Original Article

Comparison of an intra-articular suture technique and a lateral suture technique in toy breed dogs with cranial cruciate ligament rupture

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Abstract

Cranial cruciate ligament rupture (CCLR) can result in inflammation, pain, lameness and osteoarthritis. Because there is no isometric point for surgical stabilization for CCLR, the anatomical replacement of the ruptured cranial cruciate ligament with synthetic material may provide better outcomes. This retrospective study compared short-term post-operative outcomes between an intra-articular suture technique and a lateral suture technique for treating CCLR in toy breed dogs. Twenty dogs with unilateral CCLR were divided into two groups. The lateral suture technique was a lateral circumfabellar tibial suture with monofilament nylon and the intra-articular suture was performed by passing a suture through the femoral condyle tunnel and the tibial tunnel to stabilize the knee joint with non-absorbable braided polyester fiber. All dogs were assessed for lameness using an adapted five-point lameness scoring system at 0, 7, 30 and 60 days after surgery. Pre-operative lameness scores were comparable between the intra-articular suture and the lateral suture techniques (3.3±0.7 vs. 3.5±0.5, p>0.05). The post-operative lameness scores of dogs with the intra-articular suture were significantly lower than the scores of dogs with the lateral suture at day 7 (1.6±0.5 vs. 2.4±0.7, p<0.05) and day 30 (0.3±0.5 vs. 1.2±1.3, p<0.05). Nonetheless, there was no significant difference in the post-operative lameness scores of dogs in the two groups at day 60 (0.1±0.3 vs. 0.3±0.5, p>0.05). This study suggests that an intra-articular technique may provide a faster return to limb function than a lateral suture technique in toy breed dogs affected by CCLR.

Keywords: cranial cruciate ligament, dogs, intra-articular suture technique, lateral suture technique

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Introduction

The cranial cruciate ligament (CrCL) has three main functions: (1) prevention of cranial displacement of the tibia in relation to the femur, (2) prevention of knee hyperextension and (3) prevention of tibial internal rotation. In normal stifle kinematics, the swing phase involves flexion-extension, internal-external rotation and abduction-adduction movements, whereas the stance phase involves only flexion and extension (Korvick *et al.*, 1994; Tashman *et al.*, 2004). Cranial cruciate ligament rupture (CCLR) is one of the most common causes of hindlimb lameness in dogs (Johnson, 1994). A stifle loses its stability after CCLR, leading to inflammation, pain, lameness and osteoarthritis, and affected dogs commonly present with disability of the affected limb and an inability to bear weight on it (Cook, 2010; Griffon, 2010; Hayashi *et al.*, 2004; Vasseur *et al.*, 1985). Cranial displacement of the tibia relative to the femur will occur with CCLR (Slocum and Slocum, 1993). Many methods of surgical treatment for CCLR have been developed to stabilize the stifle joint, including intra-articular, extra-articular and tibial osteotomy techniques (Vasseur *et al.*, 1991).

Lateral suture techniques are widely used for the treatment of the deficient CrCL (Leighton, 1999), and they involve suture stabilization from the lateral fabella to cranial tibial tuberosity in order to control abnormal movement of the stifle and improve the stability of the affected limb (DeCamp *et al*., 2015). Variation in this technique includes the stitching method used at the fabella or the hole position of the tibia. The tension needed to maintain the stability of the stifle is not well understood and may vary among surgeons. It should be noted that excessive suture tension at the time of surgery may pose more of a danger than minor instability of the stifle joint (Fischer *et al.*, 2010). Because there is no isometric point for surgical stabilization for CCLR, replacement of the original anatomy of the CrCL is an attractive concept for better clinical outcomes. An intra-articular suture technique can be achieved by anatomically replacing the ruptured ligament with an autogenous graft, allograft or synthetic materials. A synthetic ligament theoretically shares the graft-based benefits but may have distinct advantages (Prada, 2018). A synthetic graft will make the technique easier, reduce surgery time and avoid donor site morbidity (Johnson, 1994). Although intra-articular reconstruction for CCLR with fascia lata has performed worse when compared with an extracapsular technique or a tibial plateau-leveling osteotomy (Conzemius *et al.*, 2005), attempts at intra-articular stabilization have been conducted mostly in large breed dogs (de Rooster, 2001; Vasseur *et al.*, 1991). Knitted polyester is an artificial material that is highly durable and increases resistance to elongation or rupture (Cook, 2010; Giles *et al.*, 2008). It is possible that the application of a knitted polyester for intra-articular stabilization in small breed dogs may provide better results compared with a lateral suture technique.

The purpose of this study was to demonstrate an intra-articular surgical technique for small breed dogs as well as to evaluate short-term outcomes in toy breed dogs undergoing surgical correction for CCLR, comparing between a lateral suture technique and an intra-articular suture technique.

Materials and Methods

Ethical approval and informed consent: This study was approved by the Kasetsart University Institutional Animal Care and Use Committee (ACKU61-VET-031) and by the Ethical Review Board of the Office of the National Research Council of Thailand (NRCT license: U1-00500-2558). Written consent was obtained from all dog owners and the experiment complied with the Kasetsart University Institutional Animal Care and Use Standards.

Animals: A retrospective study was conducted in CCLR affected dogs visiting the Orthopedic Unit at the Kasetsart University Veterinary Teaching Hospital, Bangkhen campus, between November 2019 and January 2020 that were enrolled in the study. Dogs with a history of patellar luxation or hip dysplasia were not included in the study. The twenty toy breed dogs that were enrolled in the present study were randomly divided into two groups. The first group (n=10) received the lateral suture technique, which involved applying a lateral circumfabellar-tibial suture with 50 lb monofilament nylon. Dogs enrolled in the first group included the following breeds: Pomeranian (n=2), Yorkshire terrier (n=3), Chihuahua (n=2) and Poodle (n=3). The second group (n=10) received the intra-articular suture technique, which involved the use of non-absorbable braided polyester coated with silicone (PremiCron®, USP size 2, diameter 0.6 mm) as a synthetic ligament. Dogs enrolled in the second group included the following breeds: Pomeranian (n=5), Yorkshire terrier (n=3) and Chihuahua (n=2).

Anesthesia and surgery: All dogs received the same anesthetic protocol. After intravenous catheterization, intravenous fluids (0.9% NSS or lactated Ringer's solution) were administered at 5 ml/kg/hr. Dogs were pre-medicated with 0.5 mg/kg of morphine sulfate pentahydrate (FDA of Thailand; M and H manufacturing, Thailand) intramuscularly and 0.3 mg/kg of diazepam (SIPAM®; Siam pharmaceutical, Thailand) intravascularly for 20–30 minutes. Anesthesia induction was performed using 4 mg/kg propofol (TROYPOFOL®; Pinyopharmacy, Thailand) intravenously. After endotracheal intubation, the anesthesia was then maintained with isoflurane inhalation (AERRANE®; Baxter, Puerto Rico) and 100% oxygen delivered in a semi-opened rebreathing system. A pre-operative epidural injection of 0.5% bupivacaine (Marcain®; AstraZeneca AB, Sodertalje, Sweden) at a dose of 1 mg/kg was given to all dogs. Cefazolin sodium (CEFAZOL®; General Drugs House, Thailand) (20 mg/kg, IV) was administered by intravascular injection.

Suture stabilization technique: Both procedure types involved the following preparation steps before stabilization of the stifle. Dogs were anesthetized, put in a dorsal recumbent position and prepared for stifle surgery with aseptic surgical preparation. A lateral arthrotomy was performed in the affected stifle. The remaining ruptured CrCL was removed using a surgical blade No. 11. Both medial and lateral meniscus were evaluated during the surgery. The stifle joint was lavaged with sterile saline and then the stabilization technique was performed.

The lateral suture technique was performed after closing the stifle joint with 3-0 monofilament synthetic absorbable material. A 1.5 mm hole was drilled across the tibial tuberosity through the cranial eminence of the extensor groove using a drill bit.

After identification of lateral fabella, a 50 lb monofilament nylon, attached to the J needle, was passed around the fabella. The suture was then passed under the patellar ligament in a lateral to medial direction. At the medial aspect of tibia, the nylon suture was inserted passing through the tibial hole in a medial to lateral direction. The free end of the nylon sutures were passed throught the crimp tube. The stifle joint was held in flexion at 100 degrees, with external rotation of the tibia, and the tail of the nylon was pulled tightly. The crimp tube was cramped three times with pliers to secure the nylon under tension (Fig 1).

For the intra-articular suture technique, after the preparation steps, the femeral bone tunnel was created by drilling a hole with a drill bit 2.0 mm from the origin of the CrCL at 40° inclination to the anatomical axis in the frontal plane of the femur to exit the cortex at the lateral metaphysis of the distal femur. The tibial bone tunnel was drilled with a drill bit 2.0 mm from the insertion of the CrCL at 30° inclination to the anatomical axis in the frontal plane of the tibia to exit the cortex at the medial metaphysis of the distal tibia. Silicone-coated braided polyester (PremiCron®, USP No. 2, 0.6 mm) was used as the synthetic ligament in this study. The stifle joint was flexed at 60 degrees. The guidewire was inserted through the tibial tunnel in a medial to lateral direction and was pulled out at the surface of the intra-articular site of the tibia. Tension was applied allowing the washer to lay down on the medial aspect of the tibia. Another guidewire was inserted from the lateral aspect of femur condyle, passing through the femoral tunnel in a lateral to medial direction. The intra-articular prosthetic sutures were pulled out from the femoral tunnel. The prosthetic sutures were then tied with a washer laid on the lateral aspect of femoral condyle, while the leg was held at 100 degrees with slight external rotation of the tibia. Subcutaneous tissue and skin were closed routinely after the stifle stabilization (Fig 2).

Post-operative lameness scoring: For each dog, the patient's history was taken, clinical signs were evaluated and a physical examination was conducted. All dogs were assessed for lameness using an adapted five-point (0–4) lameness scoring system (Table 1) (Cook *et al.*, 2016) at days 0, 7, 30 and 60 after the operation. Cranial drawer signs and cranial tibial thrust were also recorded.

Statistical analysis: Two groups were randomly drawn from the Kasetsart University Veterinary Teaching Hospital database. The data is summarized as mean±SD and the analysis was performed using GraphPad Prism version 6 (GraphPad Software, Inc., La Jolla, CA, USA, and STATA v 12, StataCorp, College Station, Texas, USA). Lameness scores were compared at different time points between the lateral suture and the intra-articular groups. The analysis was performed using a t-test with unequal variance. A p-value of less than or equal to 0.05 was considered statistically significant.

Figure 1 Lateral suture technique using a nylon suture and a crimp clamp for surgical stabilization of stifle joint in dogs affected with cranial cruciate ligament rupture. A: lateral view, B: medial view and C: anterior view.

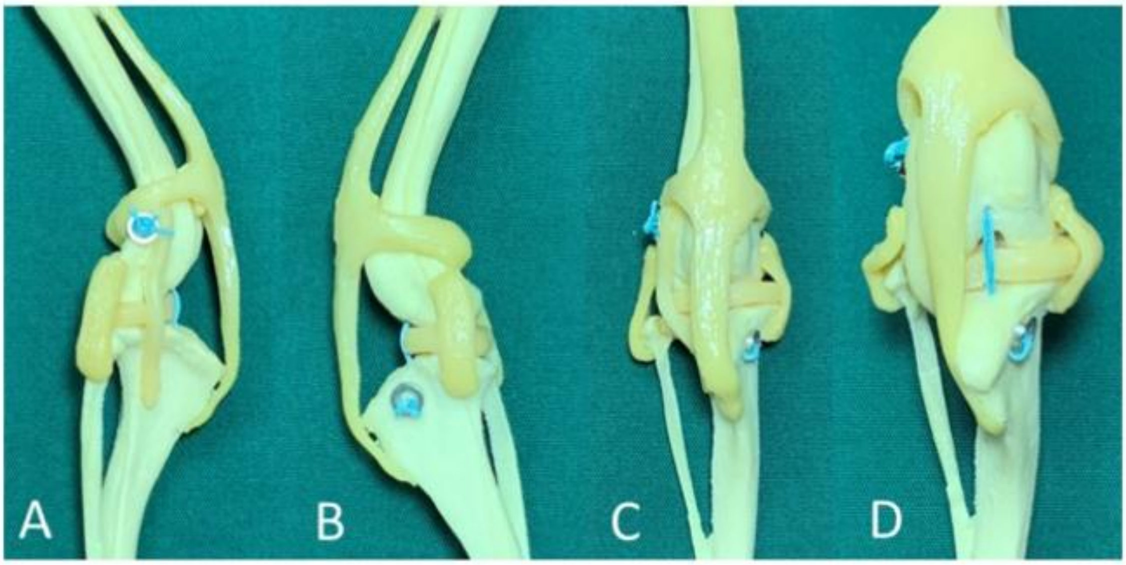

Figure 2 Intra-articular technique using double polyester braided sutures for surgical stabilization of stifle joint in dogs affected with cranial cruciate ligament rupture. A: lateral view, B: medial view, C: anterior view and D: intra-articular view.

Table 1 Visual assessment of a five-point lameness scoring system in dogs

Lameness score	Description
0	No observable lameness
1	Weight-bearing lameness
2	Weight-bearing lameness with intermittent non-weight bearing
3	Non-weight-bearing lameness with intermittent non-weight bearing
4	Non-weight-bearing lameness at all times

Results

The clinical information on the toy breed dogs in the lateral suture and the intra-articular groups is presented in Table 2. The number of males and females was comparable between the intra-articular suture group (5 males and 5 females) and the lateral suture group (4 males and 6 females, $p>0.05$; Table 2). Dogs in the intra-articular suture and the lateral suture groups were also similar in age (6.0±2.4 years vs. 7.7±1.8 years, $p>0.05$), body weight (4.6±1.9 kg vs. 5.2±1.6 kg, $p>0.05$) and body condition score (3.9±0.9 vs. 4.0±0.7, $p>0.05$; Table 2). There was no significant difference in the duration of CCLR before surgery between the intra-articular suture group (10±9 days) and the lateral suture group (12±8 days, $p>0.05$; Table 2).

Pre-operative lameness scores were comparable between the intra-articular suture technique and the lateral suture technique (3.3±0.7 vs. 3.5±0.5, $p>0.05$; Fig 3). The post-operative lameness scores of dogs in the intra-articular suture group were significantly lower than the scores of dogs in the lateral suture group at day 7 (1.6±0.5 vs. 2.4±0.7, $p<0.05$; Fig 3) and day 30 (0.3±0.5 vs. 1.2±1.3, $p<0.05$; Fig 3). However, there was no significant difference between the post-operative lameness scores of dogs in the two groups at day 60 (0.1±0.3 vs. 0.3±0.5, $p>0.05$; Fig 3). No drawer signs or surgical complications were detected in any of the dogs in the study (Fig 3).

Table 2 General characteristics of canine patients with CCLR undergoing surgical operation with a lateral suture technique or an intra-articular suture technique

Parameter	Lateral suture	Intra-articular suture
N	10	10
Age (years)	7.7±1.8	6.0±2.4
Male	4	5
Female	6	5
Body weight (kg)	5.2±1.6	4.6±1.9
Body condition score (1–5)	4.0±0.7	3.9±0.9
CCLR before surgery (days)	12±8	10±9

CCLR = cranial cruciate ligament rupture
All parameters (mean±SD) were not significantly different between groups.

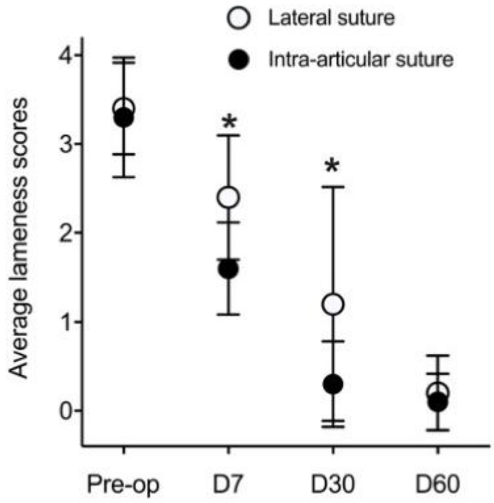

Figure 3 Lameness scores (mean ± SD) of dogs with cranial cruciate ligament rupture, comparing a lateral suture technique (white circle) and an intra-articular suture technique (black circle). The lameness scores were recorded at pre-operation (pre-op) and post-operation (at days 7, 30, and 60 post-operation). An asterisk (*) indicates a statistical significance of $p<0.05$ when comparing the two groups at each time point.

Discussion

Multiple factors are suspected as the etiology of CCLR in dogs, including genetics, sex, neutering status, hormonal influences, ligament pathology and mechanics of the stifle (Comerford *et al.,* 2011). From a clinical standpoint, large breed dogs affected with CCLR tend to be younger and small breed dogs tend to be middle-aged. In the present study, all cases had a high body condition score (mean±SD: 4.0±0.8), which may have been a result of neutering and aging. In obese dogs, an accumulation of white adipose tissue in the body can promote pro-inflammatory mediators (adipokine) that may be linked to the degeneration of ligaments. Currently, there is no evidence that adipokine is linked to CCLR in dogs (Comerford *et al.,* 2011). Nonetheless, risk factors of CCLR-affected dogs often include CrCL degeneration and being overweight, which can cause a high load on the CrCL in the stifle joint, leading to the development of CCLR (Brown, 1996; Colborne *et al.,* 2005; Edney and Smith, 1986).

Many types of CCLR treatment have been developed in the past decade. The surgical stabilization of a stifle joint can be classified into extracapsular techniques, intracapsular techniques and tibial osteotomy. Conservative management of CCLR in dogs with a body weight <15 kg can be achieved in current clinical practice (Comerford *et al.,* 2013). Nevertheless, a survey of veterinary surgeons recommended surgical stabilization of a stifle joint with either extracapsular stabilization (80%) or intra-articular stabilization (14%) in small dogs (<11 kg) (Korvick *et al.,* 1994), indicating that extracapsular stabilization techniques are commonly used in clinical practice.

Extracapsular stabilization using a circumfabellar tibial suture is a popular surgical technique for veterinary practitioners for CCLR treatment in small breed dogs (Comerford *et al.,* 2013; Korvick *et al.,* 1994). Various researchers have attempted to demonstrate an isometric point for the placement of the femur-tibial anchoring suture in order to reduce stifle instability after surgical stabilization of the stifle joint with a lateral suture technique in large and small breed dogs (Cook *et al.,* 2010; Fischer *et al.,* 2010; Harper *et al.,* 2004; Roe *et al.,* 2008; Thitiyanaporn, 2018; Tonks *et al.,* 2011). However, it may be impossible to identify an isometric anchoring point because the canine femoral condyle is more oval in shape. In small breed dogs, an anchoring point from the fabella and the caudal part of the tibial tuberosity has been suggested for treatment of CCLR (Thitiyanaporn, 2018). Moreover, a slight external rotation of the tibia has been suggested to improve the surgical stabilization of the stifle joint (Thitiyanaporn, 2018). In addition, an intra-articular injection of hyaluronic acid immediately after surgery using a lateral suture technique resulted in better clinical outcomes when compared with surgery without an injection (Trairatthanom, 2019).

Intra-articular suture stabilization techniques for the stifle have been suggested previously but these techniques have been discoraged due to a lack of success. Many types of suture materials have been used, including Teflon (Butler, 1964), carbon fiber (Denny and Goodship, 1980), Mini-TightRope® (Pinna, 2020), nylon (Prada, 2018), polyester (Prada, 2018) and an ultra-high molecular weight polyethylene terathalate core contained within a braided porous non-expanded polytetrafluoroethylene sheath (Barnhart *et al.,* 2016). Double lines of silicone-coated polyester (PremiCron®, USP No. 2) were selected for the intra-articular suture technique in the present study. A braided suture possesses high flexibility and silicone coating helps lubricate suture materials, thus reducing the peri-suturing hole trauma. Rapid recovery in dogs undergoing an intra-articular suture technique was identified at day 7 and day 30 after the operation, a finding that is consistent with previous studies (Barnhart *et al.,* 2016; Pinna, 2020; Prada, 2018). It should be noted that a high complication rate after the use of an intra-articular suture technique may occur (Barnhart *et al.,* 2016); nonetheless, the present study and others (Pinna, 2020) revealed good surgical outcomes after intra-articular suture stabilization, which could be the result of these studies' focus on toy breed and small breed dogs. In addition, the intra-articular suture technique simulates the natural attachment point of the CrCL, reducing the likelihood of common complications associated with lateral suture techniques, such as patellar dislocation and abnormal lateral compression between the lateral femoral condyle and the lateral tibial plateau.

Different materials for each technique may affect the clinical outcome. Non-absorbable braided polyester fiber is widely used in Intra-articular technique in both animals and humans with high elongation resistance and knot security (De Rooster, 2001). nylon has relatively good strength but has lower resistance to stretch compared to polyester. Nylon is relatively slippery material and may require four or five more throw to ensure knot security. It is possible that larger knot tying may exacerbate surrounding tissue irritation and impede tissue healing. Development of a crimp clamp system help improve knot security as well as reduce irritation to the surrounding tissue from knots (Sicard, 2002).

The present study demonstrated better post-operative outcomes in small breed dogs with CCLR for which an intra-articular suture technique was used compared with dogs for which a lateral suture technique was used. An intra-articular technique provided faster post-operative recovery, demonstrated by lower lameness scores at day 7 and day 30 after the operation. The lameness scores in both groups were not significantly different at day 60 and all dogs had near to normal gait. Thus, the present study suggests that an intra-articular technique may be an alternative surgical stabilization method in small breed dogs affected by CCLR.

The study had several limitations caused by retrospective studies. Several factors such as BCS , history of MPL, radiographs , physical examination at the discretion of the individual surgeon, may occur. Lack of owner compliance in terms of post-operative cage detention, physical rehabilitation or compliance with a post-operative care plan may result in a poor outcome. Moreover, veterinarians should also consider other methods of treating CCLR in medium and large breed dogs. Tibial plateau leveling osteotomy (TPLO) and the tibial tuberosity advancement (TTA) appear to be excellent methods for surgical management of cranial cruciate ligament injuries in medium and large breed dogs (Conzemius *et al*., 2005; DeCamp *et al*., 2015). This may be due to the fact that suture stabilization cannot provide long term biomechanics properties of the knee joint suffering from CCLR. Although the present study provided evidence of a good outcome after intra-articular stabilization for CCLR, the use of gait analysis and radiographic monitoring of OA development are necessary for the follow up to demonstrate the long-term outcomes after an intra-articular stabilization. Thus, we only recommend the use of an intra-articular technique specifically for toy breed dogs. For medium and large breed dogs, we still recommend the use of TPLO or TTA. Since TPLO and TTA involve osteotomy and fixation of the proximal tibia, application of TPLO or TTA may be technically challenging in small breed dogs with a limited area of the proximal tibia. Both lateral suture technique and intra articular suture technique are useful for surgical management of CCLR only in small breed dogs.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

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