Cruciate Injury/Degeneration in the Dog
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INTRODUCTION
Disease of the cranial cruciate ligament (CCL) is the most common condition to affect the canine stifle joint. The postulated factors involved in the pathogenesis of CCL rupture are many and include: genetics, breed, age, gender, neutering, ischaemia, obesity, immune mechanisms, tibial plateau angle, intercondylar notch, and local biomechanics. CCL rupture occurs in all sizes of dogs but affects larger breed dogs more often than smaller dogs, and at a younger age. Epidemiological studies have indicated an increased prevalence of CCL disease in breeds such as the Newfoundland, Rottweiler and Labrador retriever, within frequent occurrence in the Greyhound, Bassett Hound and Old English sheepdog. CCL rupture occurs more commonly in neutered animals, particularly females. It is unknown if this is secondary to abnormal weight gain, as it has been reported that 45.4% of spayed bitches are obese. It is now known that CCL disease has an inherited component in the Newfoundland and Boxer. The classic acute cranial cruciate ligament rupture occurs rarely in dogs. More commonly, slow degeneration of the ligament and osteoarthritis of the joint occurs, due to unknown etiology, before functional failure of the ligament occurs. A high percentage of dogs with unilateral cranial cruciate ruptures subsequently rupture the opposite cranial cruciate ligament. Therefore, there has been significant research into the potential causes of this common problem.

BIOLOGY
With increased risk of CCL disease in certain breeds and neutered animals, one can ask many questions relating to the nature of the tissue in these animals. Is the CCL “normal” in these animals? For example, is the structure and turnover of the CCL normal? Is the biochemistry of the CCL normal? Earlier studies examined CCL biochemistry, ultrastructure and biomechanics of CCLs from two at-risk breeds (Labrador and Golden Retriever) and compared these to a low risk breed (Greyhound). Collagen fibril diameters were measured and it was found that the mean fibril diameter in the Labrador is significantly smaller than that of the Greyhound. Markers of collagen turnover in CCLs in these breeds of dog have also been assessed. These data suggest that collagen turnover in CCLs from at-risk breeds is increased. Recent work has focused on the cell morphology. Alterations in cell morphology may alter the ability of cells to produce healthy matrix and repair damage through disruption of collagen production. There are marked regional variations in the cell morphology of the canine CL complex. Additionally, chronic inflammation has been suspected in the path physiology of CCL dysfunction.

Conformation Biomechanical Perspectives
In recent years, the tibial plateau has been a subject of much debate. Does an excessive slope to the tibial plateau contribute to the incidence of CCL disease? One study suggests that dogs with CCL rupture do have an excessive slope to the tibial plateau. However, other studies have failed to substantiate these data. Interestingly, one recent study has raised the possibility of tibial tuberosity conformation being a risk factor for CCL disease. Another study looked at a variety of conformational variables and suggested that cranial angulation of the proximal portion of the tibia, excessive steepness of the tibial plateau, and distal femoral torsion appeared more likely to be associated with CCL deficiency than femoral angulation, tibial torsion, intercondylar notch stenosis, and increased inclination of the patellar ligament. Currently there is no complete understanding of the reasons why CCL fail in dogs.

MANAGEMENT OF CCL DYSFUNCTION
Conservative Management
Exercise restriction, weight loss, and physical therapy has been recommended for treatment of cranial cruciate rupture. It seems to be more often attempted in small dogs (< 10 kg) and cats. In this author’s
experience, however, lameness does not often completely resolve in these animals and they often return for surgery.

**Surgical Management**

Currently recommended surgical techniques can be roughly divided into two groups; techniques that change the mechanics of the stifle to achieve stabilization and techniques that act to restrict drawer motion with a physical device. The former group includes TPLO, TTA, and various modifications of the tibial wedge osteotomy. The latter include long-described extracapsular suture techniques and intracapsular reconstructive techniques. Currently, some form of Tibial Plateau Leveling Osteotomy (TPLO), Tibial Tuberosity Advancement, (TTA) and Extracapsular Suture (including the TightRope®) are the three most widely accepted treatment methods. No perfect treatment for cruciate rupture has been identified in the dog.

Extracapsular stabilization with sutures is still a useful technique with proven positive outcomes. The most common methods employ a synthetic suture passed around the lateral fabella and through the tibial crest or employ bone anchors in the distal femur and proximal tibia. In two recent publications, extracapsular stabilization was compared to TPLO and was found to provide significant improvements in function after surgery but was inferior to the TPLO. In a retrospective study, complications were recorded in 63 of 363 lateral fabellotibial suture surgical procedures (17.4%) and 7.2% required a second surgery to manage the complications. Factors significantly associated with a higher rate of complications were high body weight and young age of dog at the time of surgery. These findings are similar to other previous retrospective studies of extracapsular procedures including the TightRope® procedure.

**Tibial Plateau Leveling Osteotomy (TPLO)**

Tibial Plateau Leveling Osteotomy (TPLO) has been applied to clinical cases for over two decades now. The TPLO mechanically reduces cranial tibial thrust in the weight-bearing phase by “leveling” the tibial plateau. It is important to note that there is no difference in tibial plateau angle between dogs that rupture or don’t rupture their cruciate ligaments, but that correction in the angle biomechanically stabilizes the stifle. The overall complication rate after TPLO in 1000 cases was 14.8% (6.6% major), which included 2.8% meniscal injury and 6.6% infection. TPLO may be combined with tibial wedge osteotomy for dogs with complex tibial deformities or exaggerated tibial plateau angles. Earlier studies found a much higher complication rate, which is to be expected as the procedure was being refined.

**Tibial Tuberosity Advancement (TTA)**

The Tibial Tuberosity Advancement (TTA) seeks to eliminate tibial thrust by positioning the patellar tendon perpendicular to the shear forces in the stifle, resulting in the same redirection of vector force as the TPLO. TTA theoretically relieves patellar ligament tension whereas TPLO may increase it. The overall complication rate after TTA has been reported to be between 25 and 31.5%. Three published studies reflect the early clinical experiences with the TTA technique. These three studies (249 cases) report a total overall complication rate of 20.0%–59% in cranial cruciate ligament deficient stifle joints repaired using the TTA. The major complications were between 12–38%, with a re-operation rate of 11.3–14.0%. Again, as with the TPLO, these studies were done early in the use of this procedure and the complication rate is probably much lower now.

**Meniscal Removal or Release**

Medial meniscal injuries are quite common following rupture of the cranial cruciate ligament. An incidence of 50–70% of meniscal injury, identified at the time of surgery for CCL injury has been reported in dogs. The medial meniscus is most commonly damaged as it is more firmly attached to the joint capsule and medial collateral ligament than the lateral meniscus. However lateral discoid tears, and longitudinal tears of the lateral meniscus are reported. The lateral meniscus is attached to the femur by a ligamentous attachment and when cranial drawer occurs in a CCL deficient knee, the lateral meniscus remains with the femur and is loaded normally. However, the medial meniscus moves cranially resulting in the caudal horn being loaded abnormally. The management of these injuries usually involves removal
of the damaged area. Meniscal resection induces osteoarthritis. Any surgical intervention on menisci should be carefully considered. Meniscal injuries are associated with pain necessitating surgical intervention. Resection of meniscal tears improves short-medium term outcome but carries a poorer long-term outcome. Damage can also occur following surgical treatment of a cruciate injury. Currently, a more perplexing issue is the practice of the meniscal release (either transection of the ligament of the caudal pole of the medial meniscus or the transection of the mid body of the medial meniscus) as part of cruciate ligament rupture management in conjunction with a TPLO or TTA. Furthermore, some surgeons have recommended meniscal release as the preferred method of primary treatment of any meniscal pathology.

WHY MENISCAL RELEASE?
Late meniscal injury has been reported and is believed to be the result of continued cranial tibial thrust. Postliminary (“late”) meniscal injuries are reported in dogs. These injuries have been reported to occur from 3 weeks to 9 months post-operatively, with an average of 6 months after the first surgical procedure. Dogs with this injury will typically present as having had a normal recovery after the first surgery and then present with an acute lameness 6 weeks to 6 months in the previously operated limb. With rupture of the cranial cruciate ligament, there is loss of the passive restraint to the cranial tibial thrust allowing the femoral condyle to displace caudally over the tibial plateau. The medial meniscus is especially susceptible to injury due to the rigid attachment of the caudomedial meniscotibial ligament. This attachment essentially holds the meniscus in place while the femoral condyle crushes the caudal horn with excessive tibial thrust.

It has been shown that meniscal release results in increased contact stress between the femoral and tibial condyles, thus predisposing the cartilage surfaces to increased stress and likely subsequent degeneration and formation of osteoarthritis. Recently the TPLO and TTA have become popular surgical interventions for the cranial cruciate ligament deficient stifle aimed at neutralizing cranial tibial translation. Such procedures have two schools of thought behind them, but neither has strong clinical data to support their claim. One group feels that there is a need to release the medial menisci as there is still movement between the femur and tibia and thus the meniscus is at risk, while the other group feels that those procedures are protective of the meniscus through elimination of the caudal pole impingement of the meniscus, thus obviating the necessity for the concurrent release.

Early anecdotal reports stated that without meniscal release, dogs undergoing TPLO procedures had a high rate of subsequent medial meniscal injury. These statements were never confirmed in any published peer review reports. Yet the practice of meniscal release grew over the years. The actual incidence of meniscal injury following cruciate rupture is unknown. There is some data from studies following initial surgical visualization. Data collected from other methodologies of repair (extracapsular sutures and intraarticular graft replacements) suggested that about 12 percent of cases had subsequent meniscal injuries which required repair. However, dogs with clinical problems were the only ones who had second surgical explorations, thus the actual number may be higher. A recent relatively small study suggests that there is between 3% (joints explored with arthroscopy) and 10% (joints explored with an arthrotomy) of cases of subsequent medial meniscal injury without meniscal release after TPLO. However, no large prospective, randomized clinical trial has been completed evaluating the effects of meniscal release on the rate of secondary meniscal tears in surgically stabilized cranial cruciate deficient stifles. Recent retrospective studies indicate that the meniscal release procedure does not prevent secondary tears from occurring. These data counter earlier data suggesting the procedure was needed. Thus the conundrum facing us today, do we release or leave the apparently normal meniscus alone? In vitro studies have produced data that do not answer all the questions and have some conflicting results. Not surprisingly, in vitro canine cadaveric data has shown that meniscal release has some significant effects on the joint. In one study, radial transection of the medial meniscus resulted in significant alterations in pressure magnitude and distribution through the axially loaded stifle joint. Other data found an increase in pressure on the cartilage of the medial tibial condyle with meniscal release and TPLO. Also meniscal release was equivalent to caudal pole hemimeniscectomy in regards to load-bearing, implicating the loss of hoop tension for this high and non-uniform pressure distribution. The effect of meniscal release on stifle joint stability was not different from caudal pole hemimeniscectomy,
suggesting that the former had no advantage over the second in regards to contributing to stifle joint stability. Meniscal release also caused greater cranial tibial thrust in the CCL deficient stifle joint compared to the intact stifle joint in cadaveric limbs. The limited in vivo data strongly suggested that release of the medial meniscus does induce significant pathological changes in the stifle joint or in the function of the limb.

**CONCLUSIONS**

CCL dysfunction is very common in dogs. The disease process is complicated and rarely involves a supra-physiologic injury. Thus bilateral CCL rupture is not uncommon. Regardless of the technique used, extracapsular techniques or tibial osteotomies should result in an estimated 85-90% improvement in the surgical population following surgery. No current technique will result in return to normal weight-bearing in all dogs, but several techniques will result in high client satisfaction at long periods of follow up. No current technique will halt the progression of DJD.

**REFERENCES**

References are available upon request.