Effects of postoperative rehabilitation on limb function after cranial cruciate ligament repair in dogs

Gregory S. Marsolais, BS; Glenda Dvorak, DVM; Michael G. Conzemius, DVM, PhD, DACVS

Objective—To determine the effects of early postoperative rehabilitation on limb function in dogs after surgery for ruptured cranial cruciate ligament (RCCL).

Design—Prospective clinical study.

Animals—51 client-owned dogs.

Procedure—Dogs weighing between 20 and 40 kg (44 to 88 lb) that had RCCL and medial meniscal injury were studied. After removal of the RCCL and complete meniscectomy, the stifle joint was stabilized by use of a latero retinacular stabilization technique. Twenty-five dogs were included in a postoperative rehabilitation group, and 26 dogs were included in an exercise-restricted group. Limb function (peak vertical force [PVF] and vertical impulse [VI]) was determined before surgery and 6 months after surgery, using force platform gait analysis.

Results—Prior to surgery, mean PVF and VI in affected limbs were similar between groups. Six months after surgery, PVF and VI were significantly increased in dogs of both groups. However, PVF and VI in dogs in the rehabilitation group were significantly greater than those of dogs in the exercise-restricted group. At this time, differences in limb function (as measured by PVF and VI) between the repaired and normal limbs were not evident in dogs in the rehabilitation group. Conversely, limb function in the repaired limb of dogs in the exercise-restricted group was still significantly less than that of the normal limb.

Conclusion and Clinical Relevance—Dogs that have surgery for RCCL and a torn medial meniscus benefit from postoperative rehabilitation; rehabilitation should be considered part of the postoperative management of these patients. (J Am Vet Med Assoc 2002;220:1325–1330)

Rupture of the cranial cruciate ligament (RCCL) is a common cause of lameness and is also the most commonly diagnosed stifle injury in dogs. Nonsurgical management of dogs with a body weight greater than 15.9 kg (35 lb) provides a satisfactory outcome (lameness less than 1 d/wk) in < 20% of cases. Using variables such as orthopedic examination, client questionnaire, and force plate gait analysis, reports have documented success following surgical management of RCCL in dogs in 51 to 100% of cases. Although much attention has been given to the role of various surgical techniques for repair of RCCL, peer-reviewed literature addressing the role of postoperative management is scarce. Anecdotal reports suggest postoperative management should include application of a Robert Jones bandage for up to 14 days and activity restricted to a leash for up to 12 weeks. Most of this management is seemingly geared toward increasing the strength of periarticular fibrous tissue and mechanically protecting the repair technique.

It has been demonstrated that prolonged immobilization after joint surgery is closely associated with degenerative alterations in connective tissue, cartilage, ligaments, muscles, and bone-ligament complexes while allowing for hypertrophy of periarticular fibrous tissue. Studies in humans have revealed that restricted knee motion after anterior cruciate ligament (ACL) reconstruction in people contributes to joint pain, muscle atrophy, decreased joint mobility, increased arthrofibrosis, soft tissue weakness, and functional impairment. In dogs, loss of joint mobility and joint instability disrupt normal joint kinematics and can lead to osteoarthritis. Similarly, in humans, loss of mobility causes pain and effusion after prolonged weight bearing, crepitus during extension, altered gait, and decreased knee function and reduces the likelihood of return to complete function.

Alternatively, early motion and aggressive postoperative rehabilitation after ACL surgery in humans has been reported to improve prognosis. Early physical rehabilitation results in earlier and more complete return to function (often by 4 to 6 months after surgery), reduces the chances of reinjuring the joint, and does not increase intra-articular graft failure rates. In athletes recovering from ACL surgery, it has been reported that physical rehabilitation reduces pain, joint effusion, capsular contraction, and periarticular fibrosis while increasing range of motion, muscle mass, and limb strength. Finally, it has been suggested that early postoperative physical rehabilitation reduces the development of arthrofibrosis and osteoarthritis.

In animals, rehabilitation has been suggested to decrease muscle spasm, promote tissue healing and repair, increase range of motion, decrease edema, and increase muscle strength and endurance. Improved range of motion, cartilage nutrition, and orientation and strength of collagen fibers in the cranial cruciate ligament (CCL) of animals are additional beneficial effects of early motion following joint surgery. It has been suggested that low impact exercises, including swimming and walking, avoid worsening of osteoarthritis while maintaining muscle strength, joint mobility, and function. Finally, it has been reported that rehabilitation after joint surgery decreases adhesions, is valuable for maintenance of muscle mass, bone, cartilage, and ligaments, and provides the stress needed for reorganization of transplanted tissues.
The purpose of the study reported here was to determine the effects of early postoperative rehabilitation on limb function in dogs after surgery for repair of RCL.

Materials and Methods

Dogs—All adult dogs examined at the Iowa State University Veterinary Teaching Hospital (ISU VTH) between June 1999 and December 2000 were considered for inclusion in the study. Selection criteria included a body weight between 20 and 40 kg (+4 and 88 lb), unilateral RCL, complete tear of the CCL, presence of medial meniscal injury (intra-articular pathologic aberrations confirmed at surgery), and absence of other neurologic and orthopedic diseases. Additionally, all dogs were withheld from nonsteroidal anti-inflammatory medications for 7 days prior to enrollment in the study, and all owners signed an informed client consent form. Postoperative rehabilitation was offered to all owners at no additional cost. Dogs were then assigned to 1 of 2 treatment groups: postoperative rehabilitation or exercise restriction. In effect, dogs were not randomly assigned to treatment groups; they were assigned solely on the basis of their owner's decision to have the dog participate in postoperative rehabilitation. In addition, the investigators were not blinded to the treatment groups.

Data collection—Data were generated from the patient’s history (duration of lameness), signalment (body weight, breed, age, sex) and physical examination findings (body condition score). Force platform gait analysis was performed before surgery and 6 months after surgery in all dogs, using a floor-mounted force platform. The acquired data were sent through an amplifier to a computer. The first 5 valid trials for each set of limbs were used for data analyses. A valid trial consisted of a forelimb foot strike, with the complete foot striking the force platform and no other foot being on the platform at the same time, followed by an ipsilateral hind limb foot strike in the same fashion. All valid trials had a patient torso velocity of 1.1 to 1.3 m/s and acceleration of ± 0.5 m/s². Velocity and acceleration were measured by use of 3 photoelectric cells placed 1.0 m apart coupled with a triggered timer system. The middle cell was centered at the middle of the force platform. Visual observation was used to ensure that the animal was not distracted during the trial and that each footfall was near the center of the force platform. Peak vertical force (PVF) and vertical impulse (VI) were determined by use of software specific for force platform gait analysis in dogs.

The selected velocity of 1.1 to 1.3 m/s was a walking pace in all dogs. This velocity was selected because many lame dogs that would use the affected limb at a walk would carry the limb at a trot, thereby adding to trial variation. Given the degree of lameness in the dogs in this study, gait analysis at a walk was deemed most appropriate. Data collection was also attempted at 1 and 2 months after surgery. Lack of client compliance (not returning the dogs for the 1- and 2-month examinations) for dogs in the exercise-restricted group forced us to eliminate these examination times.

Surgical treatment—Treatment included surgical debridement of the RCLL, complete medial meniscectomy, and lateral retinacular imbrication stabilization by use of 2 sutures from the lateral fabella to the tibial tuberosity. The same surgeon (MGC) performed all surgeries. Postoperative care included administration of an analgesia (morphine, 0.5 mg/kg [0.23 mg/lb], IV, q 6 h for 24 hours) and a 2- to 3-day stay in the hospital with short leash walks twice daily. No additional analgesic or anti-inflammatory medications were offered on discharge.

Rehabilitation group—All dogs were discharged from the hospital 2 to 3 days after surgery without a bandage. Owners were instructed to rest the dog at home with activity limited primarily to short (0.3 miles) walks on a leash (for urination and defecation only) twice daily until suture removal. Then 12 days after surgery, dogs were returned to the ISU VTH for reexamination and suture removal. These reexamination appointments were scheduled on Monday mornings so that the dogs could begin rehabilitation in the beginning of the third week after surgery. Rehabilitation was performed twice each day during weeks 3, 5, and 7 after surgery. During weeks 4, 6, and 8 through 16 after surgery, owners were instructed to take the dogs on leash walks twice each day for a distance of up to but not greater than 1 mile. Owners were instructed to walk at a pace that encouraged use of their dogs’ affected limb and discontinue the walk if the dog would not voluntarily use the limb. At the conclusion of week 16, owners were instructed to allow their dogs to have unlimited exercise.

All rehabilitation sessions took place at the VTH canine rehabilitation facility. Sessions began with 10 minutes of limb massage and placement of the limb through a passive range of motion followed by 10 minutes of walking and 10 to 15 minutes of swimming. For each swimming set, each dog was fitted with a personal flotation device and walked into the pool. Swimming therapy began with alternating intervals of a 1-minute swim followed by 1 minute of rest for a total of 5 minutes of swimming. This regimen was repeated twice daily (AM and PM) so that each dog received at least 10 minutes of swimming daily. Depending on each dog’s physical condition, the duration of each swimming interval could be increased up to 2 minutes, thus doubling the total swimming time. Nearly all dogs swam vigorously (limbs continuously moving) from the time they were suspended (no limbs touching the floor or stairs); however, a few required the use of a ball to encourage their activity. Swimming was performed in a pool that was 7 ft wide, 14 ft long, and 4 ft deep. Temperature, total alkalinity, total bromine concentration, and pH were maintained in accordance to standards set by the National Swimming Pool Foundation of America. The water temperature was maintained between 90 and 92 °C, total alkalinity at 80 to 120 ppm (µg/ml), total bromine concentration at 3 to 5 ppm, and pH at 7.2 to 7.6. Dogs were housed in stainless steel cages in the rehabilitation facility for the duration of the weeks they were undergoing treatment and were fed their normal diets as instructed by their owners. Therapeutic walks were performed outdoors or on a treadmill. Each dog completed 30 rehabilitation sessions during weeks 3 through 7 after surgery.

Exercise-restricted group—All dogs were discharged 1 to 3 days after surgery without a bandage. Owners with dogs assigned to the treatment group received oral and written discharge instructions that included restricting their dogs at home with activity limited to twice daily short (0.3 miles) leash walks (for urination and defecation only) until 8 weeks after surgery. Suture removal was performed 10 to 14 days after surgery at the VTH or at the owner’s referring veterinarian. During weeks 8 through 16, owners were instructed to take the dogs on leash walks twice each day for a distance of up to but not greater than 1 mile. Owners were instructed to walk at a pace that encouraged their dog to voluntarily use the affected limb and discontinue the walk if the dog did not use the limb. At the conclusion of week 16, owners were instructed to allow the dog to have unlimited exercise.

Data analyses—All data are reported as mean ± SD and are expressed as a percentage of the dog’s body weight (% BW). Comparisons of vertical forces were determined between and within groups over time by use of a repeated-measures 1-way ANOVA. Values of P < 0.05 were considered significant.
Results
Twenty-five dogs were included in the postoperative rehabilitation group. Twenty-six dogs were included in the exercise-restricted group. Significant differences were not detected between groups regarding mean duration of injury, body weight, age, or body condition score. Mean body weight for dogs in the postoperative rehabilitation group was $37.66 \pm 0.62$ kg (82.8 \pm 1.36 lb), compared with $37.57 \pm 0.63$ kg (82.6 \pm 1.38 lb) for dogs in the exercise-restricted group. Mean age was $5.15 \pm 0.76$ years for dogs in the rehabilitation group and $5.33 \pm 0.30$ years for dogs in the exercise-restricted group. Mean body condition score on a 1 through 9 rating system (with 1 being gaunt and 9 being obese) was $6.54 \pm 0.19$ for dogs in the rehabilitation group and $6.50 \pm 0.22$ for dogs in the exercise-restricted group. Mean body condition score on a 1 through 9 rating system (with 1 being gaunt and 9 being obese) was $6.54 \pm 0.19$ for dogs in the rehabilitation group and $6.50 \pm 0.22$ for dogs in the exercise-restricted group.

Discussion
Results of our study indicated that a postoperative rehabilitation program will most likely result in improved limb function (as measured by gait analysis) in dogs after surgery for a RCCL, compared with exercise restriction. We are not suggesting that the rehabilitation protocol we describe (passive range of motion, walking, and swimming introduced 10 to 14 days after surgery) is necessarily the best protocol, but it seems a safe and reasonable starting point. In fact, we can identify several areas that might improve the program we used.

Postoperative rehabilitation performed incorrectly can be deleterious to the patient’s recovery. It has been reported that exercise strengthens and tones muscles, which ultimately aids in the stabilization of joints as long as the exercises do not repeatedly stress joints.\textsuperscript{36,49} Osteoarthritis, degeneration of articular cartilage and formation of new bone at joint surface margins, is a response to instability and repeated stresses.\textsuperscript{36,50,51} Much like the effects of arthrofibrosis, osteoarthritis leads to pain and discomfort, limited ability to perform, restricted activity, and a decreased quality of life.\textsuperscript{36} Obesity and repetitive impact stresses of joints are risk factors associated with increased occurrence of osteoarthritis and should be taken into account when designing a patient-specific rehabilitation program.\textsuperscript{36} When initiating a rehabilitation program for a patient with disease muscle atrophy or obesity, activities that...
parallel the degree of atrophy and the patient’s body condition should be considered. Most of the dogs in our study had obvious disease muscle atrophy (duration of injury almost 6 weeks in dogs in both groups) and were overweight (increased body condition score).

We elected to focus on swimming in our postoperative rehabilitation program to avoid repeated high impact loads on diseased joints, especially in dogs that were overweight. Perhaps the greatest benefit of aquatic rehabilitation originates from the principle of buoyancy, which decreases the effects of gravity.52 On land, joint reactive forces can reach several times body weight. In water, the effects of gravity and axial loading can be substantially diminished or be entirely eliminated if the patient floats.53 Additional benefits of water include the effects of hydrostatic pressure and specific heat.53 It has been suggested that hydrostatic pressure can reduce joint edema, and warm pools can promote relaxation of the patient, increase blood flow to the muscles, and decrease pain.32,54,55

Performing a study evaluating limb function in dogs with naturally occurring RCCL is problematic because of the inherent number of variables that must be controlled for. In this study, we controlled for other orthopedic or neurologic diseases, body weight, presence of meniscal injury, surgical technique, surgeon, and postoperative management. Severity of preoperative osteoarthritis is an example of an important variable that we did not control for or measure during this study. We limited data collection to gait analysis because investigators were not blinded to the dogs’ treatment group and because of the subjective nature of other variables such as an owner questionnaire, pain-free range of motion, amount of cranial drawer, and thigh circumference. Dogs in this trial were not randomized. Although each owner was offered rehabilitation at no additional cost, many were reluctant because of the distance of travel required from their homes. Monetary compensation may have alleviated these problems. A few owners were unwilling as this was considered new and aggressive therapy. Client compliance issues also arose as we had initially scheduled the collection of force platform data at 1 and 2 months after surgery. Because all dogs in the rehabilitation group were present at the hospital, their data were readily collected. Owners of dogs in the exercise-restricted group, however, were reluctant to return except for the 6-month checkup. Although this data would have been beneficial, we do not feel that its absence detracts from our findings. The effectiveness of postoperative rehabilitation, although initiated in the perioperative period, must have a long-term beneficial effect for it to be more uniformly considered as part of regular treatment regimen for a RCCL in dogs. Although owners were sent home with oral and written discharge instructions, we acknowledge that we could not control treatment once the patient was discharged. A log of the dogs’ activities at home (distance walked daily, number of times the dog limped or carried the limb, medications given) may have been helpful.

In this study we performed gait analysis with the dogs at a walk. It is possible that gait analysis at a trot, a more rigorous gait, would have provided different results. As stated, we performed gait analysis at a walk because many dogs that would use the limb at a walk would be non-weight-bearing at a trot. This was especially true in dogs prior to surgery, an important data point.

Budsberg et al previously reported on 9 dogs with unilateral RCCL that received similar surgical treatment and had a postoperative protocol that included bandaging for 2 weeks and exercise restriction for an additional 6 weeks. They found that at reexamination (7 to 10 months after surgery) PVF of the operated limb had returned to normal. Although our findings suggest that dogs with this type of postoperative treatment on average do not return to normal function, it is difficult to directly compare findings. First, we are uncertain of velocity of gait analysis in the previous report. Second, all dogs in this study had a meniscal injury and complete meniscectomy; this was not uniform in the previous report. Third, our reexamination time period was earlier (6 months) and relatively narrow. It is possible that dogs in the exercise-restricted group would have continued to improve, perhaps all the way to normal. Finally, of the 26 dogs in the exercise restriction group in this study, certainly some had normal PVF at 6 months; thus, although it is possible for dogs to reach normal limb function (as measured by gait analysis), it does not typically occur in that time frame.

We believe the effect of postoperative rehabilitation observed in this study was clinically significant. If measured differences were limited to a few percent, then additional rehabilitation might not be warranted. This, however, was not what we found. Dogs in the rehabilitation group had a PVF that was 18.5% greater than dogs in the exercise-restricted group 6 months after surgery. Similarly, VI was 13.9% greater in the rehabilitation group. The most encouraging finding, however, was that dogs in the rehabilitation treatment group had mean PFV and VI that were statistically identical to that of the contralateral normal limb.

Dynamic stability (strength, endurance, appropriate recruitment of muscle fibers, and timing) is essential for normal joint function. Rehabilitation programs should strive to increase dynamic stability, aim for early return to function, and increase quality of life of the patient. These allow for the return to normal activities without episodes of instability. Additional goals should include progressive weight loss in overweight patients and maintenance of joint mobility while trying to minimize the risk of reinjury. In this study, we demonstrated that dogs that received postoperative rehabilitation following surgery for a RCCL had improved limb function 6 months after surgery. Although we elected to focus our rehabilitation program on swimming, we are not suggesting that this regimen is the only one that could be successful. Likewise, we elected to provide all dogs with the same rehabilitation program, but we are not suggesting that all dogs should necessarily receive the same program; rather, programs should be tailored to each patient. However, we are suggesting that the typical dog that has surgery for RCCL benefits from postoperative rehabilitation and that it should be considered as part of the standard care provided to these patients.
References


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