

Comparison between surgical and non-surgical treatments of concomitant cranial cruciate ligament rupture and medial patellar luxation in small-breed dogs

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Abstract

Cranial cruciate ligament rupture (CrCLR) and medial patellar luxation (MPL) are common problems that cause hindlimb dysfunction, lameness and pain in dogs. Although surgical intervention is recommended for these conditions, it may not be suitable for an individual with some underlying diseases. The objective of the present study was to compare the outcomes between surgical and non-surgical treatments for concomitant CrCLR and MPL in small-breed dogs. Seven stifles from five small-breed dogs with concomitant CrCLR and MPL were enrolled and divided into two groups. Four limbs (three dogs) in Group 1 were treated conservatively, and three limbs (two dogs) in Group 2 were treated surgically with tibial plateau leveling osteotomy (TPLO). Both groups received rehabilitation, non-steroidal anti-inflammatory drugs (NSAIDs) and dietary supplements. In Group 1, two limbs had fully recovered within 24 weeks of conservative treatment, whereas the other two limbs showed a gradually improved limb function but did not return to normal after 32 weeks. All three limbs in Group 2 returned to normal limb function without lameness within 8 weeks after surgery. In conclusion, the TPLO surgery in dogs with concomitant CrCLR and MPL is considered an effective treatment with rapid recovery and limb function restoration compared to non-surgically conservative treatment.

Keywords: cranial cruciate ligament rupture, medial patellar luxation, rehabilitation, small breed dog, tibial plateau leveling osteotomy

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Introduction

Both cranial cruciate ligament rupture (CrCLR) and medial patellar luxation (MPL) are common problems of the stifle joint and cause hindlimb dysfunction, lameness and pain in dogs (DeAngelis, 1971; Jerram and Walker, 2003). These abnormal conditions are typically independent but also could occur as coexisting issues. The concomitant occurrence of CrCLR and MPL has been reported in approximately 6% to 20% of dogs (Arthurs and Langley-Hobbs, 2007; Gibbons *et al.*, 2006). The importance of patellar malalignment in the pathophysiology of CrCLR may be related to the inflammatory responses and abnormal loads on the stifle joint, which subsequently promote the degeneration of the cranial cruciate ligament (Roy *et al.*, 1992; Gibbons *et al.*, 2006).

Numerous treatment options and clinical outcomes for both CrCLR and MPL have been reported. Surgical treatments for CrCLR include modified tibial plateau leveling osteotomy (TPLO), tibial tuberosity transposition-advancement (TTTA), TPLO combined with tibial tuberosity transposition (ITT) to adjust the alignment of the tibial tuberosity and to stabilize the cranial tibial thrust (Flesher *et al.*, 2019; Langenbach and Marcellin-Little, 2010; Yeadon *et al.*, 2010). Additional treatments used for MPL correction include trochleoplasty, TTT, distal femoral osteotomy, medial tissue release and imbrication of the lateral fascia (Brower *et al.*, 2017; DeAngelis, 1971). Although surgical treatment usually results in favorable outcomes, there are some limiting factors that complicate anesthesia, especially in old dogs and in the presence of some underlying diseases (Bille *et al.*, 2012; Gruenheid *et al.*, 2018). These also include the reported complication rates, which could range from 10% to 34% from surgical management that may occur such as implant-related infection, implant failure, and fractures (Bergh and Peirone, 2012). Hence, alternative treatments such as medical management, rehabilitation and acupuncture might be a better choice of treatment to minimize pain, reduce inflammation and aid in strengthening the muscles in these patients (Adrian *et al.*, 2013; Marsolais *et al.*, 2002; Millis and Ciuperca, 2015).

Despite the recent investigation into the treatment outcome in large breed dogs, the results in small-breed dogs remain unclear (Wucherer *et al.*, 2013). This study therefore reports the clinical outcomes for CrCLR and MPL treatment in small-breed dogs by using surgical and non-surgical procedures combined with rehabilitation and dietary supplements.

Materials and Methods

Study design and data collection: We searched for small-breed dogs diagnosed with concomitant CrCLR and MPL between 2015 and 2020 and available for frequent and long-term follow-up. Cases were required to have a complete medical record including breed, gender, age, weight, physical examinations, lameness evaluation, sufficient descriptions of the treatments and follow-up until 6 months after surgery. Radiography of the affected limb was performed to

exclude the possibility of concurrent fracture or other underlying musculoskeletal diseases. Patellar luxation was graded from 1 to 4, and a lameness score was given from 0 to 5, whereas the tibial plateau angle (TPA) was measured in the surgical group (Roy *et al.*, 1992; Gibbons *et al.*, 2006; Witte and Scott, 2011). Physical examination, lameness evaluation and treatment in this study were performed by the board-certified veterinarian (CW). Two treatment options were offered to the owners, namely surgical treatment consisting of TPLO and MPL correction and non-surgical treatment. Despite the chosen treatment options, medical management and rehabilitation were included in each case. All recorded data used in this study were performed with the owner's consent.

Non-surgical treatment: The dogs that received non-surgical treatment were classified as Group 1. The rehabilitation program consisted of photobiomodulation, which is also known as laser therapy, and an underwater treadmill once a week. Laser therapy was started in the first week after injury or TPLO surgery, with a dosage of 4 J/cm², whereas underwater treadmill therapy was started in the second week. Both laser and underwater treadmill therapy were performed weekly for 8 weeks, followed by every 2 weeks in the third month. The speed and time of the underwater treadmill were adjusted individually for each dog. The owners were asked to perform home exercises, including 10 minutes of hot compression followed by a passive range of motion at the affected joint twice a day.

Surgical treatment: Group 2 consisted of the dogs that received surgical treatment. Patients were anesthetized, positioned in dorsal recumbency, and subjected to aseptic preparation. First, arthrotomy was performed to examine the intraarticular structure, including the cranial cruciate ligament, the caudal cruciate ligament, and the menisci. Then, the remnants of a torn ligament or torn sections of the meniscus were removed as necessary. Trochlear block recession, imbrication of lateral fascia and joint capsule were performed for MPL correction depending on the surgeon's decision. A medial approach of the proximal tibia was performed by incision and reflected the insertion of sartorius caudally; osteotomy was performed according to pre-operative planning. The tibia was rotated caudally and slightly lateral translated to realign the tibial tuberosity. A 1- or 1.2-mm K-wire was used to secure the new tibia position, and a bone plate and screws were used to fix the bone. The sartorius was sutured back to its insertion, followed by suturing the fascia, subcutaneous tissue, and skin.

Post-operative care and follow-up: After surgical treatment, the dogs in Group 2 received cephalexin 25 mg/kg twice a day for 7 days. A radiographic examination was performed immediately and 12 weeks after surgery. The suture was removed at 10 days postoperatively. The other post-operative management practices including laser therapy, underwater treadmill and home exercise, were similar to those in the non-surgical treatment group.

Medical management: Medical management mainly consisted of the administration of non-steroidal anti-inflammatory drugs (NSAIDs) and dietary supplements. Depending on the pain assessment evaluated individually, NSAIDs were prescribed with carprofen 2.2 mg/kg twice a day or firocoxib 5 mg/kg once a day for 2–4 weeks, whereas marine-based fatty-acid compound was given daily for at least 3 months. Gabapentin 10 mg/kg was given twice a day and prescribed as needed; other supplements were given according to the owner's consideration.

Ethical approval: The dogs participating in this study were chosen from the Department of Surgery, Veterinary Teaching Hospital of Chulalongkorn University, Thailand. This study was performed in accordance with the ethical policies of the journal and was approved by the Institutional Animal Care and Use Committee of the Faculty of Veterinary Science, Chulalongkorn University (No. 2031032). All dogs that participated in this study were client-owned and joined the study after being informed and written consent for the treatment of their dogs.

Results

Signalment: Seven limbs from five small-breed dogs, namely two Pomeranians, two Yorkshire Terriers, and one Chihuahua, were diagnosed as CrCLR. Four limbs of three dogs were classified as Group 1, receiving non-surgical treatment consisting of rehabilitation therapy and medical management including NSAIDs and dietary supplements. The other three limbs from two dogs belonged to Group 2 and received surgical

treatment. All dogs had a history of MPL, whereas three dogs (two stifles in Group 1 and one stifle in Group 2) had been subjected to previous MPL correction surgery on the same stifle on which CrCLR occurred. Table 1 shows the signalments and history of all dogs.

Physical examinations: Based on physical examination and hematological results, except for lameness, all dogs were otherwise in good health. The orthopedic examination resulted in positive findings for both the cranial drawer sign and tibial compression test, manifesting the stifle instability and indicating the absence of the cranial cruciate ligament. Patella grading, lameness score, medial buttress, joint effusion, cranial cruciate ligament condition, meniscal injury and TPA were evaluated as illustrated in Table 2.

Radiographic examinations: Radiographs of the stifles in both groups are shown in Figures 1 and 2. Three stifles in Group 1 (only two stifles included in the study) that had previously been subjected to surgical correction for MPL remained observable by the presence of K-wires or tension band wires. The radiographs revealed distinguished cranial tibial translation on all stifles diagnosed with CrCLR, except the right stifle of case No. 4 in Group 2. After TPLO surgery performed in Group 2, post-operative TPAs were in an acceptable range, with the absence of cranial tibial translation. The osteotomised tibia was utterly healed at 12 weeks follow-up, as indicated by the absence of a fracture line (Fig. 2).



Figure 1 Radiographic images of the dog in case No. 1 (A), 2 (B), and 3 (C) in craniocaudal and lateral views of the right and left hindlimb. Cranial cruciate ligament rupture (CrCLR) was diagnosed on left stifle in case No. 1 (A) and 2 (B), while bilateral CrCLR was diagnosed in case No. 3 (C). Cranial tibial translation was presenting in all stifles diagnosed with CrCLR.



Figure 2 Radiographic images from pre-operative, post-operative, and at 12 weeks follow up of the dog in case No. 4 with both right (A-C) and left (D-F) cranial cruciate ligament rupture (CrCLR) and the dog in case No. 5 with right (G-I) CrCLR. The tibial plateau leveling osteotomy (TPLO) technique was chosen to stabilize the femorotibial joint from CrCLR.

Post-operative care and clinical outcomes - Case No 1:

The dog received rehabilitation therapy and medical management as a conservative treatment. Carprofen 2.2 mg/kg and marine-based fatty-acid compounds were given for 2 and 12 weeks, respectively, as pain control. The rehabilitation therapy was started immediately after the owner's decision for non-surgical treatment. At the 8-week follow-up, the limb function improved, with a decreased lameness score (1/5), whereas the observable lameness had completely disappeared at the 10-week follow-up. However, the dog had intermittent lameness at 18 weeks follow-up, which gradually improved until it had completely disappeared at 24 weeks follow-up.

Post-operative care and clinical outcomes - Case No 2:

Weight control was recommended for this dog, together with rehabilitation therapy and medical management as a conservative treatment. The dog received carprofen 2.2 mg/kg and gabapentin 10

mg/kg for 4 weeks. In addition, glucosamine/chondroitin sulfate and marine-based fatty-acid compound were prescribed for 12 weeks. The dog was able to fully bear weight on the left hindlimb, with a lameness score of 1/5 at 12 weeks follow-up. Subsequently, it received glucosamine/chondroitin sulfate and marine-based fatty-acid compound on alternating days for 12 more weeks. Lameness was gradually improved until it had completely disappeared at 24 weeks follow-up.

Post-operative care and clinical outcomes - Case No 3:

The dog received rehabilitation therapy and medical management as a conservative treatment. Carprofen 2.2 mg/kg was given for 4 weeks, whereas glucosamine/chondroitin sulfate and marine-based fatty-acid compound were given for 12 weeks. At the 12-week follow-up, the dog was able to bear weight fully on both hindlimbs without showing any sign of pain. However, lameness of both hindlimbs remained

observable, with a lameness score of 2/5. Alternate-day glucosamine/chondroitin sulfate and the marine-based fatty-acid compound were continued for 2 years. The observable lameness gradually improved but did not completely disappear after 32 weeks follow-up.

Post-operative care and clinical outcomes - Case No 4:

The dog received firocoxib 5 mg/kg for 2 weeks, together with gabapentin 10 mg/kg and marine-based fatty-acid compound for 3 weeks before having surgical treatment on the right stifle joint. Trochlear block recession and imbrication of the lateral fascia and joint capsule were used for MPL correction, whilst modified TPLO was used to stabilize the femorotibial joint and to realign tibial tuberosity. Erosion of the patella and periarticular osteophyte formation at the femoral trochlear ridge was observed. Lameness was not observed at 8 weeks postoperatively. Due to the significant improvement in limb function, the dog was running wild, and the lameness score of 2/5 was observed at week 10. Thus, a cold compression was recommended, and carprofen 2.2 mg/kg was given for 3 days. The lameness gradually improved and disappeared within 10 days after medical management. The contralateral limb was later diagnosed with CrCLR; therefore, the same management and surgical procedures were used to

correct MPL and CrCLR. Any sign of lameness was not observed after 8 weeks follow-up.

Post-operative care and clinical outcomes - Case No 5:

The dog received carprofen 2.2 mg/kg for 2 weeks and marine-based fatty-acid compound for 3 weeks before having surgical treatment on the right stifle joint. The instability of the femorotibial joint was corrected by the TPLO procedure. At 8 weeks follow-up, the limb function was improved, without observable lameness. Cranial drawer movement and positive tibial compression remained in all stifles in Group 1. Although tibial compression was mildly detected in case No. 3, the dog showed an internal rotation of both stifle joints while walking, and stifle extension was limited. The lameness of this dog remained observable after 32 weeks follow-up, whereas another two dogs fully recovered within 24 weeks. After surgical treatment, both dogs in Group 2 had swelling at the surgical site and presented lameness in the first 2 weeks after surgery; the signs gradually improved until they completely disappeared by 8 weeks after surgery. At 24 weeks after surgery, all stifles in Group 2 were rechecked for joint stability. The tibial compression test was negative, but cranial drawer movement remained. Lameness scores and treatments in each dog are indicated in Table 3.

Table 1 Signalment and history of five dogs presenting with concomitant cranial cruciate ligament rupture (CrCLR) and medial patellar luxation (MPL).

ID	Breed	Age (month)	Sex	Body weight (kg)	BCS	Disease history
1	Pomeranian	48	Male	3.6	4/5	Left MPL 4/4, Right MPL 3/4 Surgical treatment of bilateral MPL at 12-month-old Diagnosed with left CrCLR
2	Pomeranian	39	Female	5.8	5/5	Left MPL 4/4, Right MPL 2/4 Surgical treatment of left MPL at 15-month-old Diagnosed with left CrCLR
3	Yorkshire Terrier	72	Female	3.2	3/5	Bilateral MPL 3/4 No previous surgical treatment Diagnosed with bilateral CrCLR
4	Yorkshire Terrier	48	Female	2.9	3/5	Bilateral MPL 2/4 No previous surgical treatment Diagnosed with right CrCLR
5	Chihuahua	48	Female	4.7	4/5	Right MPL 1/4 Surgical treatment of left MPL at 12-month-old Diagnosed with right CrCLR

BCS; body condition score, MPL; medial patellar luxation, CrCLR; cranial cruciate ligament rupture

Table 2 Orthopedic examination for lameness score (0-5), patella grading (1-4), cranial drawer sign, tibial compression test, medial buttress, joint effusion, condition of cranial cruciate ligament, condition of meniscus, pre-operative tibial plateau angle and post-operative tibial plateau angle of five dogs presented in this study.

ID	Limb	Lameness score	MPL grade	CDS	TCT	Medial buttress	Joint effusion	CrCL	Meniscus	Pre TPA	Post TPA
1	Right	0/5	Normal*	Neg	Neg	No	No	Normal	NE	NE	NE
	Left	2/5	Normal*	Pos	Pos	Yes	Yes	Rupture	NE	NE	NE
2	Right	0/5	2/4	Neg	Neg	No	No	Normal	NE	NE	NE
	Left	4/5	1/4*	Pos	Pos	Yes	Yes	Rupture	NE	NE	NE
3	Right	3/5	3/4	Pos	Pos	Yes	Yes	Rupture	NE	NE	NE
	Left	2/5	3/4	Pos	Pos	Yes	Yes	Rupture	NE	NE	NE
4	Right	3/5	2/4	Pos	Pos	Yes	Yes	Rupture	Intact	28°	5.4°
	Left	3/5	2/4	Pos	Pos	Yes	Yes	Rupture	Intact	27°	5.6°
5	Right	3/5	Normal*	Pos	Pos	Yes	Yes	Rupture	Intact	27°	5°
	Left	0/5	Normal	Neg	Neg	No	No	Normal	NE	NE	NE

MPL; medial patellar luxation, CDS; cranial drawer sign, TCT; tibial compression test, CrCL; cranial cruciate ligament, Pre TPA; Preoperative tibial plateau angle, Post TPA; Postoperative tibial plateau angle, Pos; positive result, Neg; negative result, NE; not evaluated

*Previous MPL correction surgery

Table 3 Lameness score (0-5) pre-operatively (week 0) and at 2, 4, 6, 8, 10 and 12 weeks after surgery and treatment uses in five dogs.

ID	Limb	Lameness score* (week)							Treatment
		0	2	4	6	8	10	12	
1	Right	0	0	0	0	0	0	0	Non-surgical treatment: rehabilitation, NSAIDs and marine-based fatty-acid compound
	Left	2	1	1	1	1	0	0	
2	Right	0	0	0	0	0	0	0	Non-surgical treatment: rehabilitation, NSAIDs, marine-based fatty-acid compound and glucosamine/chondroitin sulfate
	Left	4	3	2	2	2	2	1	
3	Right	3	2	2	2	2	2	2	Non-surgical treatment: rehabilitation, NSAIDs, marine-based fatty-acid compound and glucosamine/chondroitin sulfate
	Left	2	2	2	2	2	2	2	
4	Right	3	3	2	1	0	2	0	Surgical treatment: TPLO, rehabilitation, NSAIDs and marine-based fatty-acid compound
	Left	3	2	2	1	0	0	0	
5	Right	3	2	1	1	0	0	0	Surgical treatment: TPLO, rehabilitation, NSAIDs and marine-based fatty-acid compound
	Left	0	0	0	0	0	0	0	

TPLO; tibial plateau leveling osteotomy, NSAIDs; non-steroidal anti-inflammatory drugs

*Lameness score 0; walk normally, 1; slightly lame, 2; obvious weight bearing lameness, 3; severe weight bearing lameness, 4; intermittent non-weight bearing lameness, 5; continuous non-weight bearing lameness

Discussion

Surgical treatment of CrCLR aims to stabilize the femorotibial joint during weight-bearing. The TPLO is one of the most common orthopedic procedures used to eliminate cranial tibial thrust through the proximal tibia osteotomy performed in this study. Decreasing the TPA to 5 degrees can prevent craniocaudal tibial translation in a weight-bearing position, thus allowing the stifle joint to fully return to its normal function (Ballagas *et al.*, 2004; Putame *et al.*, 2019). Despite several advantages of TPLO, non-surgical treatment may be considered in old dogs with health problems (Bille *et al.*, 2012). Concomitant CrCLR and patellar luxation have been reported in large-breed dogs (Arthurs and Langley-Hobbs, 2007; Gibbons *et al.*, 2006). Dogs with MPL tend to show an increased risk of CrCLR due to malalignment of the extensor mechanism and internal rotation of the proximal tibia, causing stress to the cranial cruciate ligament. In addition, osteoarthritis induced by patellar luxation promotes the production of inflammatory cytokines

that are involved in the degeneration process of the cranial cruciate ligament and atrophy of the periarticular supporting structures. These abnormal conditions, combined with a lack of patellar ligament stability, predispose dogs to CrCLR (Ichinohe *et al.*, 2015; Verpaalen *et al.*, 2018).

This study reported CrCLR in seven stifles from five small-breed dogs with a history of MPL. The dogs in the non-surgical group received rehabilitation therapy and medical management consisting of NSAIDs and dietary supplements. Two dogs in this group had previously been subjected to correction surgery for MPL on the same stifle that was diagnosed with CrCLR. Limb function, lameness status and muscle condition were fully recovered at 6 months after conservative treatment. However, one dog that had bilateral concomitant CrCLR and grade 3 MPL without any previous surgery performed showed delayed improvement of limb function. At 8 months after conservative treatment, weight-bearing and stifle extension were not completely restored. We suggest that the delayed improvement of this dog was related

to the aberrant load on the stifle joint due to high-grade MPL and bilateral CrCLR. The dogs in the surgical group received TPLO in addition to rehabilitation therapy, NSAIDs and dietary supplements. They were able to fully restore function without lameness observed at 8 weeks after surgery. The combination of TPLO surgery, rehabilitation therapy, and medical management in dogs with concomitant CrCLR and MPL was more effective for the restoration of the limb function than conservative treatment, as indicated by the rapid recovery. This outcome is in agreement with that of a study conducted on large-breed dogs (Wucherer *et al.*, 2013).

Pain and inflammation of the stifle joint are usually associated with CrCLR. Most of the affected dogs tend to be reluctant to place weight on the affected limb, which later could cause progressive muscle atrophy. The use of NSAIDs can effectively relieve the pain by reducing inflammation. However, the long-term use of NSAIDs is limited because of several adverse effects, utilizing dietary supplements in conjunction with NSAIDs offers an alternative approach for long-term pain and inflammation management, especially in chronic diseases such as osteoarthritis, since it does not potentially cause any adverse effects. Previous studies have shown that dietary supplements such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are omega-3 fatty acids could inhibit substances that cause inflammation (Calder, 2015; Doggrell, 2011). We suggest that appropriate pain control is necessary and could be beneficial to the quality of life and encourage limb usage, which positively affects the muscle condition of the limb.

Rehabilitation therapy helps in the restoration of muscle strength and joint function, prohibiting potential complications. Laser therapy helps to reduce pain and inflammation by decreasing prostaglandin E and F production and stimulating the inhibition of the synthesis of prostaglandin synthetase (Kuryliszyn-Moskal *et al.*, 2015; Thabet *et al.*, 2017). Moreover, underwater treadmill therapy helps to improve strength, muscle endurance, range of motion (ROM) and agility while minimizing pain and having a low impact on the joint (Millis and Levine, 2014).

In small-breed dogs, CrCLR can be treated either by surgical or non-surgical methods, depending on the health condition and owner's decision. However, surgical treatment with TPLO provides more mechanical stability and restores limb function more rapidly compared to conservative treatment, especially in dogs with MPL. Rehabilitation therapy is integrated to enhance the restoration of muscle strength and joint function. TPLO surgery for dogs with concurrent CrCLR and MPL is widely regarded as a highly effective treatment option, offering rapid recovery and significant improvement in limb function when compared to non-surgical conservative approaches. Additionally, TPLO surgery is recommended as a potent therapeutic intervention to mitigate the potential long-term side effects associated with the prolonged use of NSAIDs.

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