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Original article

LONG-TERM CLINICAL AND GONIOMETRIC FOLLOW-UP OF LATERAL SUTURE SURGERY IN DOGS WITH CRANIAL CRUCIATE LIGAMENT RUPTURE

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Summary

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The aim of this study was to evaluate the complications and the short-, medium-, and long-term outcomes following treatment of cranial cruciate ligament (CCL) rupture in dogs using the lateral fabello-tibial suture technique. The patients were ten dogs of various breeds, 62.5 ± 18.8 months of age, weighing 30.2 ± 3.3 kg, with unilateral CCL rupture. At 2, 6, 12, 24, and 52 weeks after surgery, the dogs were re-evaluated with clinical examination, gait and pain analysis, and radiography. A major complication was identified in one dog (10%), requiring second surgery due to implant failure and destabilisation of stifle joint. Minor complications occurred in two dogs postoperatively (one late meniscal injury and one case of seroma formation). The short-term outcome at two and six weeks postoperatively was considered good in six dogs and satisfactory in four dogs, while the mid-term outcome (between 12 and 24 weeks) was good to excellent in eight dogs and satisfactory in two dogs. All ten dogs had a good to excellent outcome 52 weeks after surgery. The lateral suture technique is generally safe and given the major benefits, such as lower costs, lower technical difficulty, and minimal requirement for specialised equipment, will probably remain a popular and alternative method for treatment of CCL insufficiency in dogs with good degree of owner satisfaction.

Key words: cranial cruciate ligament, dog, lateral suture, treatment

INTRODUCTION

Cranial cruciate ligament (CCL) rupture in dogs is one of the most common causes of hind limb lameness (Hayashi *et al.*, 2004). CCL rupture can result from traumatic hyperextension of the stifle or more typically, from chronic degenerative changes (Johnson & Johnson, 1993). The most commonly affected dogs are medium to large breeds between 6 and 10 years of age; however, dogs of any age and any size, including small and toy breeds, can rupture their CCL (Duval *et al.*, 1999). Meniscal pathology is often seen concurrently or as a consequence of CCL rupture; it is mainly the caudal pole of medial meniscus which shows disease (Bennett &

May, 1991). Disruption of the CCL results in joint instability and secondary inflammation, both of which may contribute to the development of osteoarthritis (Jerram & Walker, 2003). Several surgical techniques have been described to stabilise the CCL-deficient stifle yet no single technique has consistently arrested development or progression of osteoarthritis, or has consistently returned operated limb to normal function (Aragon & Budsberg, 2005).

Extracapsular stabilisation (ES) encompasses a number of different surgical techniques designed to stabilise a CCL-deficient stifle. Biological or synthetic materials are placed superficially to the joint capsule, spanning the area lateral and/or medial to the stifle joint. From the original extracapsular repair introduced during the 1960s to the current modifications of the technique, the general theoretical goal is to counteract the translational and rotational instability present when the CrCL is damaged (Vaughan, 2010).

Lateral fabellar suture (LFS) has been used to provide joint stability through static neutralisation of cranial drawer motion without alteration of the stifle joint anatomy (Vasseur, 2003). This is achieved through altering the extra-articular structures and thickening the periarticular tissues in response to the surgical procedure and implant suture (Fox & Baine, 1986). Lateral fabellar suture placement is technically easy and highly applicable with a relatively low complication rate. However, it provides short term stabilisation of the joint. The forces on the suture material necessitate a material with high tensile strength, minimal elongation, and high stiffness (Huber *et al.*, 1999; De Rooster *et al.*, 2006). Therefore, the synthetic suture material should be mechanically strong enough to withstand cyclic loading and tension until the developed periarticular fibrosis permanently stabilises the joint. Additionally, it should be handled easily, hold securely when knotted, withstand deformation during knot tying or during application of crimp-clamp, and minimise bacterial adherence (Banwell *et al.* 2004; 2005). Nylon leader line is a commonly used synthetic material for these procedures, with joint stability maintained more effectively by crimped nylon loops, compared to knotted loops (Korvick *et al.*, 1994; Vianna *et al.*, 2006).

Lateral fabellar suture is reportedly one of the most common techniques used to stabilise the CCL-deficient stifle in dogs, but in the literature, clinical results, goniometry and data for long-term follow-up of this operative technique are limited. Despite the small number of cases in our study, clinical, X-ray and goniometric examinations were performed during all follow-up periods, which provide valuable information and presence of early and last post-operative complications.

The aim of this survey was to evaluate complications, short-, medium- and long-term outcome in dogs of various breeds with ruptured CCL undergoing lateral fabellar suture technique and to share our experience regarding the clinical data, goniometric findings, meniscal damage and post-operative complications of the surgery.

MATERIALS AND METHODS

All dogs included in the present study were referred to the Small Animal Clinic of the Faculty of Veterinary Medicine, Stara Zagora, Bulgaria between September 2017 and March 2019 with history of unilateral pelvic limb lameness. Complete orthopaedic examination was performed to identify the cause of lameness. Upon detection of pain, positive cranial drawer sign, tibial compression test and joint effusion, suggesting CCL rupture, radiography of both stifle joints was done in two orthogonal views after deep intramuscular sedation with 0.025 mg/kg medetomidine hydrochloride (Dorbene vet®, 1 mg/mL, Syva, Spain) and 0.1 mg/kg butorphanol tartrate (Butomidor®, 10 mg/mL, Richter Pharma, Austria). After confirmation of the tentative diagnosis, dogs with CCL rupture dating back to 3 weeks maximum were used in the survey. All patients with bilateral CCL rupture, radiographic signs of osteoarthritis and body weight under 15 kg were excluded.

The owners of patients were informed about the alternative operative techniques (TTA rapid or intracapsular under-and-over fascial strip technique) and were allowed to participate in the survey after signing an informed consent form.

The survey included ten dogs (ten stifles) of different breeds, six females and four males, weighing 30.2±3.3 kg on the average (min–max: 22.5–36.4 kg). The average age of the group was 62.5 ± 18.8 months (from 3 to 9 years). After medial arthrotomy and inspection of the stifle joint, the CCL was found to be completely ruptured in seven dogs and partially in three dogs. In seven patients, the left stifle was affected, while the right stifle was affected in three patients. Using a meniscal probe, the medial meniscus was found to be injured in five joints: two bucket-handle tears, one horizontal tear, one longitudinal tear, and one radial tear. The lateral meniscus was intact in all cases.

The surgery was performed following a strict anaesthesia protocol. Premedication was done with acepromazine maleate (Neurotranq®, 10 mg/mL, Alfasan International, Netherlands) at a dose of 0.025 mg/kg and buprenorphine (Bupaq®, 0.3 mg/mL, Richter pharma, Austria) at a dose of 0.01 mg/kg, applied together in a syringe in m. quadriceps femoris. Thirty minutes apart, induction was done with intravenous application of 5 mg/kg propofol (Propofol Fresenius®, Fresenius Kabi GmbH, Germany). After endotracheal intubation, inhalational anaesthesia was maintained with isoflurane (Forane®, Abbott Laboratories Limited, United Kingdom) at 1.5-2.5 vol%, in 100% O_2. Fluid management was performed with Ringer lactate infusion at a rate of 10 ml/kg/h.

The lateral fabello-tibial suture (LFTS) technique is based on the procedure described by DeAngelis & Lau (1970) modified by Flo (1975). The used implants in lateral fabello-tibial suture technique were fabella needle, monofilament nylon and a crimp tube of different sizes. In all dogs 100 lb × 800 mm strength of line with medium 62 mm fabella needle and 12 mm crimp tube (SMI AG, Belgium) were used. After lateral arthrotomy, both menisci were inspected and treatment was done in all dogs with meniscal injury. Post operatively, dogs received amoxicillin/clavulanic acid (Synulox® RTU, Zoetis, Belgium) at a dose of 25 mg/kg, applied subcutaneously for 10 days and 3 mg/kg carprofen (Carprieve Pet Injection®, 50 mg/ml, Norbrook, Northern Ireland) s.c. for 5 days.

All follow-up parameters were registered at the day of surgery (day 1) and on post-operative day 14 (week 2), day 42 (week 6), day 84 (week 12), day 168 (24 weeks) and day 365 (year 1). At these periods, radiographs of both stifles were done along with goniometric evaluation. Kinetic gait analysis and evaluation of lameness, pain and joint effusion was per-

Table 1. Kinetic gait analysis system for clinical evaluation of lameness, pain and joint effusion of knee osteoarthritis in dogs (Cross *et al.*, 1997)

Parameter	Score	Clinical sign
Standing lameness	1	Normal weight-bearing
	2	Partial weight-bearing
	3	Intermittent toe touching
	4	No weight-bearing
Trotting lameness	1	Normal weight-bearing
	2	Marked lameness with partial weight-bearing
	3	Marked lameness with intermittent toe touching
	4	No weight-bearing
Pain response	1	Absence of pain and response
	2	Slight pain, allowing manipulations of the limb within the normal range of motility, manifested by turning the head and pulling the limb away
	3	Moderate pain, not allowing manipulations of the limb within the normal motility range, manifested as described for score 2
	4	Significant pain, not allowing manipulations of the limb
Joint effusion	1	Normal – palpatory compression upon the patellar ligament
	2	Weak – slight increase, the patellar ligament is palpated
	3	Moderate – marked increase, slightly perceptible ligament
	4	Significant – the patellar ligament is not palpated

formed by the scoring system reported by Cross *et al.* (1997) (Table 1).

For goniometric studies, goniometer with arms (GIMA, Germany) was used. Measurements were performed in lateral recumbency, with the studied limb exposed. The stifle range of motion (ROM) was measured in full flexion and extension by placing the tool along longitudinal axes of the femur (through trochanter major femoris) and the tibia (through maleolus lateralis fibulae). Results of operated limbs were compared with the contralateral healthy joint.

Numerical data were presented as median and range (for kinetic gait score) and mean and SEM (for other goniometric parameters). Statistical analysis of data was done either by the non-parametric Mann-Whitney test and Student's t-test at a level of significance $P<0.05$.

RESULTS

A major complication was identified in one dog (10%, case 2), requiring second surgery due to implant loosening and destabilisation of the stifle joint. Minor complications occurred in two dogs postoperatively (one late meniscal injury and one case of seroma formation). The short-term outcome at two and six weeks postoperatively was considered good in five dogs, satisfactory in four dogs and moderate in one dog, while the mid-term outcome (between 12 and 24 weeks) was good to excellent in seven dogs and satisfactory in three dog. All ten dogs had a good to excellent outcome 52 weeks after surgery.

Minimal cranial drawer motion was apparent in three operated limbs 6 weeks postoperatively with no apparent lameness. No lameness was observed 24 weeks postoperatively and at week 52 minimal progression of stifle osteoarthritis was observed in seven dogs, moderate in two dogs and advanced in one dog.

In the earliest period (2 weeks), there was a moderate joint effusion and an unevenly enlarged joint space compared to the control joints (Fig. 1 and 2). In the middle of the period (24 weeks), changes in the shape and area of the bone surfaces were seen, the epiphyseal subchondral areas showed increased density, sclerosis and epicondylar focal lysis as well as increased subchondral osteosclerosis of the femur and tibia. Osteophytes were located mainly on the joint periphery and the

Fig. 1. Pre-operative (top) and immediately post-operative (bottom) medio-lateral and caudo-cranial radiographs.

Fig. 2. Medio-lateral and caudo-cranial radiographs 2 weeks and 6 weeks post-operavively.

trochlear margins (Fig. 3).

During the last control period (52 weeks), the subchondral osteosclerosis of the femur and tibia intensified, which completely changed their architecture. The joint space was reduced and the bone margins blurred and uneven. Some radiographs from this period of the joint capsule showed increased density (periarticular fibrosis) (Fig. 4).

Data from the kinetic gait and goniometric analyses are presented in Table 2. Before the surgery, the score of the affected joint was 10 (8–13), and by the second, sixth and twelfth weeks remained statistically significantly higher ($P<0.001$) compared to contralateral stifle: 8.5 (6–11), 7 (5–9) and 6 (4–8) respectively. Until the 24th postoperative week, the difference in both stifle scores remained significant ($P<0.01$). One year after LFTS surgery, both joints had equal scores, with restoration of function in the operated limb and no significant difference.

The maximum extension angle (MEA) exhibited statistically significant difference from the contralateral healthy joint prior to the surgery and during every follow-up period. By post-operative weeks 2, 6 and 52, the level of significant difference was the same ($P<0.05$). Twelve weeks after the surgery the level of difference was highly significant and by the 24th week, it was lower ($P<0.01$).

On the other hand, the maximum flexion angle (MFA) was not statistically significant prior to the surgery, but showed significant difference during 2nd ($P<0.05$) and 6th, 12th, 24th and 52nd ($P<0.01$) post-operative week. Range of motion (ROM) differed significantly before the surgery ($P<0.05$) and during all follow-up periods ($P<0.01$ by the 2nd week and $P<0.001$ for the other periods).

The values of MEA, MFA and ROM by the first year after surgery (148.4±0.5°; 44.9±0.4° and 104.6±0.5° respectively)

Fig. 3. Medio-lateral and caudo-cranial radiographs 12 weeks and 24 weeks post-operavively.

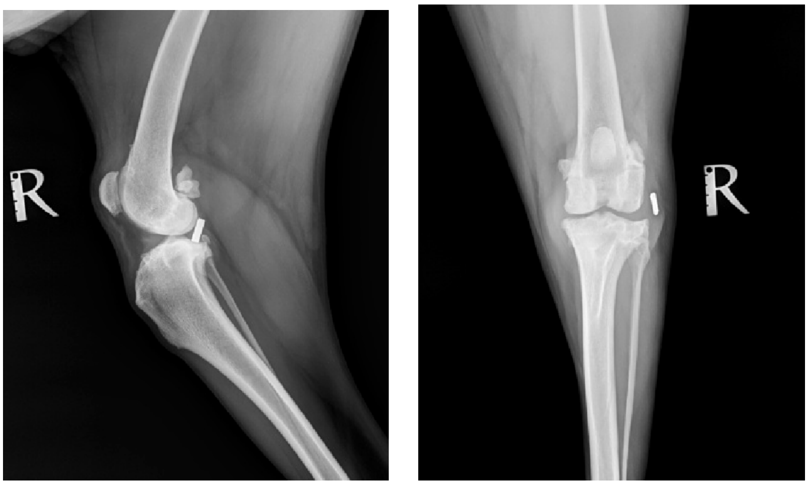

Fig. 4. Medio-lateral and caudo-cranial radiographs 52 weeks post-operatively.

Table 2. Clinical evaluation score (median and range; n=10) and goniometric analysis in dogs undergoing LFTS surgery for treatment of CCL rupture (mean±SEM; n=10)

Joint	Post-operative weeks					
	Before surgery	2	6	12	24	52
Kinetic gait analysis score						
Operated	10 (8–13)	8.5 (6–11)	7 (5–9)	6 (4–8)	5 (4–6)	4 (4–5)
Control	4 (4–4)	4 (4–4)	4 (4–4)	4 (4–4)	4 (4–4)	4 (4–4)
P	<0.001	<0.001	<0.001	<0.001	<0.01	n.s.
Maximum extension angle, degrees						
Operated	148.4±0.5	145.7±0.4	145.1±0.3	144.5±0.3	145.4±0.3	145.7±0.3
Control	146.9±0.4	147.0±0.5	146.9±0.4	147.1±0.4	147.3±0.5	147.0±0.5
P	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05
Maximum flexion angle, degrees						
Operated	44.9±0.4	45.0±0.4	47.1±0.5	46.9±0.4	46.5±0.4	46.4±0.3
Control	46.4±0.5	47.1±0.5	45.0±0.4	44.7±0.4	44.9±0.3	44.9±0.4
P	n.s.	<0.05	<0.01	<0.01	<0.01	<0.01
Range of motion, degrees						
Operated	104.6±0.5	99.3±0.5	98.0±0.4	97.6±0.4	99.0±0.4	99.4±0.4
Control	102.1±0.6	102.4±0.6	101.9±0.5	102.8±0.4	102.4±0.5	102.1±0.6
P	<0.05	<0.01	<0.001	<0.001	<0.001	<0.001

n.s. = not significant.

did not recover to preoperative values (145.7±0.3^o for MEA, 46.4±0.3^o for MFA and 99.4±0.4^o for ROM).

DISCUSSION

Extracapsular stabilisation techniques generally have good clinical outcomes. Based on clinical examination, the lateral fabellotibial suture technique resulted in satisfactory outcomes in 85.7% of 42 dogs (DeAngelis & Lau, 1970). Clinical improvement was noted in 87.5% and normal gait at a walk was noted in 60% (Moore & Read, 1995). In a third study, 94.1% of dogs were clinically sound at a walk and trot (Gambardella *et al.*, 1981). In a retrospective study based on owner assessment of function, clinician's assessment of gait, and force platform gait analysis, the owners assessed 32 of 39 dogs (82.1%) to have good or excellent function, the clinicians graded 14 of 18 dogs (77.7%) to have good or excellent function, and force platform gait analysis was considered normal in 6 of 7 dogs (85.7%) (Chauvet *et al.*, 1996).

After LFTS, owners were reportedly satisfied with outcomes in 82–90% of cases (Moore & Read, 1995). Minimal to no lameness was reported in 78–82% by 6–20 months follow up in most studies (Chauvet *et al.*, 1996; Ertelt & Fehr, 2009), although one study reported only 40% clinical improvement by 6 months (Conzemius *et al.*, 2005). On palpation examination, 55–76% of dogs had no drawer palpable at 6–20 months after surgery and 73% had no pain on stifle manipulation at 20 months postoperatively in the 11 dogs that returned for follow-up (Moore & Read, 1995; Chauvet *et al.*, 1996; Ertelt & Fehr, 2009).

One study reported that only 15% of dogs achieved normal ground reaction forces within 6 months (Conzemius *et al.*, 2005), another reported that 86% returned to normal by 20 months after surgery (Chauvet *et al.*, 1996), while a third study affirmed that dogs treated with LFTS remained significantly different from normal throughout the study period of one year (Nelson *et al.*, 2013). In the force platform study, all vertical and cranio-caudal measurements in the affected limb were significantly improved at a minimum of 7 months after surgery. In addition, at the postoperative evaluation, no significant difference was observed in any measurements between affected and normal pelvic limbs (Budsberg *et al.*, 1988). However, in another prospective clinical study of limb function analysed by force platform gait analysis, only 40% of dogs treated by lateral fabellotibial suture stabilisation improved, and 14.9% returned to normal function (Cook *et al.*, 2008).

The most common major complications associated with ES procedures occurred in 7–17% of LFTS cases, and included postoperative meniscal tear, failure of the stabilisation due to tearing of the fabello-femoral ligament or implant failure, seroma formation or implant-associated infection and peroneal nerve damage (Dulisch, 1981; Korvick *et al.*, 1994; Chauvet *et al.*, 1996; Conzemius *et al.*, 2005; Casale & McCarthy, 2009; Ertelt & Fehr, 2009; Au *et al.*, 2010; Christopher, 2013).

In one study, the risk of development of complications after LFTS was increased in dogs that were male, had a higher body weight, or were of younger age (Casale & McCarthy, 2009). When multifilament suture was used for LFTS, the risk of fabellofemoral ligament failure was increased (Lodato *et al.*, 2013), as was the risk of infection (Korvick *et al.*, 1994). The risk of infection when using multifilament suture may be further increased with decreased surgeon experience (Dulisch, 1981). In a retrospective study assessing risk factors for infection-inflammation in dogs undergoing surgery for rupture of the cranial cruciate ligament, the infection rate for the fabellotibial suture procedure was 4.2% of 496 cases (Frey *et al.*, 2010).

Late meniscal tears resulting in lameness and requiring a second surgery occurred in 7 of 363 dogs (1.9%) and post-operative meniscal tear rate was 15.2% in cases in which a meniscal release was not performed and 0% in cases in which a meniscal release was performed (Casale & McCarthy, 2009).

The most recent evidence has shown that tibial osteotomy procedures, particularly the tibial plateau leveling osteotomy, had superior outcomes when compared to ES (Lazar *et al.*, 2005; Gordon-Evans *et al.*, 2013; Nelson *et al.*, 2013; Bergh *et al.*, 2014), though there are also studies showing no difference in outcome between ES and osteotomy procedures (Conzemius *et al.*, 2005; Au *et al.*, 2010; Cook *et al.*, 2010; Mölsa *et al.*, 2013).

Goniometry is a simple, affordable, and non-invasive method to measure the joint angles and estimate the range of motion in joints. It is commonly used as an efficient, objective and reliable tool for patient assessment following joint or muscle trauma (Jaegger *et al.*, 2002; Freund *et al.*, 2016). Goniometry is also a useful technique for routine monitoring of progression and response to treatment, given the close relationship between decreased joint angles in osteoarthritic patients (Thomas *et al.*, 2006; Corfield *et al.*, 2007).

In our opinion, the maximum extension angle differed statistically significantly before surgery, because of its role as primary stabiliser for prevention of hyperextension. Both angles (MAE and MFA) as well as joint range of motion were reduced in the initial periods, most likely due to implant restriction, and in the later periods did not return to preoperative values due to the progression of osteoarthritis and periarticular fibrosis.

CONCLUSION

Lateral fabellotibial suture (LFTS) technique is generally safe for the surgical treatment of cranial cruciate ligament rupture in dogs. Given the major benefits of extracapsular over osteotomy techniques, such as lower costs, lower technical difficulty, the potential for reduction of abnormal internal tibial rotation and minimal requirement for specialised equipment, it is likely that this method will remain a popular treatment option in the future. The reported disadvantages include abnormal biomechanics such as excessive constraint, higher infection rate and poorer long-term stability.

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