Tibial plateau levelling osteotomy in eleven cats with cranial cruciate ligament rupture

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Keywords
TPLO, tibial plateau levelling osteotomy, feline, complications, short-term outcome, cranial cruciate ligament rupture, cat

Summary
Objective: To report the surgical procedure, intra- and postoperative complications, and short-term follow-up of tibial plateau levelling osteotomy (TPLO) in feline patients with cranial cruciate ligament (CrCL) rupture using a 2.0 or 2.4 mm Synthes® TPLO plate.

Study design: Prospective study.

Material and methods: Eleven cats with a CrCL rupture were included in the study. Inspection of intra-articular structures was carried out via arthroscopy or arthrotomy. Each patient was re-examined one and 10 days after surgery. Orthopaedic examination and follow-up radiographs were obtained four to 12 weeks postoperatively.

Results: Two meniscopathies and one partial CrCL rupture were detected. Minor intraoperative complications occurred in five cats (suboptimal positioning of the plate [n = 3], proximal fibular fracture [n = 1], a visible osteotomy gap [n = 1]). Postoperatively, minor complications were detected in three cats (mild patellar desmitis [n = 2], superficial wound infection [n = 1]). No additional surgical reinsertion, graded as major complication, was necessary. Four to eight weeks postoperatively, all cats showed no to mild intermittent lameness. Complete bone union was apparent within four to 12 weeks. Owners reported a high level of comfort and mobility during the last follow-up.

Conclusion: The preliminary results of this study support the use of TPLO in cats, but larger case numbers are needed to evaluate its practicability, as well as long-term outcome (>1 year), especially evaluating the development and the clinical relevance of osteoarthritis.

Introduction
Rupture of the cranial cruciate ligament is the most common orthopaedic injury in dogs (1, 2). The incidence of feline patients with the same condition is increasing, but there are only a few published reports discussing treatment options and outcome (3, 4). One reported treatment method is conservative management with cage rest and analgesics (5). In this study of 16 cats with cranial cruciate ligament rupture, the clinical outcome following several months of activity restriction was good. However, 80% had continued instability of the stifle joint, reduced range of motion, joint thickening, and radiographic signs of progression of osteoarthritis as a consequence of the conservative management.

Other studies suggest that early surgical intervention may provide for decreased development of osteoarthritis, a quicker return to function, and a more consistent recovery (4, 6–8). Although osteophyte formation appears to progress more slowly in cats than in dogs, osteophytosis became radiographically apparent only three months after experimental transection of the cranial cruciate ligament (9). The same study showed that degeneration of the stifle joint continued over a one-year period.

Overall, treatment of ruptured cranial cruciate ligament in feline patients aims to resolve lameness and signs of pain caused by joint instability, and to improve function and mobility of the affected limb. Traditionally, surgical stabilization of cranial cruciate ligament deficient stifles with an extracapsular technique was the most commonly performed procedure in cats (3, 4, 6, 10). In dogs however, corrective osteotomy with tibial plateau levelling osteotomy (TPLO) is believed to be superior to extracapsular stabilization techniques (11, 12). One case report of a cat with cranial cruciate ligament rupture and an exaggerated tibial plateau angle due to malformation of the proximal tibia described successful treatment using TPLO and cranial closing wedge osteotomy (13). Allan published a case report using a modified Maquet technique for management of cranial cruciate avulsion in a cat, achieving rapid improvement in lameness postoperatively (14).

Our purpose was to report the surgical procedure and short-term clinical outcome of TPLO in feline patients. To our knowledge, the application of TPLO as a single procedure in feline patients with cranial cruciate ligament rupture has not previously been reported. Our aims were to...
determine if TPLO would be technically feasible in cats and would result in satisfactory return to function.

**Materials and methods**

**Animals**

All cats presented to our clinic between July 2014 and July 2015 that were diagnosed with partial or complete cranial cruciate ligament rupture were enrolled in the study. Cases with other concurrent orthopaedic disease were excluded. Owners were asked for consent prior to enrolment into the study. History (duration of lameness, previous surgery), general clinical examination findings, breed, age, and weight of each patient were recorded. Lameness was scored subjectively (grade 0 = no lameness, grade 1 = mild, grade 2 = moderate, grade 3 = severe, grade 4 = non weight-bearing lameness).

During complete orthopaedic examination, the presence or absence of joint effusion, pain during manipulation, cranial drawer, and tibial compression test of the affected limb were evaluated. Finally, a mediolateral radiograph of the affected stifle was obtained to exclude primary neoplasia of the distal femur or proximal tibia.

Radiographic features indicative of osteoarthritis included signs of increased soft tissue opacity within the joint consistent with joint effusion, osteophytes, enthesophytes, and joint-associated mineralization. Mineralizations were classified as extra-articular if they were associated with the joint capsule or tendons, sclerosis, or subchondral bone erosions or cysts. Intra-articular mineralization included meniscal mineralizations and new bone formation. Based on a study by Frerre and others, severity of each radiographic change was graded on a five point scale as follows; normal = 0, trivial = 1, mild = 2, moderate = 3, and severe = 4 for each stifle joint (15).

Using this as a guide, we defined radiographic osteoarthritis grades from 0 to 10 (0 = no radiographic abnormalities identified; 1 = mild osteoarthritis; 4 = moderate osteoarthritis; 7 = severe osteoarthritis; 10 = most severe osteoarthritis).

**Preoperative procedure**

All preoperative radiographic measurements were obtained under general anaesthesia immediately prior to surgery. Cats were premedicated with midazolam\(^a\) (0.3 mg/kg IV) and levo-methadone\(^b\) (0.25 mg/kg IV). General anaesthesia was induced with propofol\(^c\) (2 to 4 mg/kg IV) and maintained with inhaled isoflurane\(^d\). Additional perioperative analgesia consisted of meloxicam\(^e\) (0.3 mg/kg SC). Cephazolin\(^f\) (20 mg/kg IV) was administered 20 minutes prior to surgery and repeated every 90 minutes until the end of surgery.

After intubation, orthogonal radiographs were obtained of each affected stifle joint to evaluate limb alignment and to determine tibial plateau angle (TPA) according to a previously described method with a digital radiography system\(^g\) (11, 16, 17). Radiographic analysis was performed on screen using commercial veterinary software\(^h\). Each TPA was measured by a board certified surgeon (SS) and an experienced senior orthopaedic surgeon (DM). Measurements were performed preoperatively and immediately postoperatively.

Concerning correct osteotomy positioning, measurements were performed on mediolateral radiographs preoperatively in each stifle joint. We measured two distances: the first distance was measured along the cranioproximal border of the tibia, and equalled the distance from the patellar ligament insertion to the point at which the intended osteotomy exits the tibia. The second distance was measured along a line perpendicular to the cranial border of the tibial crest and equalled the distance from the patellar ligament insertion to the intended osteotomy (37).

**Surgical technique**

All surgical procedures were performed by a board certified (SS) or a senior orthopaedic surgeon (DM). Prior to TPLO, examination of the intra-articular structures was performed via arthroscopy or arthrotomy. Arthroscopy was conducted via standard approach in the cats where a partial cranial cruciate ligament rupture or a meniscopathy was suspected due to chronic lameness but where the cranial drawer was absent. A medial arthrotomy immediately caudal to the medial collateral ligament was performed in the remaining cats. A medial approach to the proximal tibia was carried out in every procedure.

Upon access to the stifle joint, the medial meniscus was explored using a mensical probe. A partial meniscectomy was conducted if a meniscopathy could be identified. The joint capsule was closed in a standard fashion with interrupted sutures.

Afterwards, the joint surface was identified by inserting a 23-gauge needle caudal to the medial collateral ligament. In some cats, a stab incision was made caudal to the medial edge of the patellar ligament just proximal to its attachment to the tibia. An 18-gauge needle was introduced to avoid damage to the patellar ligament whilst sawing. We did not apply the TPLO jig as initially described by others (11). A 12 mm saw blade\(^i\) for TPLO was selected for every cat. Tibial tuberosity width, saw blade exit angle on the caudal tibial cortex, and adequate size of the tibial plateau segment to properly fit the TPLO plate were all confirmed before the osteotomy was conducted (11).

Subsequently, a 1.2 mm diameter Kirschner wire was placed in the tibial plateau segment, and the magnitude of tibial plateau rotation was determined from a TPLO chart\(^j\) designed to achieve a 5° postoperative TPA. After adequate positioning of the tibial plateau segment, a 0.8 mm diameter Kirschner wire was introduced through the tibial tuberosity into the tibial plateau segment for temporary fixation. The 1.2 mm Kirschner pin was removed after adequate rotation was confirmed.

A 2.0 mm or 2.4 mm locking TPLO plate\(^k\) was applied using standard internal

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\(a\) Midazolam-Actavis\(^a\): Actavis, Munich, Germany
\(b\) L-Polamivet\(^b\): InterVet/MSD, Unterschleißheim, Germany
\(c\) PropoVet\(^c\): Abbott, Hannover, Germany
\(d\) Isoflurane\(^d\): Henry Schein, Hamburg, Germany
\(e\) Metacam\(^e\): Boehringer, Dortmund, Germany
\(f\) CephAZOLIN\(^f\): Frensuis KABI, Bad Homburg, Germany
\(g\) XDR2-S, Samsung 1717: Samsung Electronics GmbH, Schwalbach am Taunus, Germany
\(h\) eazyImage: VetZ GmbH, Isenhagen, Germany

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\(i\) Synthes, Oberdorf, Switzerland

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\(j\) Schattauer 2016

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fixation techniques. Three cortical screws were used in the tibial shaft (C1-C3 from proximal to distal), whereas locking screws were used in the proximal tibial segment (L1-L3 from cranial to caudal) [Figure 1]. The C1 screw was inserted first in a neutral position and tightened. The plate was pushed proximally against the screw and correct positioning confirmed. The screw hole of C3 was drilled eccentrically, and a cortical screw inserted and tightened until it nearly touched the bone plate. Next, L2 was inserted, followed by L1 and L3 in varying order. In those cases where the Kirschner wire hindered drilling, it was removed before the third proximal screw hole was drilled. The C3 (load screw) was tightened completely to achieve compression of the osteotomy gap. Finally, C2 was inserted in a neutral position. The tightness of all screws was checked, and adequate compression of the osteotomy gap, as well as alignment of the osteotomy and limb, were verified. The fascia, subcutaneous tissue, and cutis were closed routinely. Cranial drawer sign and tibial compression test were evaluated immediately postoperatively.

Postoperative care

Wounds were covered with a non-adhesive dressing for 24 hours. Levo-methadone\(^{6}\) was administered intramuscularly every four hours with a tapering dosage for 24 hours. The day after surgery, all patients were clinically evaluated and discharged with an Elizabethan collar and instructions to owners to administer meloxicam\(^{6}\) (0.05 mg/kg PO once a day) and cefalexin\(^{1}\) (20 mg/kg PO twice daily) for 10 days. Cage rest was advised for four to six weeks.

Clinical outcome

Inspection of the surgical site, limb function, and severity of lameness were evaluated one day postoperatively, at the time of suture removal ten days after surgery, and during each follow-up radiographic assessment. At the last follow-up, six to twelve weeks postoperatively, the owners were asked to subjectively evaluate lameness (none = grade 0, mild = grade 1, mild intermittent to moderate = grade 2, severe = grade 3, non-weight-bearing = grade 4) and level of patient mobility and comfort, as well as give their own level of overall satisfaction regarding the surgical procedure and amount of clinical follow-up provided.

Radiographic outcome

Immediately after surgery, orthogonal radiographs of each stifle joint were obtained to evaluate osteotomy and implant positioning, limb alignment, and achieved TPA (11, 17).

The first follow-up radiographic evaluation was carried out four to eight weeks postoperatively and then repeated every four to six weeks until radiographic signs of bone union were categorized as good to excellent. Osteotomy healing was assessed on a mediolateral projection alone by evaluation of the osteotomy line cranial and caudal to the TPLO plate with the patient positioned in lateral recumbency without any sedation. Bone union was defined as fusion of the osteotomy line, the presence of bridging callus, or the disappearance of the osteotomy line. The level of bone union was scored as follows: 1 = poor union, <25% healing; 2 = fair union, 25 – 50% healing; 3 = good union, >50 – 75% healing; and 4 = excellent union, >75% healing (18). Radiographic progression of osteoarthritis was evaluated and documented in every cat, using the grading system described previously. Pre- and postoperative grades were compared in order to evaluate the progression of osteoarthritis.

Outcome evaluation

Clinical and radiographic evaluations of the stifle joints were performed by one of the authors or the referring veterinarian. If the radiographic images were not obtained in-house, they were sent to us online along with a clinical report. Clinical outcome was subjectively reported as poor (severe or non-weight-bearing lameness), fair (moderate lameness), good (mild lameness), excellent (no lameness) based on the orthopaedic examination findings and the owners’ subjective grading obtained at the final follow-up.

Complications

Intra-operative complications were defined as those occurring during or immediately after surgery upon radiographic examination. Postoperative complications were those developing one day to twelve weeks postoperatively. Complications associated with the surgical procedure were classified as major if surgical intervention was required, or minor if it could be managed without further surgery.

Statistical analysis

Commercially available software\(^{k}\) was used for all statistical analysis. All of the values are presented as a numerical value and standard deviation (SD). The TPA of each stifle joint was measured by each of the two surgeons and the average value of both measurements calculated for each joint. Next, mean TPA was determined from the average value of all stifles. To allow for interobserver variability, the intraclass correlation coefficient (0 to 1) as well as the coefficient of variation were calculated. In addition, mean pre- and postoperative TPA were measured by the two surgeons for each cat and the differ-

\(^{1}\) Cefalexin: cp-pharma, Burgdorf, Germany

\(^{6}\) Levo-methadone, \(^{6}\) Meloxicam, \(^{1}\) Cefalexin

\(k\) SPSS Statistics 23 for Windows: IBM, Chicago, IL, USA
ences visualized with the aid of a Blund-Altman Plot (19).

Results

Animals

Eleven client owned cats were enrolled in the study. None of the cats had to be excluded due to additional orthopaedic disease. Mean age at time of surgery was eight years (range: 3 - 13; SD: ± 3 years) and mean body weight was 5.7 kg (range: 3.8 - 11; SD: ± 2 kg). Represented breeds included nine Domestic Shorthaired cats, one Savannah, and one Turkish Van. There were five females and six males. All patients were outdoor cats. Eight cats had an acute onset of symptoms, whereas three cats were presented with chronic lameness. One cat had had two previous surgical procedures, an extracapsular stabilization and a capsulorrhaphy. Neither surgical procedure was successful in achieving an acceptable outcome as the stifle joint was still unstable and the cat showed a non-weight-bearing lameness.

General clinical examination was unremarkable in all cats. Upon orthopaedic examination, eight right and three left limbs were affected. Joint pain and stifle joint effusion were present in every patient. Ten of the 11 cats enrolled had a positive cranial drawer sign and a positive tibial compression test. The remaining cat showed a chronic lameness without a detectable instability of the stifle joint. Severity of lameness was classified as grade 3 in eight cats and grade 4 in three cats.

Preoperatively, mediolateral radiographs of the affected stifle joints did not show any evidence of primary neoplasia. Osteoarthritis was classified as mild in one, as moderate in four, and as severe in six joints (15). Radiographs also revealed a small intra-articular osseous fragment at the level of the cranial tibial plateau in seven of the eleven cases. Normal limb alignment was documented in every cat when performing orthograde radiographs during general anaesthesia, preoperatively, and postoperatively. Mean preoperative TPA was 27° (range: 24 to 32; SD: ± 3°) (Supplementary Table 1: available online at www.vcot-online.com; Figure 2).

Surgical technique

Five surgical procedures were performed by SS and six by DM.

A partial cranial cruciate ligament rupture, as well as a lateral and medial meniscopathy were detected arthroscopically in one cat. Debridement of both menisci was conducted with a 3.0 mm power shaver.

A medial arthrotomy was carried out in the remaining 10 cats. One revealed a bucket-handle tear of the medial meniscus which was treated with a partial meniscectomy. Nine cats did not show a medial meniscectomy.

A TPLO was performed as described above, using a 2.0 mm locking TPLO plate in 10 cats and a 2.4 mm locking TPLO plate in one cat weighing 11 kg. Immediately postoperatively, 10 cats showed a positive cranial drawer and a negative tibial compression test. Both tests were negative in the cat having a partial cranial cruciate ligament rupture.

Mean postoperative TPA was 8° (range: –2 to 15; SD: ± 5°) (Figure 3). The intraclass correlation coefficients for pre- and postoperative TPA were 0.52 and 0.67 respectively with a coefficient of variation of 0.13 and 0.63 respectively.

Interobserver variability

There was a distinct deviation when comparing the measurements made by each surgeon, especially for the postoperative TPA. The differences of both surgeons’ measurements were plotted against their mean (Figure 4). The intraclass correlation coefficients for pre- and postoperative TPA were 0.52 and 0.67 respectively with a coefficient of variation of 0.13 and 0.63 respectively.

Clinical outcome

One day postoperatively, all cats showed moderate lameness with regular wound appearance, swelling of the stifle joint, and signs of pain during manipulation. At the time of suture removal, lameness was graded as grade 2 in three cats and as grade 1 in eight cats. At four to twelve weeks postoperatively, all cats showed either no lameness (n = 3), or grade 1 (n = 2), or mild intermittent lameness (n = 6), mild joint effusion, and full range of motion. Cranial drawer and tibial compression test were not further evaluated during follow-
The aetiology of cranial cruciate ligament rupture in cats still remains unknown. Most published reports describe a traumatic rupture in cats, but the observation of a population of older, overweight cats suffering from cranial cruciate ligament rupture in the absence of significant trauma, suggests a degenerative injury similar to that seen in overweight dogs (3, 6).

All patients enrolled in our study were outdoor cats. Even though trauma was not observed or reported by any of the owners, it cannot be excluded as a possible cause. Duration of lameness varied amongst our patients. The majority of cats showed an acute onset of lameness, which might indicate a traumatic cranial cruciate ligament rupture. Osteoarthritis however, was graded as moderate to severe in 91% of the joints; a finding that does not support the assumption of acute traumatic cranial cruciate ligament rupture and making a degenerative aetiology more likely (9). One report of a histological sample from a ruptured feline cranial cruciate ligament showed similar degenerative changes to those observed in dogs (6). These included chondroid metaplasia, disorganized collagen fibres, and increased numbers of fibrocytes.

Assuming a degenerative and therefore chronic event, early surgical stabilization, via TPLO, might be beneficial to prevent progression of osteoarthritis. Overall, further investigations are needed and up. Owners reported a high level of comfort and mobility in every cat at the final last follow-up, despite a positive “sit test” in seven cats.

Radiographic outcome

During the first radiographic evaluation four to eight weeks postoperatively, bone union was recorded as grade 1 in one cat, grade 2 in three cats, grade 3 in three cats, and grade 4 in four cats. Six to twelve weeks after TPLO, bone union was classified as grade 4 in all cats. There was an increase in osteoarthritis evident in three cats, with two of them showing the most severe osteoarthritis (grade 10) of the operated stifle joint (Figure 5).

Complications

Minor intra-operative complications occurred in five cats. Osteotomy positioning was either more distally, more proximally, or more caudodistally than preferred in three cats due to incorrect positioning of the centre of rotation. The course of the achieved osteotomy was slightly oblique in four cats. A gap between tibial shaft and proximal tibial segment was visible in one cat. A proximal fibular fracture without fragment displacement occurred during drilling of one of the proximal screw holes in one cat (Figure 3, Figure 5). Overall, there was no delay in osteotomy healing and limb function. There were no major intra-operative complications.

Postoperatively, minor complications occurred in three cats. These complications consisted of a superficial wound infection due to uncontrolled licking in one cat and a mild patellar desmitis in two cats. In one of the two cats with this complication, a needle was used to retract the ligament while sawing, potentially causing iatrogenic damage. Mild patellar desmitis resolved after two weeks of prolonged treatment with meloxicam (0.05 mg/kg PO once a day). The superficial wound infection was successfully treated with five more days administration of oral antibiotic medication and the application of an Elizabethan collar. No major postoperative complications were detected.

Discussion

Tibial plateau levelling osteotomy in feline patients was performed without major technical difficulties and only minor intra- and postoperative complications. A level of comfort and mobility in every cat at the final last follow-up and complete return to function six to twelve weeks postoperatively was achieved in every patient, thereby supporting our aims.

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All patients enrolled in our study were outdoor cats. Even though trauma was not observed or reported by any of the owners, it cannot be excluded as a possible cause. Duration of lameness varied amongst our patients. The majority of cats showed an acute onset of lameness, which might indicate a traumatic cranial cruciate ligament rupture. Osteoarthritis however, was graded as moderate to severe in 91% of the joints; a finding that does not support the assumption of acute traumatic cranial cruciate ligament rupture and making a degenerative aetiology more likely (9). One report of a histological sample from a ruptured feline cranial cruciate ligament showed similar degenerative changes to those observed in dogs (6). These included chondroid metaplasia, disorganized collagen fibres, and increased numbers of fibrocytes. Assuming a degenerative and therefore chronic event, early surgical stabilization, via TPLO, might be beneficial to prevent progression of osteoarthritis. Overall, further investigations are needed and
Orthopaedic evaluation in feline patients can be more challenging compared to canine patients. A focused, efficient orthopaedic examination, including gait observation and limb palpation, and supplemented with appropriate history, is vital in deciding whether or not musculoskeletal disease can be ruled out (23, 24). A prospective study of 28 cats with osteoarthritis, which was designed to identify clinical signs, found that ability to jump, height of jump, lameness, stiff gait, and activity level of cats were signs clients could recognize (25). A recent study confirmed that ground reaction force measurements can objectively evaluate lameness and most easily recognize treatment effects in feline patients (26). Force plate analysis was not available for our patients.

Small, intra-articular osseous fragments in the region of the cranial tibial plateau can be indicative of cranial cruciate ligament avulsion or of a calcification or ossification of the cranial meniscus (15, 20). An avulsion of the cranial cruciate ligament, rather than tearing, most commonly occurs in skeletal immature patients. The average age of the cats in our study however was eight years. This makes a calcification or ossification of the cranial meniscus more likely; a fact that could not be completely confirmed during the conducted caudomedial arthrotomy due to insufficient visibility of the cranial horn of the meniscus.

A retrospective study evaluating 98 feline stifle joints with naturally occurring cranial cruciate ligament disease identified 94% complete ruptures compared with only 6% partial ones (21). This is in contrast to canine patients, in which a larger proportion of dogs have partial cranial cruciate ligament ruptures identified at the time of surgery, with an incidence of 40% in a retrospective study of 476 TPLO procedures (22). Only one partial cranial cruciate ligament rupture was detected in our study, which might be due to a low incidence in cats, low case numbers, or the fact that minimal clinical signs are not observed by owners.

After the clinical diagnosis is made, correct preoperative planning is essential in order to achieve a satisfying outcome in corrective osteotomies. In our study, the two surgeons experienced difficulties establishing the correct anatomical landmarks of the tibial plateau when measuring TPA in a few joints, especially when osteophyte formation was present at the joint margins. This explains the distinct inter-observer variance between SS and DM (Figure 4) (27). Overall, the medial tibial articular surface is less definable in cats compared to that in dogs. A previous study compared TPLO in cats with and without cranial cruciate ligament rupture and found a significant difference in TPA measurements between inexperienced and experienced observers (17). Possible causes were poor definition of the cranial and mainly caudal bone landmarks. The amount of osteoarthritis present at the caudal point of TPA impedes correct measurements in dogs and cats (28). Those findings concur with our results, although both of our observers were experienced surgeons who had been performing TPLO in dogs on a regular basis for five and more than 10 years, respectively.

According to Schnabl and colleagues, cats with cranial cruciate ligament rupture had a significantly greater mean TPA (24.7 ± 4.5°) compared to those without any evidence of cranial cruciate ligament injury (21.6 ± 3.7°) (17). Mean TPA in our cats was 27° (range: 24 - 32; SD: ± 3°), which was higher than the previously reported one. Whether or not the greater TPA increases the risk of cranial cruciate ligament rupture remains unknown; it does however make TPLO even more reasonable as choice of stabilization technique. Larger case numbers are needed for further evaluation.

The incidence of concurrent meniscal injuries in cats with cranial cruciate ligament rupture was previously reported to be 67% (21). In our study we only detected a meniscectomy in two cats. When performing caudomedial arthrotomy, visibility of the cranial part of the medial meniscus is reduced. Therefore, the incidental discrepancy might arise from undetected meniscal injuries at time of surgery or a non-representative case number.

The use of a jig and saw guide™ aids correct osteotomy orientation, stabilizes the bone segments during osteotomy reduction and rotation, and facilitates limb alignment, but increases surgical trauma and duration of surgery (11, 33). Since we only performed TPLO without a jig, we are not able to evaluate its practicability in cats. However, though we did not record a change in the tibial axis postoperatively, we did experience a slightly oblique orientation of the osteotomy in four cats (Figure 3).

Measurement techniques for osteotomy positioning in TPLO in dogs are important for correct planning (35). We measured the two distances as described previously (35). In three cats, osteotomy positioning was suboptimal, which possibly could have been prevented by using a jig. Nevertheless, it did not impair the patients’ outcome.

Concerning intra-operative complications, neither the cat that showed a visible gap between the tibial shaft and proximal tibial segment, nor the cat with an iatrogenic fibular fracture caused by drilling, suffered any delayed osteotomy healing visible on mediolateral radiographs or an inferior clinical outcome.

Although the mean TPA achieved in our cases (8°) was close to the 5° – 6.5° rec-
ommended in dogs, two cats had a postoperative TPA lower than 5° (-2° and 4°). Both cats recovered uneventfully and a caudal cruciate ligament rupture was not observed during the short-term follow-up. Nevertheless, it might remain a concern and would still need to be evaluated at a later time (36).

A retrospective study of 32 Labrador Retriever dogs found no significant relationship between postoperative TPA and ground reaction forces at more than four months after TPLO, where the postoperative angle was between 0 and 14° (44). Additionally, no significant relationship was found between the preoperative TPA and postoperative function.

Bilmont and colleagues evaluated the effect of TPLO on stability of the feline cranial cruciate ligament-deficient stifle joint in an in vitro study, showing that the values of cranial tibial subluxation and tibial rotation angle after TPLO with TPA of 5°, 0° and −5° did not differ significantly from those obtained after cranial cruciate ligament transection (38).

The reported incidence of postoperative patellar desmitis after TPLO in dogs varies from 0.3 to 25.5% (39). Possible causes are excessive patellar ligament retraction, heat development while sawing, or increased stress postoperatively. Larger case numbers are needed to evaluate whether or not this contributes to the development of patellar desmitis in the cat.

The overall level of bone union achieved in our study was comparable to that reached after TPLO in small breed dogs; which showed a median osteotomy healing grade of 3 at six to eight weeks postoperatively (18).

Since a control group of conservatively managed cats with cranial cruciate ligament rupture is lacking, the influence of surgical stabilization on further development of osteoarthritis in feline patients still needs to be established. In a study of 295 dogs undergoing TPLO, a small but significant increase was found in mean osteoarthritis score eight weeks after surgery, compared with mean preoperative score (40). Different studies evaluated general prevalence and extent of osteoarthritis in cats (41–44). Godrey reported radiographic signs of osteoarthritis to be found in 22% of a feline test population with only little correlation between clinical and radiographic signs (41). In two studies of 100 cats, radiographic evidence of osteoarthritis was evident in 90 – 92% (41, 45).

There are some limitations to our study. In order to further report complication rates and prove significance regarding outcome and development of osteoarthritis, larger case numbers as well as a longer follow-up period are necessary.

Additionally, there was an inevitable variation in case management. Due to the fact that patients were examined by different surgeons postoperatively, some even solely by their referring veterinarian, there was a high subjective interobserver variance. This is why the cranial drawer sign and tibial compression test could not be further reported during follow-up. Some of the patients’ owners were living far away, and therefore were unable to return to our clinic for follow-up examinations, a fact that needs to be recognized as a major limitation. Furthermore, orthogonal radiographs could not be obtained postoperatively due to the fact that patients were not sedated for radiography. This is also the reason why postoperative TPA could not be measured and why osteotomy healing could only be graded from mediolateral radiographs.

The preliminary results from this study support the use of TPLO in cats, but larger case numbers are needed to evaluate its practicability, as well as long-term outcome greater than one year, especially when evaluating the development and the clinical relevance of osteoarthritis.

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Conflict of interest

There are no conflicts of interest to declare for any of the authors.

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