Damage of the CCL in dogs is one of the most common injuries encountered by veterinarians and is the most common cause of lameness of the stifle joint.\(^1,2\) Stifle joint instability from CCL rupture results in pain, lameness, and progressive degenerative joint disease.\(^3\) Early surgical stabilization is recommended, particularly in dogs weighing >15 kg (33 lb), because poor results are reported for most dogs that undergo nonoperative management.\(^4\) A variety of surgical techniques for management of CCL injury have been described, and currently, a single best technique has not been determined.\(^5,6\) One of the most widely performed procedures is extracapsular stabilization with LFS.\(^7,8\)

The LFS technique is a modification of the extracapsular technique first reported in 1970.\(^8\) Stability is provided to the stifle joint by passing heavy, nonabsorbable suture material behind the lateral sesamoid bone of the gastrocnemius muscle and through 1 or 2 bone tunnels made in the tibial tuberosity. The suture position is intended to mimic the orientation of the CCL, thus eliminating cranial drawer motion. The LFS technique relies on periarticular fibrosis for permanent stabilization of the joint.\(^9,10\) Imbrication of the lateral fascia at the time of surgery may help to further stabilize the stifle joint.\(^10\) Good to excellent clinical outcome in 77% to 82% of dogs that underwent LFS surgery has been reported.\(^11\) Numerous reports of complications associated with other surgical techniques to treat dogs with CCL rupture exist, but few reports of complications associated with the LFS approach have been published. For example, suture reactions were detected in 18% to 21% of dogs after extra-articular stabilization of the stifle joint with multifilament, polyamide suture.\(^12,13\) Other complications associated with that procedure were not described. The purpose of the study reported here was to evaluate the rate and range of complications that develop after a large number of LFS surgeries.

### Materials and Methods

**Case selection**—Records were reviewed to identify dogs evaluated at the Foster Hospital for Small Animals from January 1997 through December 2005 and treated with LFS.
at the Cummings School of Veterinary Medicine and that underwent LFS surgery for management of CCL injury from January 1997 through December 2005. A dog was eligible for inclusion when the diagnosis of CCL injury was confirmed at surgery, a follow-up examination was performed, and the medical record included signalment, details of the surgical procedure, postoperative management, and follow-up examination.

**Medical records review**—Data obtained from the medical records included signalment, body weight, affected limb, and nature (unilateral vs bilateral) of the CCL rupture. Surgery time (interval from skin incision to closure) and anesthesia time (interval from induction to discontinuation of gas anesthesia), primary surgeon (staff surgeon vs resident), extent of CCL damage (complete vs partial rupture), meniscal damage and treatment (excision vs release), implant type, postoperative bandage application, and duration of follow-up were recorded. Type and number of complications were also recorded.

A complication was defined as any undesirable outcome associated with the surgical procedure or occurring after surgery that was confirmed via physical examination of the dog at the hospital. Complications were categorized as intraoperative, neurologic, infection (confirmed via positive result of bacteriologic culture of a sample obtained from the surgical site), incisional (without positive result of bacteriologic culture), meniscal, and implant related. Complication rate was defined as the number of surgical procedures with complications divided by the total number of surgical procedures.

**Surgical treatment**—All dogs underwent standard lateral parapatellar arthroscopy for exploration of the stifle joint. Remnants of the CCL were removed, and the menisci were inspected. When a meniscal tear was evident, the torn component was removed. When the meniscus was intact, the caudal horn of the medial meniscus was left intact or a meniscal release was performed at the discretion of the surgeon. Medial meniscal release was accomplished by severing the meniscocapsular ligament of the caudal horn of the medial meniscus. The LFS surgeries were performed by passing suture material around the lateral sesamoid of the gastrocnemius muscle and through 1 or 2 bone tunnels created in the proximal aspect of the tibia. The suture material was then secured with hand ties or a commercially available crimp clamp system. The LFS technique, a modification of the original extracapsular technique, varied primarily in the type of implant material used. Anesthetic protocols varied and were not evaluated.

Most dogs received perioperative administration of cefazolin (22 mg/kg [10 mg/lb], IV, q 2 h). A modified Robert Jones bandage was applied to the affected limbs of most dogs after surgery. Bandage removal was at the discretion of the surgeon, and the duration that the limb remained bandaged varied from 24 hours to 2 weeks. Dogs were typically discharged 48 hours after surgery, and suture removal was performed 10 to 14 days after surgery. Dogs generally returned for suture removal at 2 weeks and a follow-up appointment at 6 weeks after surgery. Postoperative administration of analgesics and antimicrobials was at the discretion of the surgeon, but most dogs were treated with narcotic analgesics for 48 hours and discharged with instructions for owner administration of NSAIDs. Postoperative antimicrobials were not routinely used.

**Statistical analysis**—Data were examined graphically, and data that were not normally distributed were transformed before analysis. Data are reported as mean ± SD for normally distributed data or median and range for nonparametric data. Distributions of categoric data (eg, type of surgery and sex) were compared by use of a χ² test. Continuous variables (eg, surgery time, age, and body weight) were compared by use of independent t tests. Statistical analysis was performed with commercial statistical software. A value of P < 0.05 was considered significant for all analyses.

**Results**

Of the 490 records of dogs with LFS procedures during the study period, 305 fulfilled the criteria for inclusion in the study. Fifty-eight dogs underwent bilateral LFS surgery, for a total of 363 surgeries performed. Nine of the bilateral LFS procedures were performed during the same anesthetic episode. In addition, 5 dogs had bilateral surgery consisting of LFS surgery performed on 1 stifle joint and TPLO performed on the contralateral stifle joint, one of which was performed during the same anesthetic episode. The TPLO surgeries were not counted in the total number of surgeries. One hundred ninety-three LFS surgeries were performed on the left stifle joint, and 170 were performed on the right stifle joint.

**Signalment**—The 305 dogs that underwent LFS surgery consisted of 175 (57.4%) neutered females, 10 (3.3%) sexually intact females, 111 (36.4%) neutered males, and 9 (2.9%) sexually intact males. Median age of dogs at the time of surgery was 6 years (range, 0.8 to 15.1 years), and median body weight was 31.8 kg (70.0 lb; range, 2.5 to 104 kg [5.5 to 228.8 lb]). Males (median weight, 36.0 kg [79.2 lb]; range, 3.0 to 104.0 kg [6.6 to 228.8 lb]) were significantly (P < 0.001) heavier than females (29.0 kg [63.8 lb]; range, 2.5 to 71.2 kg [5.5 to 156.6 lb]). Sixty-six (21.6%) dogs were of mixed breeds, whereas 239 (78.4%) were purebred. Fifty-five breeds were represented, and the most common were Labrador Retriever (n = 64; 21.0%), Rottweiler (17; 5.6%), Golden Retriever (16; 5.2%), and German Shepherd Dog (9; 3.0%).

**Surgery**—Median duration of surgery was 65 minutes (range, 21 to 147 minutes), and median duration of anesthesia was 126 minutes (range, 53 to 272 minutes). There was perioperative administration of cefazolin during 346 (95.3%) surgeries. A bandage was applied after 328 (90.4%) surgeries; however, duration of bandaging was not recorded.

In 315 (86.8%) LFS surgeries, the implant material used was nylon leader line. The nylon ranged in size from a test weight of 20 to 80 lb, with 60 lb being the most common size used (n = 128 surgeries; 40.6%). One suture was placed in 80 surgeries, 2 sutures in 172 surgeries, 3 sutures in 3 surgeries, and 4 sutures in 1 surgery (all were LFSs). In 59 surgeries, the number of
sutures was not recorded. In 81 (25.7%) surgeries, the nylon suture was secured with crimps. In the remaining surgeries, the suture was secured by hand ties. Other materials used include braided polyester (21; 5.8%) and polypropylene (2; 0.6%). The material used in 25 (6.9%) surgeries was not recorded.

Arthroscopy with evaluation of the CCL and meniscus was performed during all surgeries. A complete tear of the CCL was reported for 233 (64.2%) surgeries. Damage to the caudal horn of the medial meniscus was reported in 136 (37.5%) surgeries. In dogs with damaged menisci, the torn or crushed component was excised. In dogs in which menisci were intact, MMR was performed (n = 113; 71.1%) or the meniscus was left intact (46; 28.9%). The condition of the medial meniscus and associated treatment (removal, MMR, or left intact) were not reported in 68 (18.7%) instances. Two hundred thirty-eight (65.6%) LFS procedures were performed by a board-certified surgeon; the remainder was performed by surgical residents. Median duration of follow-up was 30 weeks (range, 2 to 312 weeks).

Complications—Sixty-five complications resulting from 63 of the 363 (17.4%) LFS procedures were recorded. One complication was recorded for 61 dogs, and 2 complications were recorded for 2 dogs. No dog in the study group had > 2 complications. Two of the 9 dogs that underwent bilateral LFS surgery in the same anesthetic episode developed complications. Both dogs had 1 complication on 1 limb. This was not significantly (P = 0.47) different from results for dogs that underwent unilateral surgery. Side of surgery did not influence the complication rate; the percentage of LFS procedures that resulted in complications on the left hind limb (n = 30; 47.6%) was not significantly (P = 0.33) different from the percentage of surgeries that resulted in complications on the right hind limb (33; 52.4%).

Median age of dogs with complications after LFS surgery was 4.8 years (range, 0.8 to 10.9 years), which was significantly (P = 0.048) younger than the median age of dogs that did not develop complications (6.1 years; range, 0.8 to 15.1 years). Median body weight of dogs that developed complications was 35.7 kg (78.5 lb; range, 7.7 to 60 kg [16.9 to 132 lb]), which was significantly (P = 0.003) heavier than dogs that did not develop a complication (31 kg [68.2 lb]; range, 2.3 to 104 kg). Sex of dog influenced the rate of surgery-related complications significantly (P = 0.021), with more neutered and unneutered males (n = 35) developing complications than neutered and unneutered females (28).

Of the 63 dogs that developed complications, 15 (23.8%) dogs were of mixed breeds. The 4 most common breeds that developed complications were Labrador Retriever (n = 16; 25.4%), Rottweiler (5; 7.9%), Golden Retriever (3; 4.8%), and Boxer (3; 4.8%). Median duration of surgery in dogs that developed complications was 70 minutes (range, 30 to 145 minutes), and median duration of anesthesia was 128 minutes (range, 68 to 240 minutes). There were no differences in durations of surgery (P = 0.53) and anesthesia (P = 0.90) between dogs that developed complications and those that did not. Fifty-eight (92.1%) dogs that developed complications received cefazolin in the perioperative period. A soft-padded bandage was applied to the affected limbs of 58 (92.1%) dogs after surgery. The complication rate was not influenced by the administration of cefazolin in the perioperative period (P = 0.18) or by bandaging after surgery (P = 0.84).

Nylon was the implant material in 36 (88.9%) surgeries that resulted in complications. Type of implant material used during LFS surgeries was not significantly (P = 0.64) associated with the percentage of surgeries that resulted in complications. Board-certified surgeons performed 238 surgeries, including the surgeries on 38 of the 63 (60.3%) dogs that developed complications (16.0% complication rate), whereas surgical residents acted as the primary surgeon for 125 surgeries, including those that involved the other 25 (39.7%) dogs that developed complications (20.0% complication rate). The difference between complication rates was not significantly (P = 0.36) different.

An intraoperative complication was recorded in 1 (0.3%) LFS procedure. In the affected dog, the suture tore through the attachment of the lateral sesamoid of the gastrocnemius muscle when the suture was tightened. A screw and washer were then substituted for the sesamoid attachment. No additional treatment was required, and the dog recovered without any additional complications.

Neurologic deficits attributed to peroneal nerve damage during surgery were evident in 1 dog after surgery. The day after surgery, the dog was observed dragging its leg, which was originally attributed to the bandage. Knuckling of the toes continued after the bandage was removed. The dog was discharged but returned to the hospital 5 days after surgery for electromyographic evaluation. The electromyogram confirmed blocked nerve conduction at the level of the stifle joint. Because improvement was dramatic in the first week after surgery, no additional treatment was performed. By 4 weeks after surgery, no neurologic deficits were apparent.

Surgical site infection, confirmed by use of positive results of bacteriologic culture of samples from surgical sites, developed after 14 (3.9%) surgeries. Infection was detected within the first year after surgery in all situations, with most (n = 9) dogs developing an infection within 6 weeks after surgery. *Staphylococcus* spp (n = 12), *Streptococcus* spp (1), and *Pseudomonas* spp (1) were isolated from samples obtained at the time of second surgery or arthrocentesis. Three dogs that developed an infection did not receive cefazolin in the perioperative period. Nylon was the implant material in most dogs (n = 13) that developed an infection. Additional surgery was performed in all 14 dogs. Treatment included exploration of the stifle joint and joint lavage (n = 13), antimicrobials (12), implant removal (10), implant removal with replacement (1), and exploration of the incision and lavage (1). No additional treatment was required in 12 dogs. A third surgery for lavage of the stifle joint was performed in 2 dogs; in both, results of bacteriologic culture at the time of the third surgery remained positive. (P = 0.83) for the 38 of the 63 (60.3%) dogs that developed complications (16.0% complication rate), whereas surgical residents acted as the primary surgeon for 125 surgeries, including those that involved the other 25 (39.7%) dogs that developed complications (20.0% complication rate). The difference between complication rates was not significantly (P = 0.36) different.

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Signalment of dogs in the present study was similar to that in other reports. Labrador Retriever, Rottweiler, Golden Retriever, and German Shepherd Dog were the most common breeds. Data regarding general admissions to the hospital over the period of the study were not available, so whether these breeds were overrepresented in our sample was unknown.

In the present study, the rate of complications associated with the LFS procedure was not associated with breed. Median age of dogs (6 years) was slightly higher than that reported for other studies. To our knowledge, no studies have revealed an association between age of dog and increased risk of postsurgical complications. In our study, dogs that developed postsurgical complications were significantly younger than those that did not develop complications. It is possible that the younger dogs developed more complications because they were more active and postoperative restriction of exercise was more challenging, compared with the situation in older dogs. Age of dog at the time of CCL rupture decreases as body weight increases, suggesting that larger dogs may tear their CCL earlier.

Although results of other studies indicate that body weight is a factor in recovery from CCL surgery, with improved clinical outcome in light dogs, surgery-associated complication rates were not considered. Body weight of dogs that developed complications in the present study was significantly higher than that of dogs without complications. Body condition score was not routinely recorded and was therefore not considered; however, body condition is an important consideration because as many as 71% of dogs with CCL rupture are overweight. In human surgical patients, obesity is a risk factor for surgical site infection. Another veterinary study revealed that obese dogs and cats appeared to have higher postsurgical infection rates than did nonobese dogs and cats; however, the differences were not significant. In the present study, significantly more male than female dogs developed complications after the LFS procedure. This was an unexpected finding but may have been attributable to differences in body weight between sexes because males were significantly heavier than females.

Durations of surgery and anesthesia for dogs that developed a complication (including infection) were not significantly different from respective durations of surgery and anesthesia for dogs that did not develop a complication. Longer durations of surgery and anesthesia are reportedly correlated with an increased probability of infection, but this phenomenon was not evident in our study. Risk of infection in dogs reportedly doubles with approximately every 70 minutes of surgery time. Because the median duration of the LFS procedure was short (65 minutes) and the range of durations of surgery was fairly narrow in our study, it is possible that there was not enough variation in either of these variables to detect an association with complication rate. In addition, other potential risk factors such as the number of people in the surgical suite, hypotension or hypothermia of dogs while anesthetized, and underlying endocrinopathies or immunodeficiencies were not considered in the present study.

Surgeon experience was not associated with complication rate after the LFS procedure. This finding is
similar to that of another study. Most surgeries in the present study were performed by board-certified surgeons. Because the study took place in a veterinary teaching hospital, even when the resident acted as a primary surgeon, the procedure was often overseen by a staff surgeon.

Dogs that underwent LFS surgery had an infection rate of 3.9/100 surgeries, which was within the expected (2.5% to 5.8%) infection rate reported for most clean surgical procedures in veterinary34–35 and human36 surgery. Only dogs with a positive result of bacteriologic culture of samples from the joint or deep to the incision were classified as having an infection. Dogs categorized as having incisional complications that were empirically treated with antimicrobials were not included in this group; therefore, the actual infection rate may have been higher than 3.9/100 surgeries. In another study,13 > 21% of dogs required implant removal after LFS surgery because of infection, but a multifilament suture available only in cassettes was used as the implant material. Positive results of bacteriologic cultures of joint material were obtained in 10.3% of dogs after LFS surgery in another study;22 however, the sample included only 29 dogs, and 11 dogs had an unsatisfactory outcome after surgery. The low infection rate in the present study may have been the result of improved surgical implants or techniques. Alternatively, low-grade infections may not have been clinically apparent in some dogs.12

Infection attributable to surgery was treated aggressively; all dogs underwent an additional surgery for implant removal, joint lavage, or irrigation of the incision. Staphylococcus spp were the most common bacteria isolated from these infections, which is consistent with findings of other studies.2,13,31 Infection rates following other types of surgical procedures for CCL repair have been reported. Infection is associated with 1.3% of fibular head transposition procedures18 and 7.8% of intracapsular repairs in which a screw and spiked washer are used.31 Infection rates after TPLO are reportedly as high as 8.9%,14 although not all infections were confirmed via bacteriologic culture in the associated study. Infection develops after 3% of TPLO procedures when only dogs with positive results of bacteriologic culture are included.14 After tibial tuberosity advancement procedures, 2.6% of dogs develop infections.17 Although perioperative antimicrobial use did not influence the complication rate in the present study, most (95.3%) dogs received cefazolin during the surgical procedure.

Incisional complications developed after 8.8% of the LFS procedures. This finding is similar to that of other studies in which complications following other methods of CCL repair were investigated. For example, incisional complications reportedly develop after 3.6% to 15.1% of TPLO and 8.9% of tibial tuberosity advancement procedures.14–17 None of the dogs that underwent the LFS procedure and developed an incisional complication in our study had additional problems. Lack of an association between incisional complications and development of infection after CCL surgery has been reported14 and is supported by the results of the present study. Application of a bandage in the postoperative period did not appear to influence the rate of complications in our study, but bandages were applied to > 90% of dogs after surgery. Duration of postoperative bandaging varied from 24 hours to 2 weeks, depending on tolerance of the dog and bandage care by the owners. Many bandages were removed by owners or referring veterinarians, so an accurate determination of duration of bandaging was not possible for most dogs. Although a bandage may help prevent self-inflicted trauma to the incision, there were also 7 bandage-related complications.

The meniscus plays an important role in stabilization and function of the stifle joint. It aids in load transmission and energy absorption during weight bearing.34 Removal of menisci from clinically normal stifle joints results in increased load and wear of the articular cartilage and development of osteoarthritis.34 The medial meniscus also acts as a wedge between the femoral and tibial condyles, preventing additional cranial tibial translation in CCL-deficient stifle joints.35 Without the CCL, the medial meniscus becomes the primary restraint against cranial tibial thrust and is prone to injury.33

Meniscal injuries reportedly occur in approximately 50% of dogs with CCL rupture.36–39 Damage to the caudal horn of the medial meniscus occurred in 37.5% of dogs in the present study. Because most meniscal tears involve the thin inner portion of the meniscus, which is avascular and heals poorly, removal of the torn component is usually recommended.40 All dogs that had meniscal tears at the time of the first surgery had the torn component removed. The proportion of dogs with meniscal injury requiring a second surgery after LFS without meniscectomy or MMR is reportedly 13.8%.36 In the present study, dogs with intact menisci at the time of surgery had the meniscus left intact, or MMR was performed axially by severing the menisco-tibial ligament. Meniscal complications only occurred in dogs that had intact menisci at the original surgery and that did not have MMR performed. Seven meniscal tears occurred after surgery among the 46 dogs that did not undergo MMR.

Once MMR became a standard procedure during LFS surgeries at our hospital in mid 1998, postoperative meniscal tears ceased to occur, indicating that MMR may prevent future meniscal injury after LFS surgery. However, controversy exists regarding the use of MMR. Elimination of the wedge effect by displacing the caudal horn of the meniscus may not only prevent additional injury to the meniscus but also eliminate the stability function of the meniscus and is similar to caudal horn hemimeniscectomy.35 Additional research is necessary to determine whether MMR leads to poorer outcome because of subsequent development of severe osteoarthritis, although MMR had no effects on dog owner-assessed outcome after TPLO in another study.31

Implant complications such as suture reaction developed in 2.8% of dogs that underwent LFS surgery. This percentage is lower than that of another report.12 However, multifilament suture was the only implant material in the other study, and in the present study, the most commonly used type of implant was monofilament nylon leader line. All of the dogs that developed an inflammatory reaction to the suture material in the present study had nylon implants. Although the knot from hand ties may contribute to irritation of the soft tissue, there was no difference in the proportion of dogs

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that had suture reactions when crimps versus hand ties were used. The duration of follow-up in the present study (median, 30 weeks) was similar to that of other studies in which surgical complications after TPLO and tibial tuberosity advancement were evaluated. For TPLO, the range of follow-up in 1 study was 6 months to 4 years for 78% of the affected dogs, but the median duration of follow-up was not reported. In a different study, the longest duration of follow-up for 93% of dogs was 8 weeks, which may explain the lower reported complication rate. Following tibial tuberosity advancement, 92% of affected dogs had in-hospital evaluation 3 to 63 weeks (mean, 13.5 weeks) after surgery. Telephone follow-up with owners was performed for 90% of these dogs at 3 to 15 months (mean, 8.4 months) after surgery.

Several limitations of the present study need to be considered when interpreting the findings. Because this was a retrospective study, dogs were not randomly assigned to undergo the LFS procedure. Other procedures for CCL injuries were being performed at the teaching hospital during the study period. Choice of procedure may have been influenced by signalment of affected dogs and financial concerns of owners. Another potential limitation is that only dogs that returned for follow-up were included in the study. It is possible that there were complications that we were unaware of because some dogs may have been reevaluated by the referring veterinarians. It is also possible that the true complication rate was lower than was reported here because dogs that developed surgery-related problems may have been more likely to be returned for follow-up examination. Because of the large number of dogs included in the study and the long study period, contact of dog owners was not attempted.

Results of the present study indicated that the overall complication rate after LFS surgery was 17.4%, with additional surgery required in 7.2% of affected dogs. The overall complication rate was lower than that reported for other methods for surgical treatment of CCL rupture. Insufficient evidence is currently available to recommend any specific surgical procedure for CCL injury in dogs on the basis of clinical outcome; however, complication rate should be an important consideration when recommending a method of surgical repair for CCL ruptures in dogs. High body weight and young age are associated with a higher complication rate, and owners should be warned of this when options for management of CCL ruptures are discussed.

References

12. Dulsich M. Suture reaction following extra-articular stifle stabi-
13. Dulsich M. Suture reaction following extra-articular stabi-
Am J Vet Res—Immobilization of the tarsal joint did not eliminate strain during weight bearing in dogs. Decreased isometric muscle contraction during the swing phase of the gait could account for smaller minimum strain in immobilized joints. Continued muscle reaction forces were measured before and after immobilization. Peak vertical force; vertical impulse; and impulse-time; maximum, average, and minimum strain; and percentage strain were analyzed by repeated-measures ANOVA and paired t-tests. Results—Timing of strain data correlated closely with foot strike of the hind limb and EMG activity in all dogs. Maximum tendon strain was simultaneous with peak vertical force. Conclusions and Clinical Relevance—Immobilization of the tarsal joint did not eliminate calcaneal tendon strain during weight bearing in dogs. Decreased isometric muscle contraction during the swing phase of the gait could account for smaller minimum strain in immobilized joints. Immobilization is frequently applied after Achilles tendon rupture to alleviate strain and force on the sutured repair, with possible complications because of the immobilization method. Consideration of these findings could be important in adjusting current treatment recommendations. (Am J Vet Res 2009;70:134–140)