertical force, 0.8 ± 0.1) was significantly (P = 0.010) increased, compared with the tensile force for the CrCL-intact (0.4 ± 0.0) and readjusted (0.4 ± 0.0) conditions. Mean tensile force of the gastrocnemius muscle for the CrCL-intact condition (ratio of tensile force to vertical force, 2.2 ± 0.3) was not significantly (P = 0.922) different, compared with the value for the CrCL-transected condition (2.3 ± 0.4). Mean tensile forces of the released (ratio of tensile force to vertical force, 1.1 ± 0.4) and readjusted (1.3 ± 0.4) conditions were significantly (P < 0.001) decreased, compared with that for the CrCL-intact condition. Additionally, tensile forces of the released and readjusted conditions were significantly (P < 0.001) decreased, compared with that for the CrCL-transected condition. There were no significant (P = 0.764) differences in tensile force between the released and readjusted conditions.

Cranial displacement and internal rotation of the tibia—Mean ± SD cranial tibial displacement in the released (7.2 ± 2.3 mm) and readjusted (7.5 ± 2.5 mm) conditions was significantly (P < 0.001) increased, compared with the value for the CrCL-transected condition (2.1 ± 1.3 mm; Figure 5). There was no significant (P = 0.975) difference in cranial tibial displacement between the released and readjusted conditions.

Mean ± SD internal rotation of the tibia for the released (18.9 ± 5.1°) and readjusted (18.1 ± 4.9°) conditions was significantly (P < 0.001) increased, compared
with the value for the CrCL-transected condition (4.7 ± 1.7°; Figure 5). There was no significant (P = 0.941) difference in internal rotation of the tibia between the released and readjusted conditions.

Cranial displacement force on the paw—Mean ± SD cranial displacement force on the paw for the released (15.5 ± 4.1%) and readjusted (13.9 ± 4.1%) conditions was significantly (P < 0.001) increased, compared with the value for the CrCL-transected condition (3.2 ± 3.9%; Figure 6). There was no significant (P = 0.730) difference in cranial displacement force between the released and readjusted conditions.

Discussion

In the study reported here, tensile force of the semitendinosus muscle in the transected-CrCL condition was increased to nearly twice that for the CrCL-intact condition. Additionally, there was minimal cranial displacement and internal rotation of the tibia when there was tension on the semitendinosus muscle in the present study. In stifle joints with an anatomically normal structure, the CrCL is the primary restraint against cranial displacement of the tibia.20,21 Furthermore, limitation of the internal rotation of the tibia depends on the cranial displacement force and VF were measured in kgf. See Figure 4 and 5 for remainder of key.

Stifle joints for the CrCL-transected condition and a consequently released tension of the semitendinosus muscle had cranial tibial subluxation attributable to the tension of the quadriceps and gastrocnemius muscles. This result suggested that the quadriceps and gastrocnemius muscles are antagonists for the CrCL. The quadriceps muscle is known to contribute to cranial tibial subluxation as a result of craniodistal traction of the tibia and caudal pressure of the patella against the femoral trochlea.20 Also, it is generally recognized in human medicine that the quadriceps muscle is an anterior cruciate ligament antagonist.7,11

The relationship of the gastrocnemius muscle and CrCL has been described with respect to tibial compression tests.6 The gastrocnemius muscle originates from the caudal aspect of the distal portion of the femur, and contraction of this muscle creates a strong caudodistal traction on the femur during weight bearing. This force is then applied against the CrCL. Contraction of the gastrocnemius muscle increases anterior cruciate ligament strain in human knee joints.12,13 As such, the gastrocnemius muscle is regarded as an anterior cruciate ligament antagonist.12,13

When the tensile force was reapplied to the semitendinosus muscle after prior release of the tension, cranial tibial displacement and cranial internal rotation of the tibia did not change. Therefore, in this extreme model in which there was tibial subluxation, our simulation of the semitendinosus muscle (which is only 1 portion of the biceps femoris, semimembranosus, and semitendinosus muscles that comprise the hamstring muscle group) was not able to provide adequate stability to the stifle joint to overcome subluxation. In dogs, CrCL-deficient stifle joints are cranially displaced during the stance phase; thus, muscular forces are unable to compensate for the loss of restraint provided by the CrCL.20–31

Knee joints of humans with an injured anterior cruciate ligament can be stabilized by use of a dynamic stabilizer. In such cases, there is compensation for the injured knee joints by the quadriceps muscle (decreas-
ing the force generated by the muscle) or the biceps femoris, semimembranosus, and semitendinosus muscles (increasing the force generated by the muscles) during ambulation. In the present study, the cranial tibial displacements were not decreased when the tensile force of the semitendinosus muscle was reapplied. However, if the semitendinosus muscles were given a stronger tensile force or the quadriceps muscles were exposed to a weaker tensile force, displacement of the tibia could be overcome and the tibia returned to an anatomically normal position. By use of sophisticated computer simulation analysis, increasing the force generated by the semitendinosus muscle is more effective than is decreasing the force generated by the quadriceps muscle for reducing anterior tibial displacement in an anterior cruciate ligament–deficient gait in humans. In contrast, a study that involved the use of a 2-D anatomic knee model found that 56% of the maximal force of the biceps femoris, semimembranosus, and semitendinosus muscles could reduce the anterior displacement of the tibia to an anatomically normal amount during the stance phase of the gait. The consequence of increased force of the biceps femoris, semimembranosus, and semitendinosus muscles reportedly includes quadriceps muscle force and joint contact force. Hence, simply increasing the tensile force of the semitendinosus muscle did not result in restraint of the tibia; there was cranial tibial displacement in the model used in the present study.

In the present study, internal rotation of the tibia was observed with cranial tibial displacement associated with the release of the tensile force of the semitendinosus muscle. In CrCL-deficient stifle joints, internal rotation of the tibia with cranial tibial displacement has been reported in biomechanical studies on the stifle joint of dogs. It is speculated that to generate internal rotation of the tibia, the lateral collateral ligament is not as taut as the medial collateral ligament when the stifle joint is in flexion. Thus, the lateral aspect of the tibia moves further cranially than does the medial side. In the present study, a slight internal rotation of the tibia was observed for the CrCL-transected condition that retained a tensile force for the semitendinosus muscle, and this result was considered to be associated with a lack of cranial tibial displacement. However, the wire that mimicked the semitendinosus muscle was inserted in a mediolateral direction on the proximal aspect of the caudal portion of the tibia because the termination of the medial collateral ligament was defined as the insertion of the semitendinosus muscle. Therefore, when there was a tensile force on the semitendinosus muscle, the tibia was pulled equally in the caudal direction from the medial and lateral sides. These uniform forces may control internal rotation of the tibia. However, the proximal aspect of the mediolateral portion of the tibia, which is the insertion of separate muscles in vivo, may have different activity. In light of these findings, we could not elucidate whether the semitendinosus muscle inhibited the internal rotation of the tibia in the present study.

The cranial displacement force of the stifle joints for the released and readjusted conditions increased significantly, compared with the force for the CrCL-transected condition. This result was likely related to the cranial tibial subluxation associated with the release of the semitendinosus muscle. Cranial tibial subluxation may have caused cranial displacement of the paw. Because we were investigating changes that result in maintaining the same standing position as with intact stifle joints, the paws were fixed in the intact position. Therefore, displacement of the paws may be measured as the cranial displacement force. The increase of this force may be associated with a significant decrease of the tensile force of the quadriceps and semitendinosus muscles for the released and readjusted conditions. The tarsal joint for the CrCL-transected condition was significantly flexed, compared with flexion for the CrCL-intact, released, and readjusted conditions. This dorsiflexion of the tarsal joint may have led to the increase in the tensile force of the gastrocnemius muscle for the CrCL-transected condition. However, there was no significant difference, compared with tensile force for the CrCL-intact condition. To observe the effect of the transected CrCL, tensile force of the muscles was not adjusted during the CrCL-transected condition. Additionally, the distance between the origin and insertion of the gastrocnemius muscle was decreased by the slight cranial tibial displacement associated with the CrCL transection; therefore, the tarsal joint could be flexed. Flexion in the tarsal joint and the accompanying slight increase in the tensile force of the gastrocnemius muscle may have influenced the tensile forces of the other muscles. However, there were no significant differences between the CrCL-transected and CrCL-intact conditions; hence, the effects appeared to be limited.

The joint and pelvic angles were given careful attention in the experimental conditions of the study reported here. In the model used, it was essential to preserve the pelvis to ensure the origin of the semitendinosus muscle. Because the tensile force of the semitendinosus muscle may be affected by the positional relationship between the pelvis and femur, it was necessary to determine the slope of the ilium with the horizontal and the hip abduction angle. Each angle configured in the present study corresponded closely with angles in other reports. Therefore, the angles used in the present study appeared to be appropriate.

The present study had some limitations. The model used mimicked the joint angles and peak vertical force when clinically normal Beagles walked at a velocity of 1.2 m/s. The walking velocity was selected on the basis of another study, thus defining the tensile force of the semitendinosus muscle at 22.8% of body weight. However, we were unable to match the value of 0.9 m/s reported in that other study. Additionally, the acceleration and angular acceleration generated at each joint were not considered; therefore, the conditions at peak vertical force were not reproduced perfectly. Another limitation was that the tibial plateau angle in the present study was greater than that reported for clinically normal dogs. Thus, this difference may have influenced internal rotation of the tibia, tibia cranial displacement, and tensile force of each muscle. In particular, cranial tibial displacement for the released and readjusted conditions was substantial. However, displacements in the tibial subluxation were resolved
immediately by releasing the tension of the wires that mimicked the quadriceps and gastrocnemius muscles.

To our knowledge, this model is the first that mimics the tensile force of the semitendinosus muscle in dogs. The semitendinosus muscle is an important muscle required for flexion of the stifle joint; therefore, this muscle should be reproduced when evaluating biomechanics of the stifle joint. The models used in the present study were considered appropriate for reproducing the primary muscles of the hind limb muscles because results were consistent with those of other reports and projections.

Additionally, it is possible to infer the typical tensile force of periarticular muscles of the stifle joint by use of this model. Therefore, we believe that it is also possible to evaluate effects of surgical procedures that may lead to a change in the tensile force of the patella ligament after an operation, such as tibial plateau leveling osteotomy and tibial tuberosity advancement. Furthermore, this model may be useful for studies on conformational differences among breeds and patellar luxation in dogs.

For the present study, we concluded that the semitendinosus muscle acts as an agonist of the CrCL and that the quadriceps and gastrocnemius muscles act as antagonists of the CrCL in the canine stifle joint. However, after CrCL transection, the semitendinosus muscle in this model incompletely resisted cranial tibial displacement. The risk of rupture of a CrCL may be increased by diseases (such as cauda equina syndrome) associated with a decrease in activity of the biceps femoris, semimembranosus, and semitendinosus muscles.

References


