Comparison of lateral fabellar suture and tibial plateau leveling osteotomy techniques for treatment of dogs with cranial cruciate ligament disease

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Objective—To compare 1-year outcomes after lateral fabellar suture stabilization (LFS) and tibial plateau leveling osteotomy (TPLO) for the treatment of dogs with cranial cruciate ligament disease.

Design—Randomized blinded controlled clinical trial.

Animals—80 dogs with naturally occurring unilateral cranial cruciate ligament disease.

Procedures—All dogs were randomly assigned to undergo LFS (n = 40) or TPLO (40). Clinical data collected included age, weight, body condition score, history information, stifle joint instability, radiographic findings, surgical findings, and complications. Outcome measures were determined prior to surgery and at 6 and 12 weeks and 6 and 12 months after surgery, including values of pressure platform gait analysis variables, Canine Brief Pain Inventory scores, owner satisfaction ratings, thigh circumference, and stifle joint goniometry values.

Results—Signalment and data for possible confounding variables were similar between groups. Peak vertical force of affected hind limbs at a walk and trot was 5% to 11% higher for dogs in the TPLO group versus those in the LFS group during the 12 months after surgery. Canine Brief Pain Inventory, goniometry, and thigh circumference results indicated dogs in both groups improved after surgery, but significant differences between groups were not detected. Owner satisfaction ratings at 12 months after surgery were significantly different between groups; 93% and 75% of owners of dogs in the TPLO and LFS groups indicated a satisfaction score ≥ 9 (scale, 1 to 10), respectively.

Conclusions and Clinical Relevance—Kinematic and owner satisfaction results indicated dogs that underwent TPLO had better outcomes than those that underwent LFS. (*J Am Vet Med Assoc* 2013;243:675–680)

Americans spend > $1.32 billion/y on treatment of dogs for cranial cruciate ligament disease[1]; surgical treatment accounts for 90% of that cost.[1] Although surgical treatment improves outcomes for large- and giant-breed dogs with cranial cruciate ligament rupture, there is controversy regarding the surgical procedure that is most beneficial.[2–7] This topic is important for pet dogs primarily for 3 reasons. The TPLO procedure is more invasive than the LFS procedure; an osteotomy and bone plate placement are performed during TPLO, whereas the LFS procedure involves placement of a suture around the fabella and through a single hole drilled through the tibial tuberosity. In addition, complications associated with the TPLO procedure are typically more severe (ie, tibial plateau fracture, osteotomy nonunion or malunion, and fixation failure) than those associated with the LFS procedure.[2,3] Also, the mean cost of the TPLO procedure is 1.5 to 2 times as high as that for the LFS procedure.[7] Despite these disadvantages, many veterinary surgeons anecdotally believe that TPLO procedures provide better outcomes than LFS procedures.

This controversy regarding treatment of dogs with cranial cruciate ligament rupture has been a topic of discussion among specialists in the American College of Veterinary Surgeons. In addition, it has also been described in *The Wall Street Journal* and in blogs by pet owners.[7–9] Information in some websites suggests that veterinarians do not have a pet's best interest in mind and recommend TPLO procedures to increase profits.[7–9]

Abbreviations

BCS	Body condition score
CBPI	Canine Brief Pain Inventory
LFS	Lateral fabellar suture stabilization
PVF	Peak vertical force
TPLO	Tibial plateau leveling osteotomy

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Studies have been conducted in which TPLO and LFS procedures for dogs have been evaluated; in some of those studies, the 2 surgical techniques have been directly compared. Such studies[4,5] have had an observational design. A limitation of observational studies is confounding variables, which decrease their evidentiary value. By use of the principles of evidence-based medicine, Aragon and Budsberg[10] performed a critical review of the literature related to this topic and found no evidence of the superiority of either procedure. The only study design that allows determination of causal inference is a randomized controlled clinical trial.

The purpose of the study reported here was to compare outcomes of TPLO and LFS procedures for dogs with cranial cruciate ligament disease to determine whether one of these techniques has better patient outcomes as determined via pressure platform gait analysis and owner assessment with a validated survey instrument. The study design was a randomized blinded controlled clinical trial. Our hypothesis was that dogs that underwent TPLO would have better limb function and less severe signs of pain (as determined on the basis of owner evaluations 6 weeks, 12 weeks, 6 months, and 12 months after surgery) than those that underwent an LFS procedure.

Materials and Methods

Animals—This study was approved by the University of Illinois Animal Care and Use Committee and was performed with informed client consent. The number of dogs needed to complete the study with 80% power was calculated on the basis of the known variation of PVF values in dogs with cranial cruciate ligament disease (determined from results of another study[5] and on the basis of clinically relevant differences in PVF values). On the basis of this calculation, 80 dogs with unilateral complete or partial cranial cruciate ligament rupture were recruited for the study. The dogs were assigned (via block randomization) to undergo an LFS (n = 40) or TPLO (40) procedure, controlling for body weight at a BCS of 5 (small or medium breed, < 18 kg; large breed, 18 to 36.4 kg; or giant breed, > 36.4 kg). For dogs with a BCS higher or lower than 5, the body weight at a BCS of 5 was estimated by a single author (CB) and such dogs were assigned to the appropriate randomization block. Therefore, obese large-breed dogs were not block randomized as giant-breed dogs on the basis of weight alone. For inclusion in the study, dogs were required to have radiographic signs of cranial cruciate ligament disease (including stifle joint effusion), clinical signs of lameness, and signs of pain during extension of the stifle joint during physical examination; only dogs with unilateral clinical signs at the time of enrollment in the study were included. Dogs were excluded if there was evidence that they had other medical diseases, neurologic disease, or fractious and aggressive behavior. Meniscal disease was not used as a criterion for inclusion or exclusion because that problem is commonly secondary to cranial cruciate ligament disease and would be expected to develop in a random manner in dogs in each study group. Dogs were not excluded if they had a history of other orthopedic problems or had undergone surgery of the stifle joint of the opposite limb as long as they had no signs of pain or lameness attributable to those problems at the time of the initial evaluation and such surgical procedures had been performed ≥ 6 months prior to that time. A CBC, serum biochemical analyses, and urinalysis were performed and cranial cruciate ligament disease was confirmed for all dogs during surgery.

Confounding variables—Data were collected to identify potential confounding variables. These data included age, weight, BCS (9-point scale), history (duration of lameness and use of medications and dietary nutraceuticals), examination findings (detection of cranial drawer or cranial tibial thrust signs), radiographic findings (tibial plateau angle and radiographic signs of osteoarthritis), surgical findings (partial vs complete cranial cruciate ligament tear and meniscal damage), and complications.

All radiographic images obtained before surgery were evaluated to identify signs of stifle joint osteoarthritis and for measurement of tibial plateau angles. An investigator (MS) who was unaware of the group to which dogs had been assigned determined subjective osteoarthritis scores (mild, moderate, or severe) on the basis of the severity of osteophytosis. The tibial plateau angle was measured by use of standard anatomic landmarks by the same investigator (MS) for all dogs.[11]

Surgery—Dogs were anesthetized via an anesthetic protocol determined for each animal under the supervision of a board-certified anesthesiologist. Each protocol included appropriate drugs for analgesia, sedation, and anesthetic induction. Anesthesia was maintained with isoflurane. Analgesia for dogs after surgery was typically achieved via oral administration of an NSAID combined with injection of an opioid for the first 24 hours after surgery followed by oral administration of an NSAID and tramadol for 10 days at home. The study protocol did not restrict medications for treatment of pain while dogs were in the hospital or at home for the duration of the study.

All surgeries were performed by or under the direct supervision of a board-certified surgeon. The experience level of the surgeon was tested for correlation with kinematic data and development of complications in dogs.

The affected hind limb was clipped free of hair, aseptically prepared, and draped. Arthroscopic exploration of the stifle joint was performed as previously decribed.[12] Cranial cruciate ligament rupture was graded as partial (< 90% of the cranial cruciate ligament affected) or complete (≥ 90% of the cranial cruciate ligament affected). The cranial cruciate ligament was debrided with a shaver, the joint was placed in a drawer position via external manipulation, and the menisci were evaluated by use of a probe during direct observation. Meniscal tears were debrided, or a medial caudal pole meniscectomy was performed if meniscal damage was severe. A meniscal release procedure was not performed for any of the dogs. If the meniscus could not be observed or debrided via arthroscopic techniques, a medial arthrotomy was performed and the stifle joint was explored. Skin incisions were closed with staples or sutures at the surgeon's discretion. For both procedures, a skin incision was created on the medial aspect of the stifle joint region, and a standard TPLO or an LFS procedure with crimp clamps was performed.

The TPLOs were performed as previously described.[4,5,11] A jig pin was placed in the caudal proximal aspect of the tibia followed by placement of a second jig pin in the distal aspect of the tibia. A jig was applied, and the cranial tibial and popliteal muscles were elevated off the tibia. A saw blade (24 or 30 mm) was chosen on the basis of the size of the tibia, and an osteotomy was performed. A rotational pin was used to rotate the proximal bone segment in relation to the distal bone segment to achieve a 6° tibial plateau slope relative to the horizontal plane. A holding pin was placed, and a plate was applied to the tibia. The incision was closed via standard techniques with types of suture chosen at the surgeon's discretion.

The LFS procedure was performed as previously described.[4,5] Briefly, after creation of the skin incision, a lateral retinacular incision was created and 2 strands of 60-, 80-, or 100-lb test nylon suture were passed around the lateral fabella, under the patellar ligament, and through a hole drilled in the proximal aspect of the tibial tuberosity in a figure eight pattern. The suture was tightened until ≥ 90° of stifle joint flexion could be maintained without eliciting a cranial drawer sign. The suture was crimped, and a standard closure was performed with a suture type chosen at the surgeon's discretion.

Outcome measures—Outcome measures included results of pressure platform gait analysis, CBPI owner surveys, thigh circumference (circumference of a hind limb measured at the level of the flank) measurement, and stifle joint goniometry before surgery and 6 weeks, 12 weeks, 6 months, and 12 months after surgery. Additionally, owners were asked to rate the outcome of surgery (on a scale of 1 to 10) at 6 and 12 months after the procedure. Dogs were evaluated to detect signs of complications during recheck examinations. Owners were asked about use of NSAIDs, dietary nutraceuticals, and other pain medication for their dogs. Orthopedic and radiographic examinations were performed as indicated depending on the procedure performed or suspicion of complications. Complications recorded included stifle joint instability, suspicion of meniscal tear (determined via detection of persistent lameness and signs of pain during flexion and palpation of the medial aspect of the stifle joint with or without an audible click), infection, failure of fixation, patellar tendonitis, contralateral cruciate ligament rupture, or fibular fracture.

Pressure platform[a] gait analysis was performed at a walk (1 to 1.3 m/s) and trot (1.5 to 1.8 m/s). Data for 5 valid trials were collected at each evaluated gait and appropriate velocity with an acceleration tolerance of ± 0.5 m/s^2. The same experienced investigator (KMK) collected the gait data for each dog. All dogs were acclimated to the room and pressure platform prior to data collection. Data were analyzed as mean values for 5 trials and reported as a percentage of body weight.

Owners were unaware of the surgical procedure that had been performed for their dog unless complications required disclosure (unmasking). Efforts to maintain blinding included creation of medial skin incisions of approximately the same length and a cost to owners of $1,200 for each procedure. During recheck examinations, dogs were removed from the presence of the owners for performance of study measurements and results were not discussed unless a complication required unmasking of the owner. The same member of the family was required to complete the CBPI questionnaire during each examination. The CBPI is a validated survey instrument for use in dogs with osteoarthritis; 2 scores (severity of pain and interference with daily activity) are determined with the CBPI.[13,14]

One of 2 trained investigators (CB or KMK) measured thigh circumference and performed goniometry during each patient examination. We previously determined an interobserver variability of < 1 cm for thigh circumference measurement and < 3° for stifle joint goniometry (unpublished data). Thigh circumference was determined with a tape measure. Stifle joint flexion and extension angles were each measured 3 times, and the mean was calculated. The greater trochanter and lateral malleolus of the tibia were used for proximal and distal landmarks and the distal aspect of the femoral condyle as the center of rotation.[5,15]

Home care—An NSAID and tramadol were prescribed for each dog for 10 days after surgery. The dosages varied for each NSAID and dog. Continued use of pain medication was not restricted after that time.

Discharge instructions were similar for each dog; instructions included physical therapy exercises to be performed 3 times daily, including balancing exercises, sit to stand exercises, and walks on a leash for 15 minutes 3 times daily for 6 weeks. All dogs were examined 6 weeks after surgery. Dogs in the TPLO group underwent radiography to assess bone healing at the surgical site. At that time, owners were allowed to increase patient activity to a normal level unless incomplete bone healing or a complication that prevented such activity was detected. Examples of possible complications that would have altered exercise instructions at that time included patellar tendonitis, evidence of implant failure without bone union, or LFS failure. All dogs were reexamined 12 weeks after surgery; if the TPLO site had not healed by 6 weeks after surgery, dogs underwent radiography again at that time.

Statistical analysis—Possible confounding variables were tested to detect significant differences between groups with the Student *t* test (for normally distributed, continuous data), χ^2 tests (for discrete data), or a Wilcoxon signed rank test (for nonparametric data or for variables with low sample sizes or nonnormal distributions).

This study was conducted as an intent-to-treat trial, and animals were not removed from the study regardless of complications. The gait data were analyzed via repeated-measures ANOVA, first testing the group by time interaction and the group by breed size (small or medium breed, large breed, or giant breed) interaction. Significant interactions meant that group differences changed with respect to the covariate; for such interactions, differences between groups were analyzed in a pairwise manner for each level of the covariate.

The CBPI severity of pain and interference with daily activity scores, goniometry data, and thigh circumference measurements had high variation and were analyzed to detect improvement over time via matched-pairs *t* tests. Additionally, results of a single question by which owners were asked to rate their satisfaction with the surgical outcome (on a scale of 1 to 10) were analyzed with the Wilcoxon signed rank test. Values of $P < 0.05$ were considered significant.

Results

All 80 dogs completed the study through the 6-month evaluation time. Two dogs died (causes unknown) prior to the 12-month recheck examination, and 2 dogs did not return for follow-up at that time. Of those 4 dogs with missing gait data at the 12-month evaluation time, 3 were in the LFS group and 1 was in the TPLO group.

Values of known possible confounding variables were similar between groups (**Table 1**), except for surgical and anesthesia times, which were significantly longer for dogs in the TPLO group versus those in the LFS group. Mean ± SEM surgery and anesthesia times for dogs in the LFS group were 103.1 ± 4.4 minutes and 184.4 ± 5.9 minutes, respectively, and those for dogs in the TPLO group were 135.6 ± 6.1 minutes and 258.4 ± 6.9 minutes, respectively. The level of experience of surgeons was not significantly different between groups and was not correlated with outcomes (gait analysis data or complication rates). Likewise, rates of use of medications that may have affected stifle joint characteristics (eg, NSAIDs, corticosteroids, other medications for treatment of pain, or dietary nutraceuticals) were not significantly different between groups. Complication rates were similar between the 2 groups, and the rates of suspected postoperative meniscal tearing were 5% and 3% for the LFS and TPLO group, respectively. Although 15% of dogs in the LFS group had a palpable drawer sign at ≥ 1 year postoperative time; such dogs did not seem to have PVFs lower than the mean value for the group. Similarly, 3% of dogs in the TPLO group had a palpable tibial thrust sign at the time of a recheck examination; such dogs did not seem to have a PVF value lower than the mean value for the group. No dogs underwent a second surgery for treatment of the affected limb. Patellar tendonitis, implant infection, or tibial tuberosity or fibular fractures were not detected in any of the dogs.

Results of analysis of gait data indicated that the PVF and vertical impulse values were significantly higher for dogs in the TPLO group than they were for dogs in the LFS group 12 months after surgery at both a walk and a trot. Six months after surgery, PVF values at a trot were not significantly ($P = 0.06$) different between groups. The percentage differences in mean PVF values between groups were 5% at a walk and 8% at trot at 6 months and 6% at a walk and 11% at a trot at 12 months ($P < 0.05$; **Figures 1 and 2**).

For all dogs at the 12-month postoperative evaluation time, the mean improvement in CBPI pain severity

Table 1—Known potential confounding variables for dogs with naturally occurring unilateral cranial cruciate ligament disease that underwent treatment via LFS (n = 40) or TPLO (40) procedures.

Variable	LFS	TPLO
Age (y)	6.5 (2–12)	6 (2–12)
Sex (No. of dogs)		
Female	23	19
Male	17	21
Weight (kg)	35.9 ± 1.9	36.9 ± 2.3
BCS	7 (3–9)	7 (5–9)
Size (No. of dogs)		
Giant breed	11	10
Large breed	25	26
Medium breed	4	4
Affected hind limb (No. of dogs)		
Right	22	15
Left	18	25
Duration of lameness (mo)	3.8 (0.14–24)	3.4 (0.25–24)
Surgery time (min) *	103.1 ± 4.4	135.6 ± 6.1
Anesthesia time (min) *	184.4 ± 5.9	258.4 ± 6.9
Preoperative tibial plateau angle (°)	26.4 ± 0.4	26.5 ± 0.4
Postoperative tibial plateau angle (°)	—	6.4 ± 0.4
Meniscal tears detected during surgery (% of dogs)	32.5	32.5
Complete cruciate tears (% of dogs with ≥ 90% of the cruciate torn)	77.5	82.5
Mild to moderate osteoarthritis (% of dogs)	90	97.5
Bilateral cranial cruciate ligament disease†	20	22
Postoperative development of meniscal tears‡	5	3

Values are median (range) or mean ± SEM unless otherwise indicated.

*Data are significantly ($P < 0.05$) different between groups. †Dogs that ruptured the contralateral cruciate ligament during the study period. ‡Postoperative or latent meniscal tears were not confirmed via imaging or surgical observation.

— = Not applicable.

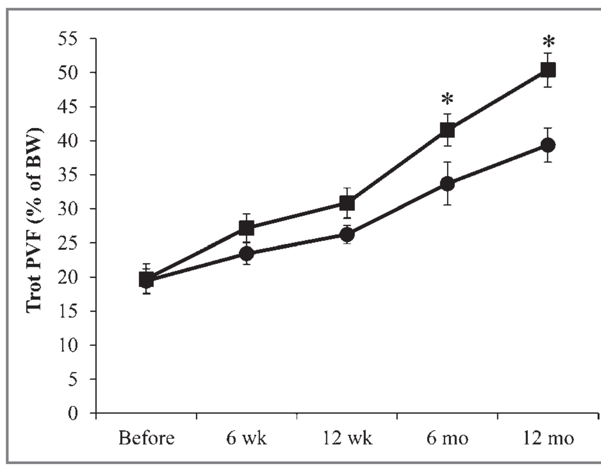

Figure 1—Mean ± SEM PVF at a trot before and 6 weeks, 12 weeks, 6 months, and 12 months after surgery for affected hind limbs of dogs with naturally occurring unilateral cranial cruciate ligament disease that underwent an LFS procedure (circles; n = 40) or TPLO (squares; 40). Data were unavailable for 3 dogs in the LFS group and 1 dog in the TPLO group for the 12-month evaluation time. BW = Body weight. *Data are significantly ($P < 0.05$) different between groups.

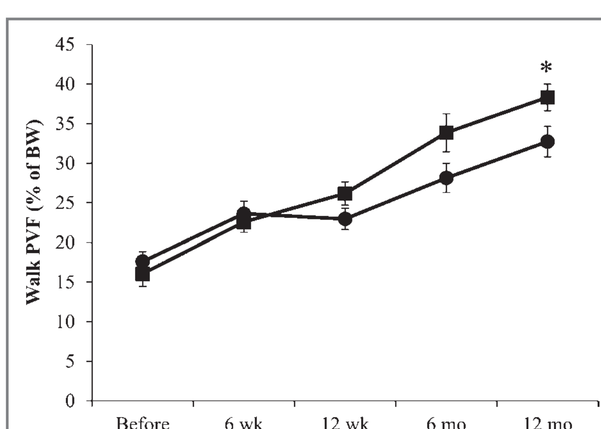

Figure 2— Mean ± SEM PVF at a walk for the dogs in Figure 1. *See* Figure 1 for remainder of key.

score versus the preoperative score was 4.19 and mean improvement in the CBPI interference with daily activity score versus the preoperative score was 5.34; these scores were significantly ($P < 0.001$) higher than preoperative values. However, no significant difference in CBPI score improvement was detected between groups of dogs. Overall, qualitative outcome scores were similar between groups; 98% of owners of dogs that underwent LFS procedures and 100% of owners of dogs that underwent TPLOs were satisfied with the procedure (indicating a rating of good, very good, or excellent at the 12-month time point). However, the satisfaction ratings (on a scale of 1 to 10) indicated by owners at 12 months were significantly different between groups; owners indicated a rating of ≥ 9 for 93% of dogs in the TPLO group and for 75% of dogs in the LFS group at that time. At 6 months after surgery, owners indicated satisfaction scores of ≥ 9 for 68% of dogs in the LFS group and 80% of dogs in the TPLO group (range of scores for both groups, 1 to 10); these data were not significantly different.

For all dogs, results of goniometry indicated the mean ± SEM increase in stifle joint range of motion from before surgery to 6 months after surgery was 1.93 ± 1.1°. From 6 to 12 months, range of motion decreased by 4.04 ± 1.29° ($P < 0.001$); however, no significant differences were detected between groups. No significant differences in thigh circumference were detected between groups, but thigh circumference values for all dogs in the study increased by 4.04 ± 1.29 cm from the preoperative evaluation time to the 12-month postoperative evaluation time; this increase in thigh circumference was significant ($P < 0.001$).

Discussion

The study reported here was the first randomized blinded clinical trial for which results indicated a significant difference in PVF between dogs that underwent TPLO versus those that underwent LFS for treatment of cranial cruciate ligament disease. However, the results must be interpreted with consideration of the clinical importance of values. The clinical relevance of changes in PVF are subjective. The authors believe the differences reported here, although not large, are clinically important.

Results of the present study differed from those of 2 observational studies[4,5] in which no significant differences were detected between dogs that underwent TPLO and those that underwent an LFS procedure. Observational studies are not randomized; therefore, an unidentified confounding variable may have improved outcomes for dogs that underwent an LFS procedure or decreased outcomes for dogs that underwent TPLO in those studies. Additionally, in both of those other studies,[4,5] dogs that underwent LFS procedures also underwent targeted physical rehabilitation at the hospital in which surgeries had been performed. In general, rehabilitation improves outcomes for dogs that undergo either procedure; however, in clinical situations, dogs may not receive such treatment, even though it is recommended.[16,17] The postoperative care instructions for dogs in the present study were designed to allow dogs to undergo safe rehabilitation exercises at home.

Significant differences between groups of dogs were not detected for any of the other clinical measurements in this study, but such measurements were likely less sensitive than PVF for detection of differences.[18,19] Although it seemed logical that thigh circumference and range of motion of joints would be related to outcomes for dogs, these outcome measures were affected by various sources of variation and may have only allowed detection of large differences between groups. Such sources of variation included inexact application of measurement instruments, changes in body condition of dogs that made anatomic landmarks difficult to identify, subjectivity in performance of measurements, and differences among breeds. We attempted to limit such sources of variation by use of various methods, including use of trained and experienced investigators who were unaware of the group to which dogs had been assigned.

Results of owner CBPI evaluations indicated that owners believed their dogs improved regardless of the type of surgery performed. Owner bias was minimized by means of blinding of owners to the group to which dogs had been assigned, charging owners an equal amount of money for each procedure, and requiring the same family member to fill out surveys at each evaluation time. Despite these methods, the CBPI questionnaire results did not distinguish between groups of dogs. The CBPI, although validated, is not specific for evaluation of a particular limb or joint, and the scores can potentially be affected by other orthopedic, neurologic, or medical problems. However, the client satisfaction survey question was intended to specifically assess surgical outcomes for dogs and results for that question seemed to be consistent with results of gait analysis, which indicated better limb function for dogs in the TPLO group versus that for dogs in the LFS group.

For intent-to-treat trials, randomization of subject assignments is of paramount importance. Dropout of subjects breaks randomization, potentially increasing the effects of confounding variables. That is, dropout of subjects in a randomized study changes the design of such a study to observational. Intent-to-treat trials are designed to decrease the chance of detecting an incorrect significant difference via preventing potential biases attributable to breaking of randomization. Events that are unrelated to a treatment but that affect outcomes for subjects should be evenly distributed between groups. In the present study, such events included development of contralateral cranial cruciate ligament disease in dogs during the study period. It is possible that procedures that cause more pain would cause dogs to bear less weight on the treated limb than would other procedures that cause less pain; such dogs may have high stress on the contralateral cranial cruciate ligament, which would increase the risk of rupture. If this were true and such dogs were eliminated from analysis, results would be affected by bias and the power of the study would decrease.

In the present study, dogs were randomly allocated to groups without consideration of surgeon experience. It seemed logical that dogs that underwent operations conducted by inexperienced surgeons would have higher complication rates or worse outcomes, compared with dogs that underwent operations conducted by experienced surgeons; however, results of this study did not indicate such differences among surgeons with various levels of experience. The effects of experience may have been mitigated by the direct supervision of inexperienced surgeons by experienced surgeons.

Results of this study indicated that dogs with cranial cruciate ligament rupture treated via TPLO had clinically better outcomes, significantly higher PVF values, and higher owner satisfaction versus those treated via an LFS procedure. However, both surgical procedures induced improvements in limb function, stifle joint range of motion, and thigh circumference in dogs and perceptions of patient pain and function by owners.

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