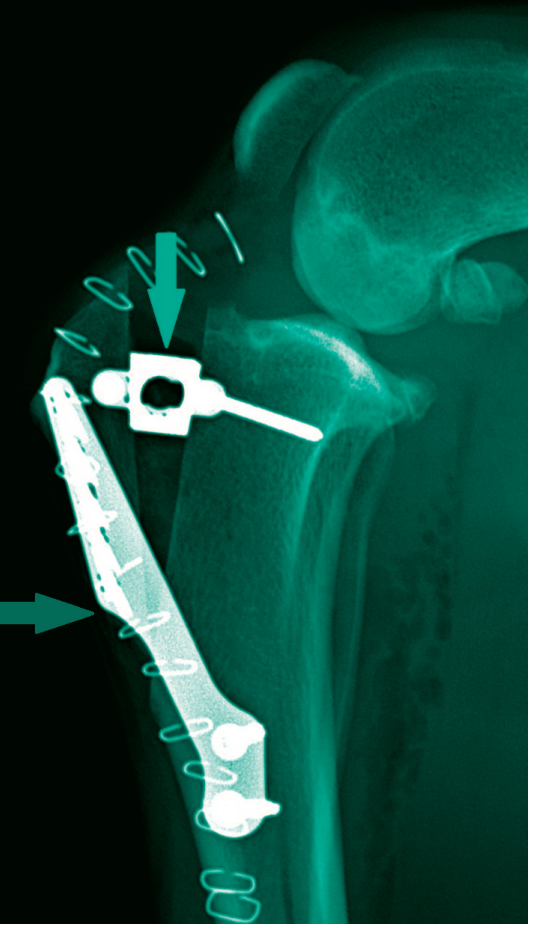

PEER REVIEWED

CANINE CRANIAL CRUCIATE DISEASE

An Evidence-Based Look at Current Treatment Modalities

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This is the second article in a 2-part series on canine cranial cruciate rupture. The first article—Canine Cranial Cruciate Disease: Updating Our Knowledge about Pathogenesis and Diagnosis—was published in the July/August 2013 issue of Today's Veterinary Practice *and is available at tvpjournal.com.*

Canine cranial cruciate ligament rupture (CrCLR) has long been recognized as a surgical disease. Of large breed dogs with CrCLR, 81% to 100% remain lame unless surgical correction is performed. In small dogs (< 10 kg) and cats, exercise restriction, weight loss, and physical therapy have been recommended for treatment of CrCLR, with reported lameness resolution ranging from 73% to 90%.

In my experience, however, lameness often does not completely resolve in animals managed nonsurgically, and they frequently return for corrective surgery after prolonged periods of lameness. In my opinion, surgical correction should be offered at the time of diagnosis for all dogs and for cats.

OVERVIEW OF TECHNIQUES

Over the past 50 years, surgical treatment of CrCLR has evolved through a number of procedures, many now obsolete. Techniques no longer recommended in dogs, include:

- Intracapsular reconstructive techniques, using fascia lata or other natural substitutes, due to documentation of decreased weight-bearing at objective recheck evaluations compared with normal dogs, and better results with other procedures[1]
- Fibular head transposition procedure, which was formerly popular.[2]

Currently, the 3 most widely accepted surgical procedures are:[3]

- Tibial plateau leveling osteotomy (TPLO)
- Tibial tuberosity advancement (TTA)
- Various extracapsular stabilization procedures, including the TightRope (arthrexvetsystems.com).

The goal of TPLO or TTA is to change the biomechanical function of the knee to limit cranial drawer during weight-bearing movement, and TPLO is currently the most commonly recommended procedure by ACVS surgeons for CrCLR therapy in dogs weighing over 60 lb.[4] Extracapsular stabilization relies on periarticular fibrosis for long-term stability since no artificial ligament substitute remains intact *in vivo* over long periods.

EXTRACAPSULAR STABILIZATION

A number of extracapsular stabilization techniques have been described and result in normal return to athletic function.

Surgical Techniques

A **lateral parapatellar arthrotomy approach** to the joint is most common:

- The intra-articular structures are examined, torn fibers of the cranial cruciate ligament (CCL) are often debrided (although no evidence exists that debridement improves recovery), and any meniscal damage is addressed.
- The joint is lavaged and the joint capsule closed with monofilament absorbable suture in the continuous or interrupted pattern of the surgeon's choice.

A **heavy monofilament synthetic suture** is often employed in recommended extracapsular stabilization techniques:

- This suture is passed around the lateral fabella and through a hole in the tibial crest in a mattress fashion.
- The suture is secured adjacent to the fabella and beneath the biceps femoris with a square knot, slip knot, or tensioning device with crimps.[5]
- A number of investigations have established that nylon leader line is the best material, and the strongest tie is secured with a metal crimp.[5]

Alternatively, **isometric placement of femoral and tibial anchorage sites** is preferred by some surgeons:

- Bone anchors are placed in the distal femur and proximal tibia in combination with a braided orthopedic suture, such as the TightRope (**Figure 1**).[6,7]
- These anchorages function best when placed at the caudal aspect of the lateral femoral condyle and just caudal to the extensor groove of the proximolateral tibia.
- A number of studies have investigated optional suture materials, tensioning and securing techniques, biomechanical characteristics, sterilization methods, and suture anchorages, and can be reviewed elsewhere.[5]

Surgical Results

Extracapsular stabilizations result in improvement in 85% to 94% of dogs.[5]

Lameness may reoccur in some dogs with advancing arthritis or those in which the periarticular fibrosis is not sufficiently strong to limit abnormal thrust when the artificial ligament fails. Based on experience, I instruct clients to expect that 10% to 20% of dogs with extracapsular stabilization will require treatment or reoperation for lameness during their lifetimes, sometimes years after the original surgery.

Clinical Comparisons

In one study comparing TPLO and lateral suture stabilization outcomes, there was no difference in objective kinetic parameters at 2 years,[8] although a more recent study showed TPLO outcomes were always better than lateral suture outcomes over any time period up to 1 year.[9]

A randomized, blinded clinical trial that compared lateral fabellar suture stabilization with TPLO in 80 dogs with naturally occurring cruciate disease concluded that TPLO resulted in higher peak vertical force and higher owner satisfaction 1-year post surgery.[10]

Finally, extracapsular stabilization may result in increased progression of radiographic osteoarthritis (OA) compared with TPLO.[11]

Complications

The complication rate for synthetic monofilament nylon techniques has not been addressed recently in the literature. The TightRope procedure has the best cyclic survival of 4 extracapsular stabilization techniques compared in cadavers, but still developed unacceptable elongation at a median of 11,537 cycles at the lowest peak force of 80N.[12] The complication rate of the TightRope procedure has been reported to be 20% (9.9% major) in a multi-institutional study of 1004 patients.[13]

TIBIAL PLATEAU LEVELING OSTEOTOMY

Surgical Goal

TPLO has been applied to clinical cases for over 2 decades. Its goal is to reduce cranial tibial thrust in the weight-bearing phase by "leveling" the tibial plateau. Although there are no consistently reported differences in the tibial plateau angle (TPA) of healthy dogs and those that rupture their CCLs, correction of the preexisting TPA acts to biomechanically stabilize the stifle.

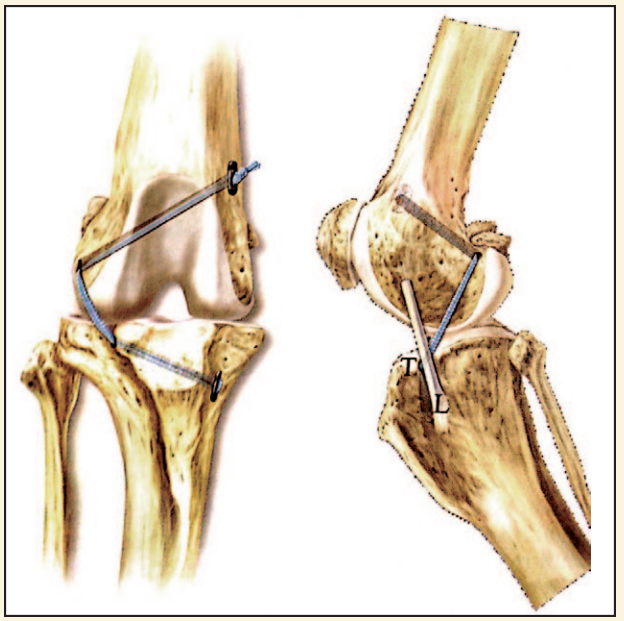

Figure 1. *In the TightRope procedure, fibertape passes from the medial aspect of the femoral condyle, through a bone tunnel to the lateral aspect, crosses the joint, and enters a tibial tunnel traversing to the medial tibia; the suture is secured at either end with a button. The exit and entry points on the lateral surfaces are near isometric points.*

Surgical Techniques

In the **TPLO procedure**:

- A medial approach to the proximal tibia and a semicircular osteotomy of the tibial plateau is performed.
- The tibial plateau is rotated based on preoperative measurements of the TPA, and the osteotomy is stabilized with a bone plate and screws (**Figure 2**, page 18).
- The incision is closed in standard fashion.

There are 4 philosophies regarding how to address preexisting joint pathology; however, none has yet proven superior for recovery of normal function. TPLO may be combined with:

1. A **medial arthrotomy** for the purpose of joint inspection and debridement
2. An **arthroscopy** to inspect and debride the joint
3. A **minimal approach** with no debridement
4. A **prophylactic caudal medial meniscal release** procedure.

Some surgeons do not use an intra-articular approach or meniscal release procedure at all.

Unlike the TightRope and TTA procedures, TPLO

can be performed in dogs with TPAs over 30 degrees, and in dogs with angular and torsional limb deformities. In dogs with complex tibial deformities or exaggerated TPAs, TPLO may be combined with **tibial wedge osteotomy**.

Clinical Comparisons

Multiple studies have compared the TPA of healthy pet dogs to those with CrCLR, greyhounds, and wolves in an effort to determine the effect of TPA on cruciate disease. There is no definitive evidence that the normal range of TPA in these animals affects the likelihood of cruciate rupture.[5]

In some studies, weight bearing completely returns to normal after TPLO but, in other studies, it has not.[14,15]

Very recent *in vivo* fluoroscopic kinematography pilot data presented by Dr. Peter Boecher at the 2013 ACVS Veterinary Symposium suggests that TPLO is less likely to leave continued caudal femoral subluxation than a TightRope or lateral fabellar suture.[16]

Figure 2. *In a TPLO, the tibial plateau is isolated by a semicircular osteotomy, the distal end rotated caudally, and the segment secured with a bone plate and screws.*

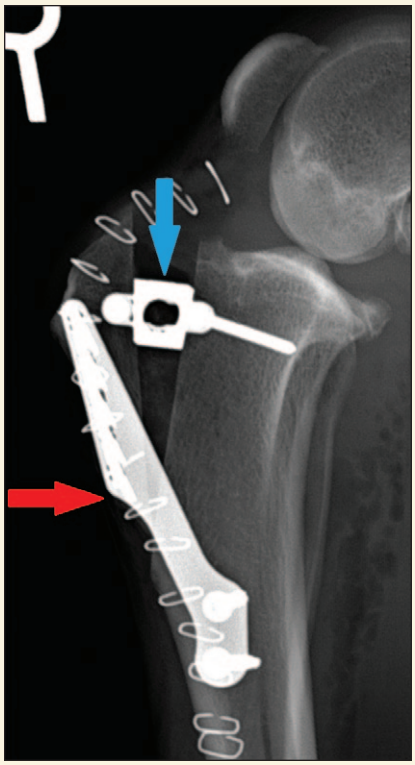

Figure 3. *In a TTA, an osteotomy of the tibial crest is performed, a cage (**blue arrow**) placed to maintain cranial displacement of the crest, and the crest is stabilized in the cranial position with a plate and fork system (**red arrow**).*

Complications

In a retrospective study of 1000 patients, TPLO carried a 14.8% complication rate (6.6% major, requiring repeat surgery or causing extended lameness), which included 2.8% late meniscal injury and 6.6% infections.[17]

TIBIAL TUBEROSITY ADVANCEMENT

Surgical Goal

TTA seeks to eliminate cranial tibial thrust by positioning the patellar tendon perpendicular to the shear forces in the stifle and tibial plateau, resulting in the same relative redirection of vector force as the TPLO.

Surgical Techniques

In the TTA, first reported in 2002:

- The procedure is accomplished through a surgical approach to the craniomedial aspect of the tibial crest.
- An osteotomy of the tibial crest is performed from just cranial to the tendon of origin of the long digital extensor muscle to the distal extent of the tibial crest.
- A spacer, appropriately sized according to preoperative measurements, is used to move the tibial crest cranially, and a TTA plate and "fork" are applied to stabilize the crest.
- A "cage" is placed into the osteotomy site and secured with a bone screw; a bone graft is placed into the osteotomy site before closure (**Figure 3**).

Clinical Comparisons

TTA does provide theoretical relief of patellar ligament tension, whereas TPLO may increase it; therefore, the occasional patellar ligament desmitis seen after TPLO is not common after TTA.

In an objective kinetic gait study, peak vertical forces after TTA were significantly higher at 6 months than preoperative forces, but were 10% lower than in control dogs.[18] In a recently published, long-term comparison of TTA, TightRope, and TPLO outcomes, the TPLO and TightRope procedure allowed significantly more dogs to reach full function than TTA.[3]

Complications

In 458 dogs, the overall complication rate after TTA was 19%, with 11.4% major complications.[19]

OTHER SURGICAL APPROACHES

A number of other osteotomies for correction of CrCLR are under current investigation, including:[20]

- Combination of the cranial closing wedge ostectomy and TPLO
- Triple tibial osteotomy
- Proximal tibial intra-articular osteotomy
- Chevron wedge osteotomy.

These all require extensive preoperative planning, are exacting in surgical technique, and none result in better functional outcomes than TPLO or TTA at present.

SURGICAL CONSIDERATIONS

Stifle Joint Arthroscopy

Stifle joint arthroscopy can be performed prior to, or in conjunction with, definitive surgical procedures to increase the accuracy of:

- Diagnosis of CrCLR
- Associated meniscal injuries
- Other stifle pathology.

Arthroscopic surgery is often requested by small animal clients who are familiar with its widespread use in human medicine, but functional benefits to its use in surgery of the canine stifle have yet to be demonstrated.

- Compared to open arthrotomy, arthroscopy has been demonstrated to result in reduced short-term postoperative morbidity in dogs with CrCLR disease when combined with an extracapsular stabilization,[21] but long-term benefits have not been investigated.
- **A landmark, placebo-controlled human trial demonstrated that arthroscopy of the stifle (knee) may not provide improved results compared with not invading the joint.[22]**
- As stated previously, no definitive comparison has been published comparing dogs that have undergone open arthrotomies and joint debridement, arthroscopic debridement, limited caudal meniscal release, or no arthrotomy or debridement at all.

Use of arthroscopic equipment often increases surgical procedure time and cost to the client. Arthroscopic techniques that replace the canine CrCLR with patellar tendon or synthetic implants have been described and clinically applied, but large clinical studies of outcome measures are presently lacking.

Medial Meniscal Injuries

Medial meniscal injuries are common in conjunction with CrCLR, and include:

- Cranial displacement of the caudal horn
- Radial meniscal tears
- "Bucket handle" tears.

Injuries can be addressed directly through arthrotomy or arthroscopy, or by combination of a blind meniscal release along with TPLO or TTA. Historically, **full or partial meniscectomy** that includes portions of dislodged or torn menisci has been recommended, particularly because meniscal suturing techniques are difficult in dogs due to size. Since the development of TPLO, **caudal meniscal release** has been advocated for dislodged or damaged menisci.

However, treatment of most meniscal injuries, particularly those in the aneural, avascular cartilage regions, has not been proven to result in better long-term outcomes in dogs.

- Partial or full meniscectomies are always detrimental to long-term joint function and may be more detrimental than the original meniscal injuries with regard to accelerating secondary OA in the knee.
- Although arthroscopy coupled with use of a probe has the highest sensitivity and specificity for diagnosis of meniscal injuries,[23] meniscal release may not be necessary and may be detrimental to recovery.
- There is no difference in ability to accomplish meniscal release by arthrotomy, arthroscopy, or a blind medial stab.[24]
- Routine meniscal release had no effect on owner-assessed outcome of TPLO and did not reduce the rate of subsequent meniscal tears.[25]

Unless specifically indicated by a meniscal "click" on physical examination, I prefer to avoid arthrotomy and do not address potential minor meniscal trauma.

SUPPLEMENTAL MEDICAL MANAGEMENT

Weight Reduction

Surgery should not be delayed in obese patients at time of CrCLR diagnosis; however, weight reduction is recommended for these dogs postoperatively. Optimally, all dogs with OA due to CrCLR should be fed commercial diets high in omega-3 fatty acids for long-term treatment of stifle inflammation and OA.[26]

Physical Rehabilitation

Physical rehabilitation may be useful to improve or speed functional recovery in postoperative patients, particularly dogs that remain persistently lame.

After TPLO, loss of motion greater than 10 degrees occurs in 21.8% of dogs, and dogs with decreased range of motion are more likely to exhibit lameness.[27] In 1 study of dogs after extracapsular stabilization, 6 months postoperatively, dogs that had a prescribed postoperative rehabilitation program bore more weight on the affected limb than dogs in an exercise-restricted group.[28] Physical rehabilitation in the treated group consisted of walking (10 min) and swimming (10 min) twice daily during weeks 3, 5, and 7 after surgery.

Adjunctive Therapies

Analgesics are necessary in the postoperative period to treat surgical pain, but prolonged carprofen or deracoxib use did not result in improvement of dogs during postoperative rehabilitation compared to those in a placebo group.[29,30]

Shock wave therapy decreases patellar ligament thickness after TPLO only at the distal quarter of the patellar ligament, so it is only mildly effective as a remedy for patellar tendonitis in TPLO patients.[31]

Nutraceuticals have not been proven effective as an adjunctive therapy during recovery of TPLO.

Alternative Therapies

There are few published anecdotal reports, but no controlled clinical trials, that support the efficacy of alternative therapies, such as **laser**, **stem cell**, or **chiropractic therapy** for treatment of CrCLR. These treatments should not be recommended at this time for this purpose.

The common course of clinical signs in an untreated dog with CrCLR is obvious lameness after rupture; then improved or mild lameness for a period of 6 to 12 weeks, followed by gradually increasing lameness as secondary OA develops in the stifle. **The improvement after initial lameness is often misinterpreted as evidence for efficacy of alternative therapies, when, in fact, it is the natural progression of the disease.**

Likewise, claims for postoperative rehabilitation efficacy of various modalities, such as laser therapy and shock-wave therapy, may also be confused with the natural course of postoperative improvement.

IN SUMMARY

TPLO, TTA, and various extracapsular stabilization techniques provide similar, satisfactory outcomes for CrCLR and are currently the most widely-accepted and common treatments. I prefer TPLO without an arthrotomy or meniscal release for the majority of patients that present with:

- Lameness due to CrCLR
- Mild stifle arthritis
- Lack of a meniscal "click" on palpation.

Based on most reports and clinical experience, TPLO:

- Carries a slightly lower risk of major complications than TTA or TightRope
- May provide better return to function than common extracapsular stabilization techniques
- May result in less caudal femoral subluxation
- Applies to a broader range of patients, including those with TPAs over 30 degrees, or with angular or torsional limb deformities.

Regardless of the technique chosen, extracapsular stabilization techniques or tibial osteotomies should result in 85% to 95% improvement after surgery. No current technique will result in return to normal weight bearing in all dogs, but each technique has been proven to improve lameness and patient comfort for long periods of follow-up in most dogs, and to result in high client satisfaction. No current technique completely halts OA progression. ■

CCL = cranial cruciate ligament; CrCLR = cranial cruciate ligament rupture; OA = osteoarthritis; TPA = tibial plateau angle; TPLO = tibial plateau leveling osteotomy; TTA = tibial tuberosity advancement

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