WHAT’S NEW IN CRANIAL CRUCIATE LIGAMENT REPAIR

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Surgical repair of all dogs having a cruciate-deficient stifle is recommended unless predisposing medical conditions contradict anesthesia or surgery. Surgical repair of the cranial cruciate-deficient stifle may take many forms. The technique selected is often based on the age and weight of the patient, duration of injury and surgeon’s preference. Factors to consider when deciding on a type of repair include signalment, intended use of the pet, duration of injury, type of injury (partial or complete tear), amount of instability, concomitant meniscal injury, patient morbidity and postoperative management.

CRANIAL CRUCIATE LIGAMENT ANATOMY AND FUNCTION

The cranial cruciate ligament (CCL) is composed of two distinct bands, the craniomedial and caudolateral bands. The ligament arises from the caudomedial aspect of the lateral femoral condyle. The ligament courses through the intercondylar fossa in a craniomedial direction to insert on the cranial intercondylar area of the tibial plateau. The CCL is primarily responsible for prevention of cranial translation (cranial drawer) of the tibia in relationship to the femur. It also acts to limit internal rotation and hyperextension. The craniomedial band is tight in flexion and extension. The caudolateral band is tight in extension, but loose in flexion.

DIAGNOSIS OF CRANIAL CRUCIATE LIGAMENT TEARS

Dogs often present with an acute non-weightbearing lameness, but many dogs will have a history of intermittent weightbearing lameness, particularly with partial CCL tears. Palpation of the stifle commonly reveals pain and swelling. As the condition becomes more chronic, a firm swelling (medial buttress) can be palpated on the medial aspect of the stifle. Pain is often present upon extension of the stifle. Affected dogs will usually have an abnormal sitting posture. The “sit-test”, described by Slocum, suggests the presence of a CCL tear if the dog sits with the affected leg held out to the side. (Figures 1,2) Dogs with CCL injury do not like to fully flex their stifles, thus sit abnormally in order to avoid full stifle flexion.

Demonstration of stifle instability can be done using the cranial drawer test or the tibial compression test. The cranial drawer test is performed by placing the index finger on the patella and the thumb of the same hand on the lateral fabella. (Figure 3) The index finger of the opposite hand is placed on the tibial tuberosity, while the thumb is placed on the head of the fibula. The tibia is pushed cranially (cranial translation) while holding the femur stationary. A positive test is associated with cranial movement of the tibia, which is diagnostic for a CCL tear. Clinically, it is important to assess cranial drawer while positioning the stifle in a flexed and extended position; partial CCL tears most commonly involve the craniomedial band and will have cranial drawer in flexion only. The tibial compression test is performed in a standing or lateral position. (Figure 4) When examining the right leg, the right hand is cupped over the patella with the index finger resting on the tibial tuberosity. The left hand is used to grasp the metatarsal area. The stifle is held in mild flexion (approximately 120-150 degrees) while the tarsus is actively flexed. Dogs having a CCL tear will have cranial translation of the tibia. This can be seen as a forward displacement of the tibial tuberosity or a cranial movement of the index finger of the right hand. This test is usually less painful and suitable for the non-sedated patient.

Figure 1 - dogs with a normal CCL sit square with the tarsus directly below their ischium.

Figure 2 - dogs having a tear of the CCL sit with their tarsus and foot abducted and away from the ischium.
Figure 3 - Cranial drawer is evaluated by positioning the stifle as shown. The tibia is advanced while holding the femur stationary.

Figure 4 - the tibial compression test is performed by holding the limb as shown. The tarsus is flexed further and the proximal tibia is observed for cranial displacement.

SURGICAL REPAIR OF THE CRUCIATE-DEFICIENT STIFLE
Surgical repair is generally recommended for dogs suffering partial or complete ACL tears due to the high likelihood of developing DJD and pain if the stifle is left unstable. It is important to understand that gross instability may not be evident in some partial tears, but micro-instability can still lead to progressive DJD. Although the TPLO procedure is quickly becoming the technique of choice for treatment of the cruciate-deficient stifle, it is important not to abandon traditional techniques of stabilization. Extracapsular suture techniques, fibular head transposition and intracapsular ligament replacement can lead to a successful outcome in 80-90% of patients. In addition, these techniques tend to cost less, giving owners another option if a more costly procedure cannot be performed.

CONCEPTS OF EXTRACAPSULAR STABILIZATION
Extracapsular repair can be performed using a standard parapatellar arthrotomy or may be arthroscopic-assisted. A prosthetic ligament is placed to assume the function of the torn CCL. The prosthetic ligament is made of monofilament or braided suture material. A heavy monofilament leader line (fishing line) is preferred. Leader line will not stretch over time to the extent that regular monofilament will. Most surgeons prefer Mason leader line (Mason Tackle, Otisville, MI), and a variety of sizes is available. I use 80-, 60-, 40-, or 200-pound test depending on the size of patient. A rule of thumb is to use a pound of test for every pound of body weight of the patient. This material can be autoclaved one time without adverse effects. If using a braided material, it is best to use a commercial, sterile medical suture material, usually no. 2 or no. 5. Braided materials can be used effectively with few complications as long as aseptic technique is used.

The prosthetic ligament must be placed as isometrically as possible. Isometric positioning maintains similar tension on the ligament throughout the range of motion, decreases the chance of stretching or breaking the ligament, and allows more normal stifle movement. A recent study assessed isometric positioning of a lateral extracapsular suture anchored to the lateral femoral condyle and the proximal tibia. (Figure 5) Proximal attachment is done at the origin of the lateral collateral ligament on the lateral femoral condyle. This site is located at the caudal extent of the condyle and at the same level as the distal pole of the lateral fabella of the gastrocnemius muscle. Attachment around the lateral gastrocnemius fabella is also acceptable. Distal attachment occurs at the proximal tibia, just caudal or cranial to the long digital extensor tendon. The hole for attachment should be positioned just under the articular surface. Care should be taken to avoid drilling the hole too distal in the tibia. The prosthesis can course below or above the long digital extensor tendon, depending on the individual patient. The prosthesis should be positioned to avoid excessive pressure on the tendon.

Figure 5 - The black dots represent toe best locations for attaching a prosthetic extracapsular prosthetic ligament when repairing a dog having a tear of the cranial cruciate ligament. The prosthetic ligament is anchored on the femoral side by passing the heavy suture around the femorofabellar ligament. It is important to incorporate the bulk of this ligament to reduce the chance of the suture pulling through this soft tissue structure. Alternatively, the ligament can be anchored to the lateral femoral condyle using a bone anchor. (Figure 6) A variety of anchors are available (Innovative Animal Products,
Securos, Imex) that can be used for this purpose. The prosthetic ligament can be anchored to the tibial side using a bone tunnel through the tibial tuberosity, passing the ligament beneath the intermeniscal ligament or using a bone anchor.

Figure 6 - Bone anchors can be used to attach the prosthetic extracapsular ligament to the femur and the tibia as an alternative to passing the suture around the femorotabellar ligament and to a bone tunnel in the tibial tuberosity.

A standard knot can be tied using a square knot with 6-8 throws. If the knot is bulky and has a tendency to stand upright, it can be pushed over to lie in a more horizontal position and tacked down to the soft tissues with 3-0 suture material. Alternatively, a stainless steel crimp can be applied in place of a knot. (Figure 7) The crimp system also has the added advantage of a tensioning device to remove cranial drawer while securing the knot. At the present time, the crimps are designed to be used with either 80 or 40 pound monofilament suture.

CONCEPTS OF INTRAARTICULAR REPAIR

Intracapsular ACL ligament repair is possible arthroscopically by two techniques (as described by Whitney and Hulse) or by an open arthrotomy as described by Hulse. The arthroscopic technique described by Whitney is similar to that used in man and utilizes an intracapsular autograft or allograft in combination with an interference screw or transfixation pin. Hulse’s arthroscopic-assisted intraarticular technique utilizes a patellar tendon/fascial lata autograft placed in the “over-the-top position” and anchored by suturing to the lateral retinaculum. Hulse’s open technique is performed in a similar fashion, but a standard arthrotomy is used to evaluate and treat the intraarticular structures, rather than arthroscopically.

CONCEPTS OF TPLO PROCEDURE

Tibial Plateau Leveling Osteotomy (TPLO) is a relatively new and innovative surgical treatment for the cranial cruciate ligament-deficient canine stifle. The stifle joint is stabilized by both passive (ligaments, menisci, joint capsule) and active (muscles and tendons) constraints. The cranial cruciate ligament functions as a passive constraint to cranial tibial translation, stifle hyperextension, and excessive internal rotation of the tibia. Historically, most surgical treatments for CCL deficiency have sought to re-create a passive constraint similar to that of the original CCL using some combination of intracapsular autografts/prosthetics, extracapsular imbrication, or advancement of the fibular head and associated lateral collateral ligament. While traditional surgical procedures have focused on re-creation of the passive constraints of the stifle joint, the TPLO is based more on the active constraints of the stifle joint. The TPLO procedure is founded on the question, “why is the CCL needed as a passive constraint?” Asked another way, “where do the forces and moments which cause pathologic stifle instability originate?” Conceptually, if we can adequately diminish these forces and moments, the active constraints of the stifle may control these instabilities to the degree that the CCL is not needed as a passive constraint. Ground reaction forces and extensor muscle forces during weight bearing generate compressive forces on the articular surface of the tibia. Because of the caudally-directed slope of the tibial plateau, tibial compression generates a cranially-oriented shear force that induces cranial tibial translation in CCL deficient stifles. The shear component of the compressive force on the tibia, called cranial tibial thrust (CTT), is passively constrained by the CCL and the caudal horn of the medial meniscus. The CTT is proportional to the slope of the tibial plateau. Progressive decreases of the slope of the tibial plateau diminish the CTT to a point where there are incremental increases in reliance upon the caudal cruciate ligament as a passive constraint to caudal tibial subluxation. The intent of the TPLO surgery is to attain a tibial plateau slope where cranial tibial thrust can be effectively controlled by the active constraints of the stifle with minimal reliance upon the caudal cruciate ligament as a passive constraint. (Figures 8,9) Because the CCL also functions to passively constrain excessive internal rotation of the tibia, we must logically question the source of these internally rotatory moments and the role of the TPLO procedure in functionally controlling them. Slocum introduced the concept of limb malalignment as a leading contributor to internal rotational moments acting about the stifle. That is to say, a dog with a “bowlegged” posture (due
to tibial or femoral varus) and a “pigeon-toed” stance (due to internal tibial or femoral torsion) experiences dramatic internal rotatory moments acting about its stifle as compared to a dog with a more “normally” aligned pelvic limb. In presentation of their data at this meeting last year, Warzee et al showed leveling of the tibial plateau (rotation of the plateau about a mediolateral axis) has relatively little effect on the rotatory instability of the stifle. Slocum has described limb-alignment adjuncts to the TPLO procedure to control excessive rotatory moments acting about the stifle in dogs with limb malalignment.

**Figure 8** - A steep tibial plateau slope (black line) is seen in this dog having a cranial cruciate ligament rupture.

**Figure 9** - The slope of the tibial plateau (black line) has been reduced to approximately 5 degrees after TPLO.

**MENISCAL INJURY**

The menisci should be examined in all patients having a complete or partial CCL tear. A Hohmann retractor can be used to help view the posterior horn of the medial meniscus. (Figure 10) It is often tempting to place an extracapsular stabilizing suture and skip this step in small dogs not having a “meniscal click”; a word to the wise- meniscal tears are very common and are not always associated with an obvious “click”. Persistent pain and lameness will occur in dogs having a meniscal tear left untreated. Always examine the intraarticular structures of the joint, either by arthrotomy or arthroscopy. Partial meniscectomy or ablation is preferable to complete meniscectomy due to the important stabilizing role played by the menisci.
Figure 10 - the tip of a Hohmann retractor is placed over the caudal edge of the tibial plateau, medial to the caudal cruciate ligament. The blade of the retractor is levered against the femoral trochlea, allowing a better view of the posterior horn of the medial meniscus (white arrow).

POSTOPERATIVE MANAGEMENT

The type of ACL repair chosen may depend on the expected ability of the dog and owner to comply with controlled postoperative activity. An intracapsular graft may not be the best choice if the patient cannot be controlled adequately for 5 months postoperatively. This technique can be very successful if the graft can be revascularized, but this will not occur if excessive stress and strain are placed on the healing tissue. This technique also may not be ideal if a postoperative bandage cannot be maintained and changed responsibly. A TPLO may be the ideal technique in dogs with osteoporosis or in older active dogs where bone healing may be slower. Screw loosening or implant failure can occur if bone healing is delayed. I generally recommend early physical therapy with all types of ACL repair to help maintain muscle mass, joint flexibility, and encourage early bone healing, in TPLO patients.