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In canine cranial cruciate ligament rupture is outcome following TPLO improved compared with lateral suture?

A Knowledge Summary by

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KNOWLEDGE SUMMARY

PICO question

In dogs over 15 kg, with cranial cruciate ligament rupture is there evidence of improved outcome following tibial plateau levelling osteotomy or lateral fabellotibial suture?

Clinical bottom line

Although the evidence is not conclusive, the literature reviewed here suggests that tibial plateau levelling osteotomy (TPLO) results in superior limb function and owner satisfaction compared to placement of a lateral fabellotibial suture (LFS).

There is currently insufficient evidence to determine if there is a difference in complication rates or osteoarthritis (OA) development following TPLO or LFS.

Clinical Scenario

A 7-year-old male neutered crossbreed dog, weighing 23 kg presents with an acute history of unilateral hind-limb lameness. On clinical examination pain is localised to the stifle joint. Radiography of the affected joint demonstrates the presence of increased soft tissue opacity suggestive of stifle effusion. At examination under sedation both cranial drawer and tibial compression tests are positive and a diagnosis of cranial cruciate ligament (CCL) rupture is made.

You discuss surgical treatment options with the client. Both TPLO and LFS placement are performed locally and are financially feasible, other techniques are not available within a distance that the client is willing to travel and so are not considered.

When considering postoperative limb function, owner satisfaction and complication rates, what evidence is there to suggest a TPLO technique is superior to LFS placement (or vice versa)?

Summary of the evidence

Abbreviations:

CCL – Cranial cruciate ligament
TPLO – Tibial plateau levelling osteotomy
LFS – Lateral fabellotibial suture
NSAID – Nonsteroidal anti-inflammatory drugs
OA – Osteoarthritis
TTA – Tibial tuberosity advancement

Molsa et al. (2014)	
Population:	Treatment group: Dogs over 17 kg bodyweight, of various breeds and crossbreeds, with naturally occurring, unilateral CCL rupture treated surgically with various methods at least 1.5 years prior to follow up evaluation. Age range was 6.9 ± 2.7 years. Weight range was 38.2 ± 9.5 kg.

	Animals were excluded if they had evidence of concomitant stifle joint disease, or other significant orthopaedic or neurological concerns as reported by their owner. Control group: Clinically healthy Rottweilers and Labradors, between 1 and 8 years of age, with no known orthopaedic disease and radiographically free of elbow and hip dysplasia according to the Federation Cynologique Internationale screening protocol.
Sample size:	Treatment group: 47 dogs Control group: 21 dogs Dogs were recruited from six individual referral practices

Intervention details:	Owners were invited to enroll their dogs in the study based on a previous questionnaire study (Molsa et al. 2013) and unpublished questionnaire data.
	Seven dogs received LFS, 19 dogs received a modified intracapsular suture repair, nine dogs received a TPLO, seven received a tibial tuberosity advancement and five dogs received a triple tibial osteotomy.
	
	Two subgroups were formed;
	• Subgroup 1 dogs had no other signs of orthopaedic disease (21 dogs)
	  ○ Force plate, static weight bearing, active range of motion, goniometry and muscle atrophy results were evaluated.
	• Subgroup 2 dogs had evidence of orthopaedic disease not affecting the stifles or tarsus (33 dogs)
	  ○ Goniometry results only were evaluated.
	
	Force plate analysis and physiotherapeutic evaluation were performed in the control group to allow comparison with treated groups.
	
	NSAIDs, opioids, short-term corticosteroid pain medication, and nutraceutical medication were withdrawn at a minimum of 7 days, long-term corticosteroids 30 days, and pentosan polysulphate 90 days prior to evaluation.
	
	During the evaluation the research team were unaware of which limb had been operated on and the technique used.
	
	Follow-up time between surgery and evaluation visit was between 1.5 and 4.4 years.

Study design:	Retrospective case series

Outcome studied:	• Orthopaedic examination
	  ○ Lameness evaluation
	  ▪ No/mild/moderate/severe weight bearing/non-weight bearing
	  ○ Evaluation of conscious proprioception and withdrawal reflex
	  ○ Stifle joint palpation
	  ▪ Pain, crepitation, periarticular swelling, decrease in range of motion
	  – No/mild/moderate/severe
	  ▪ Patellar luxation
	  ○ Cranial drawer, tibial compression, Ortolani tests
	  ○ Palpation of thoracic and pelvic limbs and spine
	• Radiography
	  ○ Under sedation
	  ○ Stifle, hip, elbow and lumbar spine evaluated for evidence of OA
	• Force plate analysis

	○ Data from five valid trials for each side were normalised for body mass and averaged ○ Peak vertical forces and vertical impulses were evaluated in all limbs ○ Distribution percentages of peak vertical forces per limb were calculated ○ A symmetry index was calculated for pelvic limb peak vertical force and vertical impulse ▪ 0 indicates perfect symmetry ▪ A positive value indicates decreased weight bearing on the treated limb ▪ A negative value indicates decreased weight bearing on the contralateral limb ○ The control group values were used to determine the cut-off value for differentiation between normal and lame dogs • Physiotherapeutic examination ○ Performed by a veterinary physiotherapist ○ Visual evaluation of lameness ○ Movement on stairs ○ Functional active range of motion and thrust from the ground ○ Manual evaluation of muscle atrophy of pelvic limbs ▪ Subjective assessment by palpating for symmetry ○ Manual evaluation and quantitative measurement of static weight bearing • Goniometry ○ Passive range of motion in stifle and tarsal joints
Main findings: (relevant to PICO question):	• Orthopaedic examination ○ The severity of stifle joint crepitation was significantly lower in the osteotomy group than in the LFS group. ○ The amount of periarticular swelling was significantly lower in the osteotomy than in the LFS group. ○ No significant differences were found between surgical techniques in pain response to stifle joint flexion/extension. • Radiography ○ Comparison between osteotomy and LFS repair was not possible from the results reported. • Force plate analysis ○ When force plate results of different surgical technique groups were evaluated, no significant differences were found between treatment groups. ○ The low number of dogs treated with the LFS technique precluded comparison of ground reaction forces to other techniques. • Goniometry ○ No significant differences were found between surgical technique groups. • Physiotherapeutic examination ○ No significant differences were found between surgical technique groups. ○ The low number of dogs treated with LFS prevented comparison of static weight bearing to other techniques.
Limitations:	• Results were collected from six individual referral practices, practice was not investigated as a confounding variable.

	• Qualification of the veterinary surgeons involved was not stated. • TPLO implant type was not reported. • The study was retrospective in nature. • Owner self-selection may have introduced bias. In particular as there was a requirement to withhold medication prior to assessment the most severely debilitated dogs may have been less likely to participate. • The sample size was small and reduced further by subgroup creation, limiting statistical power. A sample size calculation is not described. • Pre-existing OA was not documented and may account for some of the results reported. • The osteotomy group included both TPLO and tibial tuberosity advancement (TTA) procedures, which limits application to this knowledge summary. • Follow-up time was significantly shorter in the osteotomy group 2.2 ± 0.6 years compared to the LFS group (3.6 ± 0.4 years). • The condition of the meniscus was reported only in 23 (48.9%) dogs. Studies have reported progression of OA after meniscectomy (Cox et al., 1975) and this may represent a confounding factor. • Many possible confounding factors were not recorded or statistically accounted for; e.g. duration and severity of lameness prior to surgery, use of rehabilitation therapy, type of injury (partial or complete). • The number of dogs treated with LFS was too low to allow full comparison to other groups. • Not all of the data collected from physiotherapeutic examination was reported. • Subjective descriptors (mild, moderate, marked) were used to record the results of many components of the orthopaedic examination. It is not clear how these descriptors were handled in order to determine differences between groups, and if this was appropriate. • The sub-group totals represent a greater number of dogs than reported in the study population. It is not made clear if or why certain dogs were counted in both groups.
Molsa et al. (2013)	
Population:	Dogs of various breeds and crossbreeds, with naturally occurring cranial cruciate disease (unilateral or bilateral), with or without meniscal injury, repaired surgically using either an intracapsular, LFS or osteotomy technique (TPLO or TTA). The mean weight of dogs was 30.0 ± 17.9 kg. The mean age of dogs was 5.9 ± 3.3 years. Dogs were excluded if they had concomitant stifle joint disease at the time of the initial surgery, or if more than one technique was performed on the same limb.
Sample size:	253 dogs
Intervention details:	Medical records of dogs presenting to the Veterinary Teaching Hospital of the University of Helsinki or one of five private orthopaedic referral clinics in Finland between January 2004 and December 2006 were reviewed. A questionnaire designed to evaluate long-term outcome and prevalence of chronic pain after surgical repair by means of intracapsular, extracapsular, or osteotomy techniques was sent to the owners of dogs that fulfilled the inclusion criteria. If the dog underwent surgery bilaterally, the owner was asked to answer based on the

	surgery performed between 2004 and 2006. If both stifle joints underwent surgery during this period, the owner was asked to answer based on the later surgery. 87 dogs received a LFS, 63 dogs received an osteotomy procedure, of which 34 were TPLOs, 88 dogs received an intracapsular technique and 15 dogs received more than one surgeries on the limb with multiple techniques The follow-up time (interval between surgery and the questionnaire) was between 1.3 and 4.5 years.
Study design:	Retrospective case series

Outcomes studied:	• Owner questionnaire
	  ○ Signalment information
	  ○ Information regarding the injury and surgery
	  ○ Duration of postoperative lameness
	  ○ Need for long-term administration of nonsteroidal anti-inflammatory drugs (NSAIDs) and frequency of use
	  ○ Use of postoperative physiotherapy
	  ○ Opinion of surgical outcome
	  ▪ Excellent, good, fair or poor
	  ○ Helsinki Chronic Pain Index (HCPI) (Hielm-Björkman et al., 2009)
	  ▪ Previously validated for healthy dogs and those with hip and elbow OA
	  ▪ 11 questions regarding mood, behaviour and locomotion
	  ○ Frequency of lameness
	  ▪ Always, very often, often, sometimes, hardly ever.
	  ○ Willingness to bear weight equally.
	  ▪ Always, very often, often, sometimes, hardly ever.

Main findings: (relevant to PICO question):	• No significant difference was found between surgical techniques in frequency of lameness or willingness to bear weight on the treated limb at follow-up. • The HCPI in the osteotomy group was significantly lower than dogs that were treated with an extracapsular technique, however this was not the case after adjusting for the difference in age between groups. • The authors concluded that 'Owner assessments revealed no significant differences in long-term outcomes between surgical techniques'.
Limitations:	• The study was retrospective in nature and required owner recollection of past events, which may not have been accurately reported. • Details of meniscus assessment and if a tear was present and treated was reported only in 126/253 (49.8%) cases, so could not be controlled as a confounding factor. • A sample size calculation is not described. • Qualification of the veterinary surgeons involved, was not stated. • Other concomitant orthopaedic or neurological disease was not a criteria for exclusion and may have affected lameness and quality of life scoring. • Activity levels postsurgery, rehabilitation and medication use was not standardised. • TPLO implant type was not reported. • Results were collected from six individual referral practices, practice was not investigated as a confounding variable.

	• There were likely many other confounding factors due to the heterogeneous population involved. • The population of dogs receiving LFS was significantly older than the population receiving an osteotomy procedure. • There was a significant difference in body weight between groups. It is not reported which groups were heavier. • Owner assessment of lameness may not be accurate. • The follow-up period was significantly shorter in the osteotomy group (2.2 ± 0.7 years compared to 2.9 ± 0.8 years for LFS group). This is likely to have affected both function and accuracy of owner recollection. • The osteotomy group included both TPLO and TTA procedures, which limits application to this knowledge summary. • The number of dogs receiving a TPLO (34) reduced the study's statistical power.

Nelson et al. (2013)	
Population:	Treatment group: Adult dogs of various breeds and crossbreeds, over 15 kg bodyweight, with naturally occurring unilateral CCL rupture (partial or complete), treated surgically with either placement of a LFS or TPLO. Animals were excluded if there were any other abnormalities (including orthopaedic abnormalities) detected on clinical examination, or if any radiographic abnormalities were present on a ventrodorsal projection extended hip radiograph. Dogs were required to have an adequate stride length to obtain accurate ground reaction force profile. Control: Adult dogs over 15 kg, with no abnormalities on physical and orthopaedic examination and no evidence of skeletal disease on a ventrodorsal projection extended hip radiograph. Animals were excluded from this group if they had any history of orthopaedic or neurological disease; or current history of persistent injury or systemic disease.
Sample size:	Treatment group: 38 dogs Control group: 79 dogs

Intervention details:	Dogs admitted to Cornell University Veterinary Teaching Hospital, for surgical treatment of CCL rupture between July 2007 and August 2010 were evaluated for inclusion. Dogs were allocated into treatment group (LFS or TPLO) based on owner preference. Control dogs were recruited from the community. Anaesthesia protocol was not standardised. All dogs received 22 mg/kg cefazolin perioperatively every 90 minutes until conclusion of anaesthesia. In order to evaluate the CCL and medial meniscus craniomedial arthrotomy, craniomedial mini-arthrotomy, or arthroscopy was performed at the surgeon's discretion. If a meniscal tear was present a partial meniscectomy was performed. Joint capsule or arthroscopy incisions were closed routinely. TPLO (15 procedures) was performed as described by Slocum & Slocum (1993), without the use of a jig. A locking plate was used to secure the osteotomy. LFS (23 procedures) was performed with a lateral fabellotibial or lateral and medial fabellotibial suture. A bone tunnel was drilled in the tibial tuberosity. Two sutures of 80 lb. or 100 lb. monofilament nylon were placed around the lateral or lateral and medial femorofabellar ligament and through the bone tunnel. Sutures were tightened until cranial drawer was eliminated and secured with either a self-locking knot or crimps. Postoperative analgesia was not standardised. A modified Robert Jones bandage was applied after surgery and changed daily until cessation of discharge. The incision was cold-packed daily until discharge. Owners were given standardised instructions for postoperative care; these included medications (tramadol, NSAID and a transdermal fentanyl patch) and a basic rehabilitation programme (8 weeks restricted exercise, passive and active range of motion and sit to stand exercises). Follow-up was performed at between 1 and 49 days (2 week follow-up), between 50 and 149 days (8 week follow-up), between 150 and 299 days (6 month follow-up) and 300 days+ (one year follow-up) postsurgery.
Study design:	Non-randomised, prospective, observational clinical study

Outcome studied:	• Force plate gait analysis
	  ○ Performed in control dogs during a single session
	  ○ Performed in treated dogs preoperatively and 1 day, 2 days, 2 weeks, 8 weeks, 6 months, and 1 year postoperatively
	  ○ Walk = velocity 0.75–1.25 m/s
	  ▪ Assessed at all time points
	  ○ Trot = velocity 1.75–2.25 m/s
	  ▪ Assessed preoperatively and from 8 weeks postoperatively
	  ○ A symmetry index was calculated for all ground reaction forces
	  ▪ Used to evaluate weight-bearing between two limbs as symmetrical (1.0) or asymmetrical (< or > 1.0)

Main findings: (relevant to PICO question):	• Symmetry indices compared to control group
	  ○ All symmetry indices (peak vertical force and vertical impulse at both walk and trot) were significantly lower (less symmetrical) in the LFS group than in the control group at all postoperative time points.
	  ○ The symmetry indices for the TPLO group at the walk (peak vertical

	force and vertical impulse) were not significantly different to the control group from day 150 postoperatively ○ The symmetry index for the TPLO group peak vertical force at the trot was not significantly different to the control group from day 150 postoperatively ○ The symmetry index for the TPLO group vertical impulse at the trot was not significantly different to the control group from day 300 postoperatively • Symmetry when comparing treatment groups ○ At the walk the TPLO group was significantly more symmetrical than the LFS group for both peak vertical force and vertical impulse from day 50–149 postoperatively and after day 300 postoperatively ○ For peak vertical force at the trot the TPLO group was significantly more symmetrical than the LFS group at all postoperative time points ○ For vertical impulse at the trot the TPLO group was significantly more symmetrical than the LFS group from day 50 postoperatively • Contact time ○ Contact time at the walk and trot showed no difference between TPLO and LFS groups at any time point and both groups were not statistically different to the control group from day 50 postoperatively The authors conclude that 'without a formal rehabilitation programme TPLO achieves a faster return to function with a greater proportion of dogs attaining normal function within a year'.
Limitations:	• This was a non-randomised, observational study, increasing the likelihood of unidentified confounding factors affecting results • This is a single centre study which may limit application to other centres • Qualification of the veterinary surgeons involved was not stated. • Treatment group was determined by owner preference. This is likely to introduce confounding factors • Sample size was small – only 18 dogs completed the gait analysis to 12 months follow-up, this limits statistical power • NSAID use postoperatively was variable ○ Postoperative doses were not reported • The TPLO group were significantly younger than the LFS group • There was variability in the LFS technique used • Use of specialised diet, nutraceuticals or more intensive rehabilitation was not recorded or accounted for statistically
Gordon-Evans et al. (2013), addendum Gordon-Evans (2016)	
Population:	Adult dogs (age range 2–12 years) of various breeds, with naturally occurring, unilateral CCL rupture (partial or complete), treated surgically with either placement of a LFS or TPLO. Animals were excluded if there was evidence of medical or neurological disease, or if they showed fractious or aggressive behaviour. Animals were not excluded due to previous history of orthopaedic disease provided they had no associated signs of pain or lameness at initial evaluation and any surgery had been performed more than 6 months prior to enrollment.
Sample size:	80 dogs
Intervention	Dogs were assigned via block randomisation to receive either LFS (40) or TPLO (40);

details:	controlling for bodyweight at a BCS of 5 (small or medium breed, < 18 kg; large breed, 18–36.4 kg; or giant breed, > 36.4 kg). Premedications, anaesthetics and analgesics were not standardised. Arthroscopic exploration of the stifle joint was performed. The CCL was debrided and the menisci were evaluated. Meniscal tears were debrided, or a medial caudal pole meniscectomy performed if damage was severe. If this was not possible arthroscopically a medial arthrotomy was performed. For both procedures, a skin incision was created on the medial aspect of the stifle joint region. All procedures were performed by or under the supervision of a board certified surgeon. TPLO was performed as described by Slocum & Slocum (1993). LFS procedure – a lateral retinacular incision was created and two strands of 60-, 80-, or 100- lb nylon suture were passed around the lateral fabella, under the patellar ligament, and through a hole in the proximal tibial tuberosity in a figure of eight pattern. The suture was tightened until 90° of flexion could be maintained without eliciting a cranial drawer before crimping. Skin incisions were closed with staples or sutures. Patients received 10 days of tramadol and various NSAIDs postoperatively. Analgesia after 10 days was not standardised. Discharge instructions were similar and included rehabilitation therapy exercises performed three times daily. Owners were unaware of the procedure performed unless complications required disclosure.
Study design:	Randomised, blinded, controlled clinical trial.

Outcome studied:	• Preoperatively, postoperatively at 6 weeks, 12 weeks, 6 months and 12 months;
	  ○ Force plate gait analysis
	  ▪ Mean values for 5 trials reported as a percentage of weight
	  • Walk (1–1.3 m/s)
	  • Trot (1.5–1.8 m/s)
	  ○ Canine brief pain inventory (validated owner questionnaire)
	  ○ Thigh circumference
	  ○ Stifle joint goniometry
	• 6 and 12 months postoperatively
	  ○ Owners asked to rate surgical outcome
	  ▪ 1–10
	• Complications noted at re-examinations were recorded

Main findings: (relevant to PICO question):	• Surgical time was significantly longer for the TPLO group than the LFS group
	• Complication rates were similar between groups
	• Rate of late meniscal injury was not significantly different between groups
	• Force platform analysis
	  ○ At 6 months postoperatively peak vertical force values at trot were significantly higher in the TPLO group. Peak vertical forces at walk were not significantly different between groups
	  ○ At 12 months postoperatively peak vertical force and vertical impulse values were significantly higher for dogs in the TPLO group at both walk and trot
	• Canine Brief Pain Inventory owner survey

	○ No significant difference between treatment groups • Thigh circumference ○ No significant difference between treatment groups • Stifle joint goniometry ○ No significant difference between treatment groups • Owner satisfaction rating ○ Rating at 6 months was not significantly different between groups ○ Rating at 12 months was significantly higher (improved satisfaction) in the TPLO group • An addendum calculating the number of dogs that would need to be treated with a TPLO procedure in order to see an overall improvement in success (NNT) was published in 2016 ○ NNT for overall improvement in owner satisfaction was seven ○ NNT for improvement in limb function as measured by peak vertical force (defined as number of dogs achieving a peak vertical force greater than 35% of weight at walk and 58% at trot at 12 months postoperatively) was six The authors conclude that 'Kinematic and owner satisfaction results indicated that dogs that underwent TPLO had better outcomes'.
Limitations:	• This is a single centre study which may limit application to other centres • The owner survey used to assess satisfaction is a subjective, non-validated tool • TPLO implant type was not reported • Analgesia protocols from day 10 postoperatively were not standardised (though use was assessed statistically and not found to be significantly different between groups) • Closure method was not standardised and may have been a confounding factor • Weight range was not reported
Frey et al. (2010)	
Population:	Dogs of various breeds and crossbreeds, with naturally occurring unilateral or bilateral cranial cruciate ligament rupture (partial or complete), with or without meniscal injury, stabilised surgically with either LFS or a TPLO. Dogs were excluded if concurrent orthopaedic surgical procedures (including stabilisation of the contralateral stifle joint) were performed during the same anaesthetic. Age and weight range were not reported.
Sample size:	808 dogs, 902 procedures
Intervention details:	Medical records of all dogs that underwent a LFS stabilisation or TPLO as treatment for cranial cruciate rupture, at Garden State Veterinary Specialists, between January 2005 and December 2006 were reviewed. Data regarding development of postoperative infection-inflammation were obtained. Potential risk factors were identified and recorded. Dogs that had contralateral CCL ruptures repaired during separate anaesthetic were included as two separate interventions. Anaesthetic protocol and analgesics were not standardised. All dogs received 22 mg/kg cefazolin prophylactically at induction and every 120 minutes thereafter until conclusion of anaesthesia. Antimicrobial administration after surgery was at the surgeon's discretion. The hind-limb was clipped and aseptically prepared in a routine

	manner. LFS (496 procedures) was performed through a lateral parapatellar incision. Lateral arthrotomy was performed to allow meniscal inspection and debridement of CCL remnants. The stifle joint was stabilised with one or two circumfabellotibial monofilament nylon sutures secured with hand ties or metal crimps. The biceps fascia was imbricated, subcutaneous tissue and skin were closed in a routine manner. TPLO (406 procedures) was performed as described by Slocum & Slocum (1993) with minor variations in technique in accordance with surgeon preference. Cortical screws were used. A medial arthrotomy was performed to allow meniscal inspection and debridement of CCL remnants. Rate of surgical site infection-inflammation was recorded at suture removal and at follow-up within 6 months.
Study design:	Retrospective case series

Outcome studied:	Infection-inflammation rate:
	• At suture removal (within 21 days postoperatively) wounds were classified as infected-inflamed when purulent discharge, abscessation or fistulation were present or where three or more of the following were evident at the wound simultaneously:
	  ○ Erythema
	  ○ Swelling
	  ○ Signs of pain
	  ○ Heat
	  ○ Serous discharge
	  ○ Dehiscence
	• At recheck (within 6 months postoperatively) wounds were classified using the classification described above with the addition of joint effusion, moderate-severe lameness and pain at palpation of the soft tissues overlying the implant.

Main findings: (relevant to PICO question):	• Infection-inflammation developed after 55/902 (6.1%) of surgeries
	  ○ The infection-inflammation rate for the LFS group (21/496 , 4.2%) was significantly lower than that of the TPLO group (34/406, 8.4%)
	  ○ The odds ratio of TPLO to LFS surgery for the development of infection-inflammation was 2.068
	• There was a significant increase in the rate of infection-inflammation when comparing closure with skin staples to closure with sutures
	  ○ The odds of developing postoperative infection-inflammation were 1.9 times as high in these patients
	  ○ TPLO surgeries were 6.7 times more likely to be closed with stainless-steel staples
	• There was no significant difference in the rate of inflammation-infection when comparing closure with staples between groups, or comparing closure with sutures between groups
	  ○ Odds ratio calculations showed that a TPLO increased the risk of postoperative infection-inflammation by a factor of 1.2 when staples were used and a factor of 1.8 when staples were not used
	  ○ This was not significantly different
	• Patients receiving oral antimicrobials at discharge had a 5.1% rate of infection-inflammation (39/771), patients not receiving oral antimicrobials at

	discharge had a 10.7% rate of infection-inflammation (14/131) ○ These values differed significantly The authors conclude that 'TPLO was associated with a significantly higher rate of infection-inflammation'.
Limitations:	• This is a single centre study which may limit application to other centres. • Qualification of the veterinary surgeons involved was not stated. • There was no differentiation between infected wounds and sterile, inflamed wounds. Need for treatment, increased cost and morbidity would be expected to be very different depending on the presence of infection, and thus the clinical relevance of these findings is not clear. • Wounds were retrospectively categorised as infected-inflamed based on previously recorded details entered by a number of observers and data would be expected to be subject to inter-observer bias in addition to possible under-reporting. • The rate of wounds which required additional treatment or monitoring is not reported. • Mean duration of anaesthesia and mean body weight differed significantly with respect to the procedure (the TPLO group were heavier and had longer anaesthetics). The data was stratified and groups compared at 10 kg/10 minute intervals in an attempt to account for this. Odds ratios calculated for the strata with greatest overlap did suggest that duration of anaesthesia and mean body weight were not confounding variables, however sample sizes would be much reduced in these groups. • Presence of concurrent infection was not found to significantly affect the rate of postoperative infection-inflammation, however screening for the presence of concurrent infection did not appear to be standardised and could represent a confounding factor. • A non-locking implant was used for TPLO procedures – newer locking plates have been associated with a lower risk of infection (Solane et al., 2015). • Follow-up time was categorised as within 21 days and within 6 months. Grading wounds at more specific time intervals may have produced different results. Revisit times may represent a confounding factor. • Buster collar use and reported wound interference were not reported and may represent confounding factors. • Antimicrobial protocols were not standardised. • Rate of reported break in sterile technique was not compared between groups. • Age and weight range were not reported.
Au et al. (2010)	
Population:	Dogs of various breeds and crossbreeds, between 10 and 60 kg bodyweight, with naturally occurring unilateral or bilateral CCL disease, with or without medial meniscal injury, treated surgically with either placement of a LFS or TPLO. Age range 2–11 years. Animals were excluded if they had evidence of other orthopaedic or neurological disease as determined by clinical examination at admission.
Sample size:	65 dogs
Intervention details:	Patients were allocated into treatment groups on the basis of owner preference. Patients developing CCL disease in the opposite limb during the study were not

	excluded. NSAIDs were withheld for at least 1 week before surgery. Patients received a standard premedication and non-standardised induction protocol. Cefazolin (22 mg/kg I.V) was administered perioperatively. All procedures were performed by residents under the supervision of board certified veterinary surgeons. LFS procedure (35 dogs): craniolateral arthrotomy with inspection of the menisci and debridement of CCL remnants. Lateral sutures of 80 lb monofilament nylon were placed around the lateral fabella and through a hole in the tibial crest. The sutures were tensioned to eliminate cranial drawer motion before fastening with a single Securos crimp clamp. A single suture was inserted in dogs <25 kg and two sutures in dogs >25 kg. TPLO procedure (30 dogs): craniomedial arthrotomy with inspection of menisci, prior to TPLO performed as described by Slocum & Slocum (1993). In both procedures medial meniscal injury was treated by caudal pole meniscectomy. An abaxial medial meniscal release was performed at the surgeon's discretion. Postoperative analgesia was provided by hydromorphone for 24 hours postoperatively followed by deracoxib or carprofen for 7 days postoperatively. All dogs had an identical physical rehabilitation regime performed by the same handler. Physical rehabilitation was performed twice daily for 5 days during weeks 3, 5, and 7 postoperatively. NSAIDs were administered during these weeks but discontinued in between. Sessions consisted of: • 5 minutes of passive range of motion exercises • 10 minutes of land treadmill walking • 10 minutes of underwater treadmill walking During weeks 4, 6, 8, 9, 10, 11 and 12 home exercises involving passive range of motion were prescribed. Follow-up was between 6 and 24 months.
Study design:	Non-randomised, prospective observational clinical study

Outcome studied:	• Gait analysis
	  ○ Peak vertical force measurements for each pelvic limb
	  ○ Assessed pre-operatively, 3, 5 and 7 weeks, 6 and 24 months postoperatively.
	  ○ Data was collected at a walk (1.5–1.8 m/s)
	• Goniometry
	  ○ Both affected and contralateral stifle joints.
	  ○ Assessed pre-operatively, 3, 5 and 7 weeks, 6 and 24 months postoperatively
	• Thigh circumference
	  ○ At the level of the proximal quarter of the femur on both pelvic limbs
	  ○ Assessed pre-operatively, 3, 5 and 7 weeks, 6 and 24 months postoperatively
	• Radiography
	  ○ Preoperatively and at 2 year follow-up
	  ○ Paired caudomedial and mediolateral stifle joint radiographs

	○ Assessed by single board-certified radiologist ○ Scored for signs of OA with a 21-factor scale based on a modification of a system by Vasseur and Berry (1991). • Complication rate
Main findings: (relevant to PICO question):	• Gait analysis ○ There was no significant difference in peak vertical force (PVF) between groups at any time point • Goniometry ○ There was no significant difference in stifle joint range of motion between groups at any time point • Thigh circumference ○ There was no significant difference between groups • Radiography ○ There was no significant difference in OA scores between groups • Complication rate ○ There was no significant difference in complication rates between groups The authors conclude that 'This study does not support the superiority of either surgical technique.'
Limitations:	• This is a single centre study which may limit application to other centres. • Treatment group was determined by owner preference. This is likely to introduce confounding factors. • This was a non-randomised, observational study, increasing the likelihood of unidentified confounding factors affecting results. • The mean age of the LFS group was significantly older than the TPLO group. • The mean weight of the LFS group was significantly less than the TPLO group. • Patients underwent an intense rehabilitation protocol, similar aftercare may not be realistic for a typical population. This may have reduced the difference in outcome between groups as a later study suggested without a formal rehabilitation programme patients receiving TPLO had a faster return to function. • Non-locking implants were used in TPLO procedures. • Sample size was small limiting statistical power. • Gait analysis was performed at walking velocity only. It has previously been demonstrated that analysis of trotting velocity is a superior indicator of lameness when evaluating low-grade pelvic limb lameness in dogs (Voss et al., 2007). • A sample size calculation is not described and thus it is not clear if the study's power could reasonably be expected to detect a significant difference between groups. For example the authors report a greater improvement was seen in PVF in the TPLO group compared with the LFS group between 6 and 24 months postoperatively, however this difference was not statistically significant. • It is not reported if type of CCL rupture (partial or complete) was a criteria for inclusion, and statistical analysis does not appear to account for this as a confounding factor. • Use of specialised diets, non-NSAID analgesia, nutraceuticals or more intensive rehabilitation was not recorded or accounted for statistically. • Duration and severity of lameness prior to surgery was not recorded or accounted for statistically.

	• Labrador retrievers were over represented in the TPLO group. • Weight range was 10–60 kg therefore some animals would be included that would not meet the criteria specified by this PICO.
Conzemius et al. (2005)	
Population:	Treatment group: Labrador Retrievers with naturally occurring, unilateral cranial cruciate rupture (partial or complete) and concomitant medial meniscal injury; treated surgically using either an intracapsular technique, LFS or TPLO with meniscectomy (partial or complete). Dogs were excluded if intraoperative complications were reported during the surgery or if bilateral disease was present. Age and weight range were not reported. Control group: staff or student owned Labrador Retrievers, clinically normal as determined by history taking, physical examination and stifle joint radiography.
Sample size:	Treatment group: 131 dogs Control group: 17 dogs
Intervention details:	From June 1998 to September 2002, all Labrador Retrievers that were admitted to the Veterinary Teaching Hospital at Iowa State University for CCL were evaluated for inclusion in the study. Dogs were allocated into treatment groups on the basis of owner and surgeon preference. LFS (47 procedures) was performed with sutures of various sizes. TPLO (64 procedures) was performed as described in the licensing course. 20 dogs received an intracapsular repair. Force platform gait analysis was performed on the treatment group and control dogs. Anti-inflammatory medication was stopped for 7 days prior to gait analysis. Clinically important improvement was defined as limb function vertical forces at 6 months closer to mean limb function of clinically normal dogs than mean limb function of treatment group dogs presurgery. Follow-up was performed at 2 and 6 months postsurgery.
Study design:	Non-randomised, prospective, observational clinical study

Outcome studied:	• Force platform gait analysis
	  ○ Evaluated prior to surgery and repeated 2 and 6 months postoperatively
	  ○ At walking velocity (velocity 1.0–1.3 m/s acceleration, ± 0.5 m/s²)
	  ▪ Mean falling slope
	  ▪ Peak vertical force
	  ▪ Vertical impulse
	  ○ A logistic regression equation was applied to determine the probability that an individual dog could be differentiated from the control group 6 months after surgery

Main findings: (relevant to PICO question):	When mean function was compared between TPLO and LFS groups no significant difference was found over the duration of the study, or at any single time point. There was no significant difference between TPLO and LFS groups in the probability of a return to normal function.

	The authors conclude that 'Results of LFS and TPLO are similar'.
Limitations:	• This is a single centre study which may limit application to other centres. • Qualification of the veterinary surgeons involved was not stated. • The study only included Labrador Retrievers. Whilst minimising sources of variation, this may limit application to other breeds. • This was a non-randomised, observational study, increasing the likelihood of unidentified confounding factors affecting results. • Dogs were included only if meniscal injury was present. Whilst minimising sources of variation, this may limit application to a typical population. • Age and weight range were not reported. Though it is reported that there was no significant difference in either between groups. • Patients were allocated into treatment groups based on owner and surgeon preference, this is likely to introduce confounding factors. • Dogs are not reported to be screened for or excluded on the basis of comorbidities (orthopaedic or other). This may represent a significant confounding factor, particularly if concomitant orthopaedic disease influenced treatment selection. • It is not reported if groups varied significantly in severity of lameness prior to presentation. • Gait analysis was performed at walking velocity only. It has previously been demonstrated that analysis of trotting velocity is a superior indicator of lameness when evaluating low-grade pelvic limb lameness in dogs (Voss et al., 2007). • Aftercare was not standardised. The LFS group were more likely to return to exercise sooner. Early postoperative physical rehabilitation has been shown to improve outcome and function after surgical repair of CCL injury. (Marsolais et al., 2002, Monk et al., 2006) • A sample size calculation is not described. • TPLO implant type was not reported. • Follow-up time was 6 months. A more recent study found the greatest difference in treatment groups to occur after 6 months (Nelson et al., 2013).
Lazar et al. (2005)	
Population:	Dogs weighing a minimum of 22.7 kg, with naturally occurring, CCL rupture (partial or complete), with or without medial meniscal injury; treated surgically with either placement of a LFS or TPLO. Animals were excluded if they had received previous or subsequent stifle joint surgery, or if there was evidence of other disease processes at surgery.
Sample size:	66 dogs (79 stifle joints
Intervention details:	22 patients (27 stifle joints) received LFS, 44 patients (52 stifle joints) received TPLO. LFS was performed using two nylon leader sutures from the lateral fabella through two holes drilled in the tibial tuberosity, followed by biceps fascia imbrication. TPLO was performed as described by Slocum & Slocum (1993). All procedures were performed by board certified veterinary surgeons. The medial meniscus status was evaluated by visual inspection for both LFS and TPLO groups, and if damaged, partial medial meniscectomy was performed. If intact, either no procedure was done or a medial meniscal release was performed where the lateral attachment of the caudal horn of the medial meniscus was transected.

	Radiographs of each stifle joint were evaluated at preoperative and final examinations. Radiographs were evaluated by the same two reviewers. A score was determined by evaluating 32 specific radiographic features of OA. Structures evaluated included the patella, femur, tibia, and surrounding soft tissues. Each feature was graded 0–3 (absent, mild, moderate, or severe) to give a final score from 0–96. The difference between preoperative and final OA scores were subtracted and two final score categories of a change less than or equal to five or over five were created. Follow-up time was a minimum of 12 months between surgery and final examination.
Study design:	Retrospective case series
Outcome studied:	• Radiography ○ Mediolateral and either caudocranial or craniocaudal radiographic projections were obtained at preoperative and final examinations
Main findings: (relevant to PICO question):	There was no significant difference in OA scores between treatment groups at defined time periods; however dogs with greater than six point change in pre and postoperative scores were 5.78 times more likely to have been treated with a lateral fabellotibial suture placement.
Limitations:	• This is a single centre study which may limit application to other centres. • The study was retrospective in nature. • Group allocation was not randomised and is likely to be associated with various confounding factors. • Time to final examination was significantly longer in the LFS group. • Dogs receiving LFS weighed significantly less and were significantly older than dogs receiving TPLO. • Preoperative OA score was significantly lower in the LFS group. • It was impossible to blind reviewers to the procedure performed due to distinctive implants. This may have introduced bias. • All TPLO procedures were performed by the same surgeon; whilst this does limit sources of variation it may not be appropriate to apply these findings to other surgeons. • TPLO implant type was not reported. • Use of specialised diets, medication, nutraceuticals or rehabilitation was not recorded or accounted for statistically. • Duration and severity of lameness prior to surgery was not recorded or accounted for statistically. • All radiographic features were weighted equally, but may not be equally important in the progression of OA. • Though a significant difference was found between treatment groups this may not be clinically relevant as radiographic changes do not accurately correlate with clinical lameness. • Radiographic positioning was not standardised. • Sample size was small limiting statistical power.

Appraisal, application and reflection

Eight papers and one addendum were identified as relating to this question. The best quality evidence available was a randomised, blinded, controlled clinical trial (Gordon-Evans et al., 2013), this was a single centre study, with some variations in procedure and aftercare protocol.
Three non-randomised prospective observational studies were identified (Conzemius et al., 2005, Nelson et al., 2013, Au et al., 2010). In each case, treatment group allocation was based on owner preference.
The remaining papers were retrospective case series (Molsa et al., 2013, Frey et al., 2010, Lazar et al., 2005, Molsa at al., 2014).

The studies identified generally focused on one or more of the following categories; postoperative limb function, owner satisfaction, complication rates and radiographic evidence of OA.

Six studies looked at postoperative limb function (Molsa et al., 2013, Molsa et al., 2014, Gordon-Evans et al., 2013, Conzemius et al., 2005, Nelson et al., 2013, Au et al., 2010). One study (Molsa et al., 2013) found no significant difference between treatment groups as determined by non-validated, owner-completed questionnaire. Two studies (Conzemius 2005, Au et al., 2010) found no significant difference between treatment groups as determined by force plate analysis, however Au et al. (2010) reported a non-statistically significant increase in PVF in the TPLO group. One study (Molsa et al., 2014) found significantly less postoperative periarticular swelling and stifle joint crepitation in the TPLO group, but the clinical relevance of this was not clear. Two studies (Nelson et al., 2013, Gordon-Evans et al., 2013) found patients treated with TPLO had superior limb function to those treated with LFS, as determined by force plate analysis.

One study (Gordon-Evans et al., 2013) surveyed owner satisfaction after surgical repair of CCL rupture and reported that owner satisfaction at 12 months postoperatively was significantly higher in the TPLO group.
Three studies reported complication rates (Au et al., 2010, Frey et al., 2010, Gordon-Evans et al., 2013). The largest (Frey et al., 2010) reported the incidence of infected-inflamed wounds only and noted that 'TPLO was associated with a significantly higher rate of infection-inflammation'. The remaining two studies (Au et al., 2010, Gordon-Evans et al., 2013) reported the rate of all surgical complications and did not find a difference in rate between treatment groups.

Two studies looked at radiographic evidence of OA (Lazar et al., 2005, Au et al., 2010). The first (Lazar et al., 2005) found that dogs with larger OA score differences between preoperative and follow-up radiographs were 5.78 times more likely to have had LFS placement than TPLO. The second (Au et al., 2010) found no significant difference in OA scores between groups.

The conclusions made within the Clinical Bottom Line component of this knowledge summary are based on the following points:

- The best quality paper available reported a significant improvement in the kinematic results of the TPLO group compared to the LFS group at 6 and 12 months postoperatively (Gordon-Evans et al., 2013). This finding was supported by a second observational study (Nelson et al., 2013). Two studies of equivalent evidentiary quality (non-randomised, observational) found no statistical significance in force plate analysis between treatment groups. However the first study (Conzemius et al., 2005) reported follow-up to 6 months only, later studies reported the greatest difference in treatment groups to occur after 6 months (Nelson et al., 2013, Gordon-Evans et al., 2013). The second (Au et al., 2010) found a non-statistically significant improvement in the TPLO group compared with the LFS group between 6 and 24 months postoperatively. Both of these studies (Conzemius et al., 2005, Au et al., 2010) assessed patients at walking velocity only, it has been reported that trotting velocity is more sensitive for detection of low grade pelvic lameness (Voss et al., 2007).
- Only one paper – a retrospective case series – reported an improvement in any outcome (complication rate) after LFS compared to TPLO (Frey et al., 2010), however wounds were classified as infected-

inflamed on the basis of retrospective medical record review and the clinical relevance of findings (i.e. if patients required additional treatment) was not clear. Two other papers recorded complication rates, Au et al. (2010) reported that there was no significant difference between groups and Gordon-Evans et al. (2013) reported that the complication rates of both procedures were similar.
- Only one study (Frey et al., 2010) found a difference in complication rates between procedures.
- Only one paper (Gordon-Evans et al., 2013) looked at owner satisfaction as an outcome and found a significant improvement in the TPLO group compared to the LFS group at 12 months postoperatively.

However extrapolating the data reported here to make recommendations for changes in current clinical practice does have several inherent problems:

Firstly, all procedures reported were performed at referral centres. Thus it may not be correct to assume this data can be extrapolated to LFS and TPLO performed in general practice, or where the choice is between LFS performed in a first-opinion practice, and referral to a specialist centre for a TPLO procedure.

Thirdly, this summary discusses the impact of procedure selection on a limited number of outcomes. Other factors such as cost, hospitalisation duration, aftercare and local availability of services are not considered here, however are expected to vary between procedures and accordingly influence client choice.

In conclusion this knowledge summary suggests that TPLO results in superior limb function and owner satisfaction compared to placement of a LFS; however further research – including multi-centre, randomised, controlled clinical trials and investigation of the outcomes of surgery performed in general practice – is indicated.

Methodology Section

Search Strategy	
Databases searched and dates covered:	CAB Abstracts on OVID Platform 1973–Week 20 2018 PubMed accessed via the NCBI website (1910–2018)
Search terms:	**PubMed:** (Canine OR canines OR dog OR dogs OR bitch OR bitches OR canis) AND (Cranial OR anterior) AND Cruciate AND (Osteotomy OR TPLO OR tibial plateau level) AND (Lateral OR fabellar OR fabellotibial OR tibiofabella OR extracapsular OR extra-capsular) **CAB Abstracts:** Canine OR canines OR dog OR dogs OR bitch OR bitches OR canis) AND (Cranial OR anterior) AND Cruciate AND (Osteotomy OR TPLO OR tibial plateau level) AND (Lateral OR fabellar OR fabellotibial OR tibiofabella OR extracapsular

	OR extra-capsular)
Dates searches performed:	31/05/2018

Exclusion / Inclusion Criteria	
Exclusion:	• Cases occurring as a result of severe trauma with concomitant injuries • Case reports • Experimental papers • Duplicates

Inclusion:	• English language
	• Peer reviewed publication
	• Original data
	• In vivo study
	• Canine patients
	• Patients over 15 kg
	• Patients with naturally occurring partial or complete CCL rupture
	• Comparative papers including both lateral fabellotibial suture placement and tibial plateau levelling osteotomy
	• Either (or both);
	  ○ Long-term outcomes scored using at least one of the following; scored veterinary assessment, validated client questionnaires (LOAD CBPI HCPI), force plate analysis
	  ○ Short/medium term outcomes assessed including at least one of the following; infection, dehiscence, lameness, mortality

Search Outcome

Database	Number of results	Excluded – non-canine patients	Excluded-artificially induced CCL rupture	Excluded – no patients over 15 kg	Excluded – non-English language	Excluded – no original data	Excluded – not in vivo	Excluded – did not include both TPLO and LFS	Excluded – non-comparative	Total relevant papers
CAB Abstracts	63	0	1	0	13	5	9	23	3	9
NCBI PubMed	52	1	1	1	0	2	7	28	4	8
Total relevant papers when duplicates removed										**9**

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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