TightRope CCL as a Model for *Internal*Brace Ligament Augmentation Repair

Arthrex Vet Systems Research and Development

Introduction

Canine cranial cruciate ligament (CCL) repair has been performed for many years using extracapsular and/or lateral suture stabilization techniques, including the TightRope (TR) CCL (Figure 1). It is similar in concept to the *Internal*Brace technique used for stabilization and repair of ligaments in the ankle and the knee (Figures 2 and 3, respectively) using sutures and implants. This paper will review different techniques using suture to stabilize the knee, including the TR CCL technique, which can be used as a model for human ligament repair.

Figure 1

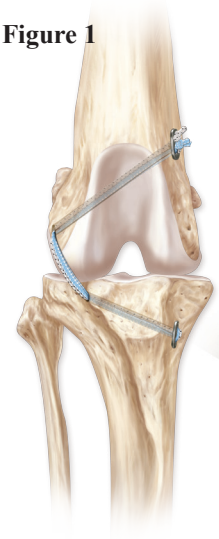
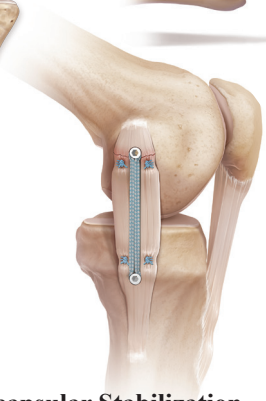


Figure 2

Figure 3



History of Extracapsular Stabilization

The history of canine knee extracapsular stabilization goes back to 1970, when DeAngelis and Lau used a lateral retinacular imbrication technique by applying two mattress stitches from the lateral fabella to the patellar tendon[1]. The sutures hold the knee in place until the body forms scar tissue around the suture, which provides final stabilization[2]. This technique was modified by Flo in 1975 by passing a mattress stitch around the medial fabella, while keeping the two lateral mattress stitiches around the lateral fabella[3]. Another technique, fibular head transposition, is similar to lateral retinacular imbrication in terms of mechanics, but this technique uses wires and a Steinmann Pin to relocate the top of the fibula cranially (towards the front)[4]. Arthrex markets two extracapsular techniques - the CCL Suture Repair technique[5] and the CCL Repair Anchor technique[6]. All of these techniques require open surgery. Extracapsular suture techniques are used in human sports medicine as well, both open and arthroscopically[7,8]. Therefore, designing an arthroscopic extracapsular stabilization technique for canines is the logical next step.

Mechanical Studies

The paper that introduced the TR CCL technique[9] presents a comparison (using FiberTape and #5 FiberWire separately) in cadavers to other extracapsular stabilization techniques such as the Arthrex CCL Suture Repair technique using #5 FiberWire, the Securos 80# monofilament leader line crimp clamp fixation system, the Securos XGEN CCR System, and the Jorgensen LigaFiba Iso Toggle System. After cycling the constructs up to 100 N for 100 cycles, the TR CCL with FiberTape and the LigaFiba Iso Toggle System both demonstrated the highest yield and ultimate loads. However, the TR CCL with FiberTape and FiberWire had much lower cyclic displacement compared to the Iso Toggle.

Another study tested the various suture materials used in extracapsular repair[10] with many of the same materials tested in the above mentioned study. Ultimate tensile load was highest for the LigaFiba suture, followed by the Securos XGEN OrthoFiber suture, #5 FiberWire, FiberTape, and generic monofilament leader line. However, FiberTape and FiberWire had the lowest elongation at failure by far compared to the other sutures. Another paper had similar findings[11]. It is important to emphasize that this study tested the actual suture material, not the construct itself. Both studies show a small amount of displacement of FiberTape and FiberWire, which demonstrates the power of these sutures and constructs for CCL repair.

Clinical Studies

The study mentioned above[9] also included a clinical study that compared the TR CCL technique to tibial plateau leveling osteotomy (TPLO), another commonly used technique to repair the CCL deficiency by leveling the top surface of the tibial joint and stabilizing the cut area with plates and screws. It is a much more invasive technique, so the theory is that there will be better retention of the natural anatomy with TR CCL vs. TPLO. The study showed that at 8 weeks and 6 months post-surgery, there were no major differences in tibial cranial thrust between techniques at any timepoint. There were also no differences in radiographic scoring and VAS clinical scores at 6 months post-surgery between techniques. Lastly, even though TPLO had a higher rate of complications compared to TR CCL, the difference was not significant. However, TR CCL had lower cranial drawer measurements compared to TPLO at 8 weeks and 6 months post-surgery. In addition, the anesthesia time and surgical time were statistically lower for TR CCL compared to TPLO. This demonstrates that TR CCL, an arthroscopic technique, is a viable option for canine knee repair compared to a more invasive technique.

One of the most complete studies using the TR CCL technique[12] involved 1,004 cases from 29 surgical centers. Patients were monitored between 3 months and 3 years, and

the dogs weighed between 2-93 kg. From these cases, 54.1% were restored to full function levels from preinjury levels, while 39.8% were restored to limited acceptable function levels from preinjury levels. This equals a 93.9% success rate. There were no catastrophic complications, but there were 9.9% major complications requiring further surgical or medical treatment (such as meniscal tears, implant/technique failures, or infections), and 10.1% minor complications not requiring additional treatment.

A retrospective clinical study compared TR CCL to TPLO and tibial tuberosity advancement (TTA), another surgical procedure for CCL repair[13]. At one year follow-up, there was a significant difference in Visual Analog Scores (VAS), as rated by the patients' owners, for return to function for the TR CCL and TPLO groups compared to TTA ($p = 0.016$), while there was no difference in VAS for pain for any group ($p = 0.44$). However, the TTA patients were found to have many more major complications compared to the TR CCL or TPLO patients; TTA and TPLO combined had many more major complications than TR CCL. Lastly, TPLO and TTA were two and seven times more likely to have complications compared to TR CCL.

Studies that use other extracapsular stabilization techniques do not perform as well. For instance, a recent paper[14] demonstrates that a lateral fabellar suture technique does not perform as well as TPLO, according to owner reports, while most other data was similar between groups. Another recent paper[15] demonstrated that TPLO performed better than the Securos lateral fabellar suture technique. Lastly, a study from 2010[16] demonstrated that there were no radiographic differences between TPLO and generic lateral fabellar suture stabilization with a Securos crimping device. Some possible reasons for this could include the type of suture used and the lack of anatomic markers for the other extracapsular stabilization techniques. All of this work demonstrates that the TR CCL technique is a viable option for stabilization of ligaments and tendons. Therefore, this technique can be translated to human suture-based techniques such as the *Internal*Brace for ligament and tendon repair.

Conclusion

This paper demonstrates that the concept of suture stabilization for ligament and tendon repair, specifically TR CCL, has been successfully used in the canine population. Therefore, this concept, in the form of the *Internal*Brace for ligament and tendon repair, can be successful for ankle and knee ligament repair.

References

1. DeAngelis M, Lau RE, *A lateral retinacular imbrications technique for the surgical correction of anterior cruciate ligament rupture in the dog,* J Am Vet Med Assoc 1970, 157(1): 79-84.
2. Lotsikas PJ, Fair LM, Lotsikas FM, *A Review of Canine Cruciate Disease Part 2*, Clean Run Newsletter, 2010, 16(October): 69-74.
3. Flo GL, *Modification of the lateral retinacular imbrication technique for stabilizing cruciate ligament injuries,* J Am Anim Hosp Assoc 1975; 11(5): 570–6.
4. Smith GK, Torg JS, *Fibular head transposition for repair of cruciate-deficient stifle in the dog,* J Am Vet Med Assoc 1985; 187(4): 375-83.
5. Canine Cranial Cruciate Ligament Repair Kit Surgical Technique, Arthrex #VLT1-0002-EN_D
6. Canine Cranial Cruciate Ligament Repair Anchor System Surgical Technique, Arthrex #VLT0003C
7. Xu H, Zhang C, Pei G, Zhu Q, Han Y, *Arthroscopic medial retinacular imbrication for the treatment of recurrent patellar instability: a simple and all-inside technique,* Orthopedics 2011; 34(7):524-9.
8. Nonweiler DE, DeLee JC, *The diagnosis and treatment of medial subluxation of the patella after lateral retinacular release,* Am J Sports Med 1994; 22(5):680-6.
9. Cook JL, Luther JK, Beetem J, Karnes J, Cook CR, *Clinical comparison of a novel extracapsular stabilization procedure and tibial plateau leveling osteotomy for treatment of cranial cruciate ligament deficiency in dogs,* Vet Surg 2010; 39(3): 315-23.
10. Rose ND, Goerke D, Evans RB, Conzemius MG, *Mechanical testing of orthopedic suture material used for extraarticular stabilization of canine cruciate ligament-deficient stifles,* Vet Surg 2012; 41(2): 266-72.
11. Burgess R, Elder S, McLaughlin R, Constable P, *In vitro biomechanical evaluation and comparison of FiberWire, FiberTape, OrthoFiber, and nylon leader line for potential use during extraarticular stabilization of canine cruciate deficient stifles,* Vet Surg 2010; 39(2): 208-15.
12. *TightRope CCL Multi-Site Data Sheet,* www.arthrexvetsystems.com/en/mediacenter/clientinformation/upload/TightRope-CCL-Multi-Site-Data.pdf
13. Christopher SA, Beetem J, Cook JL, *Comparison of long-term outcomes associated with three surgical techniques for treatment of cranial cruciate ligament disease in dogs,* Vet Surg 2013; 42(3): 329-34.
14. Gordon-Evans WJ, Griffon DJ, Bubb C, Knap KM, Sullivan M, Evans RB, *Comparison of lateral fabellar suture and tibial plateau leveling osteotomy techniques for treatment of dogs with cranial cruciate ligament disease,* J Am Vet Med Assoc 2013; 243(5): 675-80.
15. Nelson SA, Krotscheck U, Rawlinson J, Todhunter RJ, Zhang Z, Mohammed H, *Long-term functional outcome of tibial plateau leveling osteotomy versus extracapsular repair in a heterogeneous population of dogs,* Vet Surg 2013; 42(1): 38-50.
16. Au KK, Gordon-Evans WJ, Dunning D, O'Dell-Anderson KJ, Knap KE, Griffon D, Johnson AL, *Comparison of short - and long-term function and radiographic osteoarthrosis in dogs after postoperative physical rehabilitation and tibial plateau leveling osteotomy or lateral fabellar suture stabilization,* Vet Surg 2010; 39(2): 173-80.