

Stifle Injuries in the Canine

Jadid Johnson, BS*
Robert Radasch, DVM**

Introduction

Stifle injuries are the most common cause for rear limb lameness in the adult dog. The recognition and treatment of these injuries is an important part of any small animal practice. This article will discuss the diagnosis and various methods for repair of stifle disorders.

Cruciate ligament injuries are the most common lesion in the stifle joint of the dog. Although the cranial cruciate ligament is most often injured, rupture of either the cranial or caudal cruciate results in instability and predisposes the joint to degenerative changes.¹ Meniscal injury usually occurs with partial or complete tearing of the cranial or caudal cruciates.² Injuries to the collateral ligaments of the stifle are not common. The most common injury involves the medial collateral ligament and is usually seen in conjunction with cranial cruciate ligament rupture and damaged medial meniscus. This trilogy of knee injuries is called the "unhappy triad".³ When both collateral ligaments are ruptured, both cruciates are ruptured also and the diagnosis is one of a "total knee".³ Traumatic patellar luxation is a relatively rare injury and is almost always a medial luxation.¹ Patellar fractures and patellar ligament ruptures are also rarely encountered in the dog.¹

Diagnosis

Veterinarians often encounter patients with a history of lameness or pain of unknown origin. In a hospital environment, excitement and apprehension often seem to cause a chronic lameness to disappear or painful maneuvers to go unnoticed. History, observation, palpation and proper radiography are all important in assessing the patient.

One of the first tasks is to walk and trot the animal observing any gait abnormalities. If lameness is not apparent, having the animal gait in tight circles may elucidate abnormalities. After gait

observation, palpation of the affected stifle may begin. The joint is gently flexed and extended several times with the palm of one hand over the cranial aspect of the joint to detect crepitation, grating, clicking, or snapping. The areas lateral to the trochlear ridges are palpated for smoothness or roughness. If the condyles appear thick or rough, this may indicate the presence of osteophytes.⁴

Cruciate Ligament Abnormalities

Drawer movement, defined as craniocaudal instability of the stifle, is indicative of cruciate ligament abnormalities. Except in young puppies, there is no drawer movement in normal dogs. Even the slightest amount indicates some form of pathology exists.⁴ To palpate for drawer movement, the examiner stands caudal to the animal which is positioned in lateral recumbency with the stifle opposite the one to be palpated closest to the table. The index finger of one hand is placed on the proximal end of the patella while the thumb is placed over the lateral fabellar region. The index finger of the other hand is placed on the tibial crest and the thumb is positioned caudal to the fibular head. The leg is flexed slightly and the femur held steady while the tibia is pushed cranially and caudally. Drawer motion should be tested in both extension and flexion. Caudal drawer movement is often difficult to distinguish from cranial drawer. However, a sudden cessation of cranial drawer movement occurs when an intact cranial cruciate becomes taut. With cranial cruciate rupture, the cessation is not abrupt.⁴

Meniscal Injury

Meniscal injuries are best diagnosed by direct inspection of the joint. However, a pathologic meniscus may be suspected if a meniscal click is palpated or heard during flexion or extension and drawer manipulations of the stifle.⁵

Collateral Ligament Instability

To test for collateral ligament insufficiency, the

The Veterinary Student

*Dr. Johnson is a 1987 graduate of the College of Veterinary Medicine at Iowa State University.

**Dr. Radasch is an adjunct instructor in the Department of Veterinary Clinical Sciences at Iowa State University.

limb is held in extension and varus and valgus stresses are applied to the joint. In the case of medial collateral ligament rupture, the medial aspect of the joint will open when a valgus stress is applied. With lateral collateral ligament rupture, the lateral aspect of the joint will open when a varus stress is applied.³

The Cruciate Ligaments

As stated previously, cruciate ligament injuries are the most common lesion in the stifle joint of the dog. The cruciate ligaments play an important role in maintaining the stability of the stifle through the functional range of motion. Rupture of one or both cruciates results in severe instability and predisposes the joint to degenerative changes. The cruciate ligaments are dynamic structures and their anatomy and spatial relationship are directly related to their function as constraints of joint motion.¹

In order to understand the mechanism of injury and rationale behind repair techniques, it is necessary to understand their anatomy and function in relation to joint motion.

Anatomy and Function

The cranial cruciate ligament is attached to a fossa on the posterior aspect of the medial side of the lateral femoral condyle. It courses cranially, medially and distally across the intercondylar fossa and attaches to the cranial intercondyloid area of the tibia. The caudal cruciate ligament is attached to a fossa on the ventral aspect of the lateral side of the medial femoral condyle. It passes caudodistally to the medial aspect of the popliteal notch of the tibia. The caudal cruciate ligament lies medial to and crosses the cranial cruciate ligament. During flexion, the ligaments twist on each other.

As the stifle is flexed, the femoral and fibular attachments of the lateral collateral ligaments move closer together and the ligament begins to relax. This allows posterior displacement of the lateral femoral condyle on the tibial plateau and results in internal rotation of the tibia on the femur.¹ Conversely, as the knee is extended the lateral collateral ligament tightens and the lateral femoral condyle moves anteriorly causing external rotation of the tibia.¹ The twisting of the cruciate ligaments during flexion limits the amount of internal rotation of the tibia. If either cruciate ligament ruptures, there will be an abnormal increase in the amount of internal rotation.

The primary function of the cruciate ligaments is to maintain anteroposterior stability of the stifle. The cranial cruciate ligament limits forward displacement of the tibia on the femur (anterior drawer) while the caudal cruciate ligament limits

posterior displacement of the tibia on the femur (posterior drawer).

In general, the bulk of the cranial cruciate ligament is tight in extension and loose in flexion, while the bulk of the caudal cruciate is loose in extension and tight in flexion.⁶ Because the cranial cruciate ligament is tight in extension it is the primary check against hyperextension of the stifle.

Mechanism Of Injury

As mentioned, the cranial cruciate ligament prevents anterior displacement of the tibia on the femur, limits internal rotation of the tibia on the femur, and prevents hyperextension of the stifle. The most common mechanism of injury of the cranial cruciate ligament is sudden rotation of the stifle with the joint in 20 to 50 degrees of flexion.¹

As the cranial cruciate ligament tries to limit internal rotation of the tibia, it becomes wound excessively tight and is subject to trauma from the lateral femoral condyle. Clinically, this injury occurs when an animal makes a sudden turn on the weight-bearing rear limb.

With hyperextension of the stifle, the cranial cruciate ligament is the first structure subject to injury. This type of injury occurs when an animal steps into a hole while running. Extreme hyperextension of the stifle damages the caudal cruciate only secondary to rupture of the cranial cruciate ligament.

Rupture of the caudal cruciate ligament alone is rare and is usually associated with severe trauma or dislocation of the stifle.¹ Direct trauma of the tibia in an anteroposterior direction may cause the caudal cruciate ligament to rupture. Also, persistent stifle instability due to other ligament damage may lead to rupture of the caudal cruciate ligament.

Cruciate Ligament Repair

It has been established that rupture of either cruciate ligament results in joint instability which leads to progressive degenerative changes within the joint. It is for this reason that cruciate ligament injuries should be repaired. Through the years there have been many developments in the surgical repair of the cruciate ligaments. Although there are many repair techniques currently in use, the method chosen depends on surgeon preference and technical ability. Surgical techniques can be divided into two basic categories; intraarticular and extraarticular procedures. Intraarticular techniques utilize either autogenous or synthetic graft material to replace the cruciate ligament. Extraarticular techniques stabilize the joint by tightening extraarticular structures. Regardless of the method chosen, the joint should

be opened so that the torn ends of the ligament can be removed and the menisci examined. In all methods of repair, the limb is post operatively placed in a modified Robert-Jones bandage and protected from stress for two weeks.

Extraarticular Repairs

Although there are many techniques for extra-articular repair, the basic principle is the same. The lateral joint tissues are tightened in an antero-posterior direction in order to eliminate drawer movement. This is usually accomplished by placing imbrication sutures on the lateral aspect of the joint which also decreases the tendency for internal rotation of the tibia.

Capsular Imbrication

This technique, developed in 1966 by Childers uses multiple Lembert sutures placed 5 mm apart in the lateral joint capsule. The sutures are tightened with the limb in extension which creates a longitudinal fold in the lateral parapatellar area. If anterior drawer is still present an additional layer of Lambert sutures is placed over the original one. This procedure tightens the joint capsule in an anteroposterior direction to eliminate drawer and internal rotation of the tibia. This technique is reported to work well in cats and smaller dogs.

Lateral Suture Technique⁸

This procedure utilizes a standard lateral approach to the stifle. An arthrotomy is performed to remove the torn cruciate ligament and inspect the menisci. Following closure of the arthrotomy, a single mattress suture of heavy (0, #1, or #2) nonabsorbable suture material is placed on the lateral aspect of the joint. The suture material is passed around the lateral fabella and then through and back through the patellar ligament just proximal to its insertion on the tibial tuberosity. The leg is placed in a functional position and the suture tightened. If drawer movement is still present after placement of the first suture, additional sutures may be placed parallel and as close as possible to the first suture. If the patellar ligament is damaged and won't support the imbrication suture, a drill hole can be placed in the tibial crest and the suture passed through it.

Modification of the Lateral Retinacular Imbrication⁹

A modification of the lateral retinacular imbrication technique involves the use of a single imbrication suture placed on the medial as well as lateral aspect of the joint. In this technique, each

suture is pre-placed around the fabella and through a hole in the tibial crest. The lateral suture is tightened first to externally rotate the tibia to limit internal rotation. The medial suture is then tightened. Together, the two sutures act as a sling to prevent anterior drawer motion.

Posterior Capsulorrhaphy¹

The posterior capsulorrhaphy technique provides both medial and lateral support to the stifle. Following a medial arthrotomy, the joint is explored and the capsule closed routinely. The posterior sartorius muscle is transected at its insertion and advanced to the proximal aspect of the patellar tendon where it is sutured with absorbable suture material. The lateral aspect of the joint is then approached and the joint capsule identified. A small incision is made in the posterolateral joint capsule parallel to the joint line. This incision is closed with two imbrication mattress sutures. Next the biceps tendon and fascia lata are plicated over the patellar tendon with interrupted sutures that are tied while the joint is in extension. Thus, the posterolateral joint capsule is tightened to limit rotational instability. Anteroposterior instability is checked by the medial and lateral muscle advancements.

Fibular Head Transposition¹⁰

This technique involves moving the fibular head into a cranial position which alters the orientation of the lateral collateral ligament to prevent cranial drawer and minimize internal rotation of the tibia. A lateral arthrotomy is used to inspect the joint for pathology and remove the torn ends of the cranial cruciate ligament. Following closure of the joint capsule, the lateral retinaculum is separated from the joint capsule and retracted caudally to expose the attachment of the cranial tibial muscle to the tibia and fibula. A small incision is made in the connective tissue between the peroneus longus muscle and the cranial tibial muscle. The muscle bellies are separated by blunt dissection. Anteriorly, the cranial tibial muscle and long digital extensor tendon are bluntly elevated from the tibia using a periosteal elevator. Posteriorly, the peroneus longus muscle is incised at its attachment to the tibia, leaving its attachment to the fibula intact. The fibular head and attached lateral collateral ligament are palpated. A scalpel is used to incise the cranial and caudal fibular ligaments completely freeing the fibula from the tibia.

Two holes are drilled in the tibial crest cranial to the fibular head. A loop of 18 gauge orthopedic wire is passed through the holes such that the ends

of the wire emerge laterally from beneath the cranio-lateral tibial musculature. A Steinmann pin is directed through the caudal half of the fibular head and the fibula transposed cranially with the tibia in full external rotation. With the stifle in a neutral position the pin is seated into the tibia. The wire is looped around the pin in a figure 8 and tightened sufficiently to eliminate cranial drawer and minimize internal tibial rotation. The lateral retinaculum is closed using a vertical vest-over-pants imbrication. This technique is reported to give performance equal or superior to other techniques for reconstructing the cruciate deficient stifle.¹⁰

In all instances, extraarticular procedures treat the instability resulting from cranial cruciate ligament rupture by tightening extraarticular tissues. Tightening of the extraarticular tissues places additional constraints on normal joint motion. It is thought that while these constraints are well tolerated by smaller dogs (<30 lbs), the larger dogs generate sufficient force to overcome these constraints.¹ This may explain the inconsistent results observed in larger breed dogs in which extraarticular techniques have been used.¹

Intraarticular Repairs

Intraarticular techniques for cranial cruciate ligament repair involve the recreation of an intraarticular structure in the approximate orientation of the normal cranial cruciate ligament. Current intraarticular techniques use fascia lata or patellar tendon grafts. Other materials have been used with less success.

The Four-in-One Over-the-Top Technique¹¹

This technique is similar to the Over-the-Top procedure developed by Arnoczky, however, it has been modified to be technically easier.

A medial arthrotomy is performed to remove ligament fragments and inspect the menisci. A 1 to 1.5 cm graft of the fascia lata is isolated from the lateral aspect of the joint and remains attached at the junction of the patellar ligament with the tibial tubercle. The strip is fashioned by incising the fascia lata just lateral to the patellar ligament from the tibial tubercle extending proximally, a few millimeters lateral to the patella. The caudal edge of the strip is formed by incising 1 to 1.5 cm caudal and parallel to the first incision. Both incisions are continued proximally using scissors such that the length of the graft is 2½ to 3 times the distance from the tibial tubercle to the midpatella. Proximally the caudal cut follows the cranial border of the biceps femoris muscle while the cranial cut is parallel to the caudal cut. The proximal end of the

graft is cut transversely and the graft dissected free from underlying tissues. It remains attached distally.

A 5/32 to 3/16 inch hole is drilled transversely through the tibial tubercle near the tibial plateau. The proximal end of the fascial strip is passed through the hole so that the graft is transferred to the medial side of the tibia. The graft is pulled into the medial arthrotomy through the fat pad into the joint.

Lateral to the joint, the biceps is retracted to expose the lateral fabella. A curved hemostat is inserted into the femoral-fabellar ligament, pushed forward through the caudal joint capsule into the intercondylar space. The tips of the hemostat are manipulated lateral to the caudal cruciate ligament then cranially so they can be seen in the joint. The graft is grasped by the hemostat and pulled caudally through the joint and over-the-top of the lateral femoral condyle. With the leg in a functional position, traction is applied to the graft to eliminate drawer movement. Once drawer is eliminated, the graft is sutured to the tissues over the lateral femoral condyle.

The medial arthrotomy is now ready to be closed. The insertion of the caudal belly of the sartorius is partially detached from the tibia and sutured to the patellar ligament along with the joint capsule and medial fascia as far proximally as the patella. From this point proximally, the sartorius is not included in the rest of the medial closure.

The lateral fascial incision is then closed. Because a strip of fascia was removed, the biceps femoris is slightly advanced and the lateral retinaculum tightened. A suture of size 2 to 4 absorbable material is placed from the lateral fabella to the distal patellar ligament. It is tied tightly to eliminate any remaining drawer. This suture protects the graft for a few weeks. The rest of the closure is routine.

Four procedures have been performed to stabilize the joint. Advancement of the caudal sartorius and biceps muscles to create caudal traction on the tibia; fabellar-patellar ligament suture to temporarily prevent anterior drawer motion; and fascia lata graft to replace the cruciate ligament.

Over-the-Top Technique¹¹

This technique developed by Arnoczky is identical to the previous one except for the preparation of the graft. It can also be modified to include advancement of the caudal sartorius and biceps muscles, and the placement of a fabellar to patellar ligament suture.

The graft is prepared by incising the patellar ligament longitudinally at the junction of the middle and medial thirds of its width from the tibial

tubercle to the patella. The incision is extended proximally over the patella where it is directed proximal-laterally into the fascia lata. The incision proximal to the patella should be 1 to 1½ times the distance from the patella to the tibial tuberosity. An incision parallel to the first is then made starting at the medial border of the patellar ligament and extending proximally. The proximal end of the graft is cut transversely, then dissected free from the deeper tissues distally to the patella. An osteotome or saw is used to remove an anteromedial wedge of the patella with the attached graft. The rest of the procedure is the same as the previous one.

Both of the "over-the-top" techniques result in a graft which almost perfectly mimics the normal ligament. The fascial strip becomes vascularized, then undergoes fibroplasia and reorganization of collagen to resemble a normal ligament.¹¹ This process takes five to six months, thus the graft is at some risk during this time. The leg should be placed in a modified Robert-Jones bandage for two weeks post-operatively. Activity should be restricted to leash exercise early, then may be gradually increased toward the end of the healing period.

Rupture Of The Caudal Cruciate Ligament

As discussed previously, isolated rupture of the caudal cruciate ligament is rare. Most cases are due to severe trauma and accompanied by rupture of the cranial cruciate and medial collateral ligaments. In this situation, medial meniscal injuries are common. Although it has been suggested that the caudal cruciate is not functionally significant, repairs should be attempted because experimental severing of the ligament leads to degenerative joint disease.¹¹ The use of extraarticular imbrication has proven effective in smaller dogs and cats.¹ No really satisfactory technique exists for large, active dogs.

A medial or lateral arthrotomy is combined with an approach to the medial and lateral caudal compartments of the stifle.¹¹ Fragments of ligament are excised and a meniscectomy performed when indicated. The joint capsule is sutured and collateral ligament repairs made if needed. Nonabsorbable imbrication sutures are placed in the caudomedial and caudolateral aspects of the joint capsule in a vertical fashion.¹¹ A mattress suture of size 0-4 nonabsorbable material is placed in the medial half of the proximal patellar ligament and directed caudodistally where it is passed around the head of the fibula.¹¹ A mattress suture is also placed from the lateral half of the proximal patellar ligament to a hole drilled through the caudomedial corner of the tibia.¹¹ These mattress sutures are tied tightly enough to eliminate drawer motion with the

stifle positioned at the standing angle. Routine closure is performed and exercise severely restricted for three weeks, then gradually increased.

The Menisci

While primary injury to the menisci is rare, meniscal injuries secondary to cruciate or collateral ligament rupture are common.³ The most frequent injury involves the medial meniscus, cranial cruciate ligament and/or the medial collateral ligament. Meniscal damage may be acute or degenerative and usually involves the posterior and medial portions of the medial meniscus.³

Anatomy And Function

The menisci are two semilunar fibrocartilaginous discs that are interposed between the tibial plateau and the femoral condyles. Both menisci are attached to the tibia by cranial and caudal ligaments. The lateral meniscus is also attached to the caudal surface of the femur. The medial meniscus appears to be more immobile due to an attachment to the medial collateral ligament. The inner or axial portion of the menisci are essentially avascular with only the abaxial border being vascular and therefore, capable of a healing response. Meniscal functions include protecting articular surfaces, relieving the incongruity between the femur and tibia by acting as elastic and moveable washers, and aid in lubrication of the joint.³

Mechanism Of Injury

Meniscal injury is usually secondary to cranial cruciate ligament rupture and only rarely diagnosed as an isolated tear. Meniscal injury has been reported in up to 73% of stifles operated for repair of cranial cruciate ligament rupture.⁵ The instability associated with rupture of the cranial cruciate ligament results in abnormal compressive, shearing, and rotational forces on the meniscus. The medial meniscus is relatively immobile, and the caudal body becomes wedged between the femoral condyle and tibial plateau resulting in either a longitudinal or bucket-handle tear through the caudal body.⁵ Transverse meniscal tear may occur secondary to abnormal rotational forces due to cranial cruciate ligament injury.⁵ Other types of meniscal tears have been categorized and reported, however, they are less common. The lateral meniscus is only rarely injured because it is more mobile than the medial meniscus. It therefore does not easily become trapped between the femoral condyle and tibial plateau.

As mentioned earlier, tentative diagnosis of meniscal injury may be made based on preopera-

tive examination and the presence of a "meniscal click". Positive diagnosis of meniscal injury is usually made following arthrotomy and exploration of the joint.

Treatment

There is a great deal of controversy concerning the treatment of injured menisci. It has been demonstrated that tears of the periphery of the meniscus, or tears extending to the periphery will heal.⁵ However, tears that are limited to the cartilage will not heal due to the avascular nature of the cartilage.

Surgical treatment of meniscal tears consist of either a partial or total meniscectomy. Following arthrotomy and inspection of the menisci, the entire meniscus can be removed by severing the cranial tibial ligament, retracting the meniscus, and separating the meniscus from the joint capsule and medial collateral ligament. Finally, the caudal tibial ligament is carefully severed.⁵ The advantages of total meniscectomy include clinical improvement, the potential for regeneration of replacement tissue, and the fact that no tears of the menisci are inadvertently left behind. The disadvantages appear to be the potential for degenerative joint disease which has been a sequella to total meniscectomy.⁵

Partial meniscectomy is the removal of the damaged portion of a meniscus. The procedure will vary depending on the location of the injury. The advantage of partial meniscectomy is that normal meniscal tissue is left in place to protect the articular cartilage. Partial meniscectomy has been shown to produce less degenerative articular cartilage changes than does total meniscectomy.⁵ Disadvantages include the possibility of missing pathology of the meniscus, iatrogenic laceration of the meniscus, and the absence of any regenerative changes.³

The Collateral Ligaments

Damage to the collateral ligaments of the canine stifle occur infrequently. The most common injury involves the medial collateral ligament and is seen in conjunction with cranial cruciate ligament rupture and damaged medial meniscus.

Anatomy and Function

The collateral ligaments are essential to normal joint function. They restrain the joint to help prevent excessive movement when varus, valgus and rotational stresses are applied.³

The medial collateral ligament extends from the medial epicondyle of the femur to the medial border of the tibia. It remains taut throughout the range of motion but is most taut in extension.³ The

medial collateral ligament is the prime stabilizer of the medial aspect of the joint. It acts with the cranial cruciate ligament and joint capsule to neutralize valgus (lateral) angulation of the tibia.³

The lateral collateral ligament extends from the lateral femoral epicondyle to the head of the fibula. It is taut in extension but relaxes during flexion to allow internal rotation of the tibia.³ The lateral collateral ligament along with the popliteal tendon, cruciate ligaments, and joint capsule, serve to limit varus (medial) angulation of the tibia.³ Because there is more support to the lateral aspect of the joint, rupture of the lateral collateral ligament is less common than rupture of the medial collateral ligament.

Mechanism Of Injury

The collateral ligaments are strong and require tremendous force to rupture. The medial collateral ligament is usually ruptured with a severe valgus stress or external rotation of the tibia.³ The cruciate ligaments and menisci are usually also damaged with this type of force.

In young animals, avulsion fracture of the ligamentous attachments are more common than rupture of the ligament, since the ligament is stronger than its bony attachment.³ In older animals the forces may also damage bony components of the joint. Thus, with collateral ligament injuries, radiographs are necessary to rule out bony pathology.

Treatment

Complete rupture of the collateral ligaments should be repaired surgically. Although partial tears will heal with rest and immobilization, complete tears rarely heal sufficiently to provide normal function.³ Repair is directed at restoring normal function of the ligament by primary repair or prosthetic replacement.

Avulsion of the collateral ligament from its attachment is best treated by reattachment of the avulsed portion. In the case of a bony avulsion, a small lag screw or Kirshner wires are used to reattach the bone fragment.³ If no bone is avulsed with the ligament, the ligament can be reattached by using a screw with a spiked washer.³ The washer allows for a firm grip on the ligament as it is compressed against the bone.

Ruptures of the midportion of a collateral ligament can be sutured using a Bunnell or mattress suture pattern of stainless steel or nylon.³ Following this, bone screws are placed at the exact femoral or tibial origin of the ligament and a figure eight pattern of orthopedic wire or Teflon-coated dacron

is passed around the screws and tied tight with the limb in a functional position.³ With lateral collateral ligament rupture, the figure 8 is passed around a femoral screw and through a drill hole in the fibular head. It is important that the suture material is not overtightened as this may eliminate nearly all motion in the stifle.¹¹

If primary repair of the collateral ligament is not feasible, prosthetic reconstruction in the above manner is indicated. While this will not last for a great length of time, it will provide stability until scar tissue can form and provide some support to the joint.³

In all cases of reconstruction, the limb is immobilized in a Thomas splint or modified Robert-Jones bandage for at least three weeks, followed by a gradual return to full exercise.

REFERENCES

1. Arnoczky SP: Surgery of the Stifle — The Cruciate Ligaments (Part I). *Compendium on Continuing Education* 1980; 2:106-115.
2. Flo GL, DeYound DJ, Tvedten H, Johnson L: Classification of Meniscal Injuries in the Canine Stifle Based Upon Gross Pathological Appearance. *J Am Anim Hosp Assoc* 1983; 19:325-334.
3. Arnoczky SP, Tarvin GB, Vasseur P: Surgery of the Stifle — The Menisci and Collateral Ligaments (Part III). *Compendium on Continuing Education* 1980; 8:394-399.
4. Brinkner WO, Piermattei DL, Flo GL: Physical Exam for Lameness. In: *Small Animal Orthopedics and Fracture Treatment*. Philadelphia: WB Saunders Co. 1983; 212-218.
5. Hulse DA, Shires PK: The Meniscus: Anatomy, Function, and Treatment. *Compendium on Continuing Education* 1983; 9:765-774.
6. Arnoczky SP, Marshall JL: The Cruciate Ligaments of the Canine Stifle: An anatomical and Functional Analysis. *Am J. Vet Res* 1977; 11:1807-1814.
7. Knecht CD: Evolution of Surgical Techniques for Cruciate Ligament Rupture in Animals. *J Am Animal Hosp Assoc* 1976; 12:717-724.
8. Gambardella PC, Wallace LJ, Cassidy F: Lateral Suture Technique for Management of Anterior Cruciate Ligament Rupture in Dogs. A Retrospective Study. *J Am Anim Hosp Assoc* 1981; 17:33-38.
9. Flo GL: Modification of the Lateral Retinacular Imbrication Technique for Stabilizing Cruciate Ligament Injuries. *J Am Anim Hosp Assoc* 1975; 11:570-576.
10. Smith GK, Torg JS: Fibular Head Transposition for Repair of Cruciate-Deficient Stifle in the Dog. *J Am Vet Med Assoc* 1985; 187:375-383.
11. Brinkner WO, Piermattei DL, Flo GL: Diagnosis and Treatment of Orthopedic Conditions of the Hind Limb. In: *Small Animal Orthopedics and Fracture Treatment*. Philadelphia: WB Saunders Co, 1983;306-325.



Scott Solberg