Tibial tuberosity advancement in 65 canine stifles


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Summary

The tibial tuberosity advancement (TTA) procedure was developed to treat dogs with cranial cruciate ligament deficient stifles. A retrospective, descriptive study was performed on 57 dogs that underwent unilateral or bilateral TTA. Medical records were reviewed and pre-, postoperative and follow-up radiographs were evaluated for patellar ligament-tibial plateau angle (α), distance of the tibial tuberosity advancement and progression of degenerative joint disease. A questionnaire was sent to all owners to obtain their assessment of the procedural outcome. Sixty-five stifles in 57 dogs received a TTA. Mean age was 5.2 ± 2.5 years while mean weight was 39.7 ± 11.9 kg. Eighteen breeds were represented with Labrador retrievers and mixed breeds predominating. The mean duration of lameness prior to surgery was 6.2 ± 6.7 months, with a median lameness score of 3/4. Fifty-nine percent of cases encountered complications, the majority of which were minor. Major post-operative complications were uncommon but consisted of implant failure, tibial crest displacement and medial meniscal tears. The mean radiographic preoperative angle α was 100°, while the postoperative was 95.9°. Mean osteoarthrosis scores were significantly different between preoperative and follow-up radiographs with 67% of cases showing radiographic progression. Seventy percent of owners responded to the survey with overall outcome considered good to excellent in 90%. Activity level was improved in 90% of responses. TTA subjectively appears to be a useful alternative in the management of cranial cruciate ligament disease. Few severe complications were encountered. Good clinical outcome and owner satisfaction was reported with the procedure in this set of cases.

Keywords

Cranial cruciate ligament, tibial tuberosity advancement, TTA, stifle

Introduction

Rupture of the cranial cruciate ligament (CCL) is one of the most common orthopedic problems observed in the canine stifle (1–3). The cranial cruciate ligament has three passive functions in the femorotibial (stifle) joint: to limit hyperextension, excessive internal tibial rotation, as well as cranial drawer motion (4).

Rupture of the cranial cruciate ligament results in instability of the stifle (5) which is recognized clinically by cranial drawer motion and a positive cranial tibial thrust (4, 6). Instability leads to osteoarthritis and frequently results in medial meniscal injury as well as protective gait changes to limit the pain associated with joint capsule stretching and effusion (4, 7). Over the past few decades, numerous repair techniques have been developed to stabilize the CCL deficient stifle and most of these have been clinically evaluated (1). These procedures are divided into extracapsular and intracapsular techniques. Either the ligament itself is replaced, or the function of the CCL is approximated by implanting femoral-tibial restraint devices to statically restrict the cranial tibial shear forces that result in drawer motion. The more recent tibial plateau leveling osteotomy and tibial tuberosity advancement procedures provide stabilization of the stifle without mimicking the function of the ligament (8, 9).

The tibial tuberosity advancement (TTA) procedure was developed by Tepic and Montavoni in 2002 (9) as an alternative to the tibial plateau leveling procedure. TTA consists of advancing the tibial tuberosity, and thus the patellar ligament, cranially. This theoretically modifies the femorotibial joint geometry to reduce the effect of cranial tibial shear forces. TTA is being performed clinically, but to the authors’ knowledge no peer-reviewed reports are published.

The purposes of this retrospective study are to describe the operative procedure as performed, to examine the population of surgical patients, and to assess the procedure’s short-term outcome through owner evaluation, medical record review, and radiographic analysis.

Materials and methods

The medical records of each dog that underwent the TTA procedure at the Virginia-Maryland Regional College of Veterinary Medicine (VMRCVM) for treatment of cranial cruciate ligament rupture between March 2004 and February 2005 were reviewed. Dogs were included in the study if they were diagnosed as having CCL rupture by a history of hind limb lameness with stifle pain, a positive cranial drawer and/or positive cranial tibial thrust upon orthopedic examination, and supportive radiographic evidence of stifle effusion or osteoarthritis. Other requirements included follow-up evaluations performed at least six weeks post-operatively and no other surgeries performed on the operated stifle. All the dogs in this study were skeletally mature and weighed greater than 10 kg. In each case, surgery was performed by a Diplomate of the American College of Veterinary Surgery (ACVS) or by a surgical resident under direct supervision by a Diplomate of the ACVS. Information obtained from medical records of selected cases included signalment, lameness history, surgical reports, information about the perioperative recovery, descriptions of any complications encountered, and pre-operative, immediate
post-operative, and follow-up stifle radiographs when available.

Most patients had all three radiographic studies available for interpretation (52 stifles). When a study was not available, the case was excluded only from comparisons requiring that study.

Observations of intraoperative, clinical, and radiographic findings were tabulated according to the time frame in which they appeared: group 1, intraoperative (during the anesthetic episode); group 2, in-hospital post-operative (after completion of anesthesia until discharge from the hospital, generally 48 hours); group 3, early post-operative (from time of discharge through 14 days); group 4, late post-operative (greater than or equal to 15 days postoperatively).

Preoperative lameness and immediate post-operative lameness were graded on a 0–4 point scale: 0– no lameness, 1– mild lameness, 2– moderate lameness, 3– toe-touching lameness, 4– non-weight-bearing lameness.

**Surgery**

After aseptic preparation of the hindlimb, a standard medial parapatellar approach to the stifle joint was made. A cranialomedial arthrotomy was performed in all cases to evaluate the degree of cranial cruciate and medial meniscal injury. All damaged ligamentous and meniscal tissue was sharply excised completely. No releasing procedure was performed for intact menisci. A TTA procedure was then performed using commercially available equipment (Kyon, Zürich, Switzerland). This procedure was briefly described previously (10). Elevation of the proximal third of the medial tibial periosteum allowed application of a drill guide device to the cranial tibial crest. The drill guide was placed so that the drill holes were aligned 2–4 mm caudal to the most cranial aspect of the tibial crest along its entire length. The drill guide was held in place with self-retaining forceps, and a 2.0 mm drill bit was used to drill 3 to 8 holes in the crest. The guide was removed and a longitudinal osteotomy of the tibial crest was made with an oscillating saw blade starting proximally at the level of the canine equivalent to the human tubercle of Gerdy (11) and extending to the distal extent of the tibial crest, while keeping the patella luxated laterally and protecting the patellar ligament with a periosteal elevator. The osteotomy varied from 2–4 mm caudal to the line of holes. A titanium plate was applied to the tibial crest, and secured in place with a fork with the appropriate number of tines. The fork tines were lodged into the holes using a custom impactor and mallet. A 6, 9, or 12 mm wide titanium cage of a length measured from the cut proximal tibial crest surface was implanted in the proximal osteotomy gap. The width of the cage was determined preoperatively using a template on a lateral stifle radiograph with the femorotibial joint angle at approximately 135°. The cage was placed parallel to the joint surface, 1–2 mm distal to the joint surface, and secured to the tuberosity and the remaining tibial shaft with two 2.4 mm self-tapping titanium bone screws. The distal end of the plate was secured to the medial aspect of the tibia with two 3.5 mm or 2.7 mm self-tapping titanium bone screws. Using a plate with six or more tine holes requires 3.5 mm screws while smaller ones use the 2.7 mm screws. The distal tibial crest was compressed against the distal osteotomy site during screw placement with pointed reduction forceps. The joint and osteotomy site were lavaged with sterile saline. An autogenous cancellous bone graft was harvested from the medial aspect of the distal femur and packed into the osteotomy space distal to the cage. The arthrotomy and tibial osteotomy surgical sites were closed routinely.

**Post-operative care**

A modified Robert Jones bandage was applied in all cases and was removed the morning after surgery. Post-operative pain medication consisted of morphine 0.5 mg/kg IM q4–6h or hydromorphone 0.1 mg/kg IV/IM q4–6h for the first 24–48 hours. A non-steroidal anti-inflammatory drug such as carprofen 2.2 mg/kg PO q12h or meloxicam 0.1 mg/kg PO q24h was administered starting the morning after surgery and continued for 7–14 days.

**Radiographic analysis**

Radiographs were made prior to surgery, immediately following surgery, and at follow-up examination for each case, generally 6–8 weeks postoperatively. Preoperative and immediate post-operative radiographic studies consisted of caudocranial and lateromedial views of the affected leg, centered on the femorotibial joint and including at least the distal third of the femur and at least the proximal half of the tibia. The majority of the laterial medial radiographs were made with the stifle at 135° of flexion, the approximate weight-bearing angle of the stifle joint (12, 13), according to a goniometer placed over the shafts of the femur and tibia (Fig. 1). Follow-up radiographs were made either at the VMRCVM (22 stifles) or at the respective referring veterinarians of the patients (30 stifles). Follow-up radiographic studies generally consisted of a caudocranial radiograph and a lateromedial radiograph collimated closely on the stifle. On the lateromedial radiograph, the angulation of the stifle was not precisely measured, as consistency for measurements was not required, but was generally near 90° of flexion.
All observers were blinded to the patient identification, surgery date, and outcome. For the preoperative and postoperative studies, cases were randomized by case number and study performed. However, due to radiograph availability, follow-up radiographs were read subsequent to the reading of all pre- and postoperative radiographs. Within the group of follow-up radiographs, the radiographs were randomized by patient number.

The preoperative and immediate postoperative radiographs were used to make measurements related to surgical planning and technique. On each lateromedial radiograph, angle $\alpha$ was measured, where $\alpha$ is defined as the angle formed by the intersection of a line passing through the tibial plateau and the line of the patellar ligament, represented by a line drawn from the cranial most aspect of the patella to the cranial most aspect of the tibial tuberosity (Fig. 2). Preoperative and postoperative measurements of $\alpha$ were compared to each other and the theoretical standards. The required advancement was then measured on the lateromedial radiographs by aligning a commercially available TTA template with the cranial margin of the patella and the line representing the tibial plateau (Fig. 3). The template defines angle $\alpha$ as $90^\circ$, and the distance (in millimeters) of tibial tuberosity advancement required to achieve this can be read from the template. In the case in Fig. 3, a 12 mm cage would be ideal. The preoperative and postoperative measurements were then compared to determine if the desired amount of advancement was achieved. In addition, observations were collected regarding the implant positioning and deviations from the described technique (10).

Measurements of $\alpha$ and advancement distance on the preoperative and immediate postoperative radiographs were made independently by two observers (DH, JM). The mean values for $\alpha$ and the advancement distance were then calculated for each stifle. Because variation of stifle angulation can alter the measurement of $\alpha$, a study which did not include a lateromedial radiograph with the stifle in $135^\circ \pm 5^\circ$ of flexion was excluded from these measurements.

The preoperative and follow-up radiographs were evaluated for degree of osteoarthritis (DH, JM). A previously described 0–4 scale was utilized, with 0 representing no evidence of degenerative change, 1 signifying mild osteophyte formation, 2 indicating mild-moderate osteophyte formation, 3 representing moderate osteophyte formation, and 4 signifying severe osteophyte formation (14). After the blinded scores had been recorded, a direct, side to side comparison between the preoperative and follow-up radiographs was made to evaluate for subtle progression of degenerative joint disease; any change was recorded. Preoperative and follow-up scores were then compared to each other. The follow-up radiographs were also evaluated for healing of the osteotomy site. A 0–4 scale was used, with 0 indicating no osseous healing, 1 representing early bone production without bridging between the tibial tuberosity and the shaft of the tibia, 2 signifying bridging bone formation at one site, 3 indicating bridging bone at two sites, and 4 representing bridging bone at all three sites. The sites were defined as the region of osteotomy proximal to the cage, the region of osteotomy between the cage and the plate, and the region of osteotomy distal to the plate. Follow-up complications and observations were also described.

Evaluation of osteoarthritis (OA) and osteotomy healing were performed independently by three observers (DH, JM, CO). When there was a discrepancy in the score for a category, the score recorded by a majority of observers was used. Scores assigned did not vary more than one category for any measurement among observers.

**Owner assessment**

A questionnaire was mailed to the owners of all dogs included in the study, at least eight weeks following surgery. The questionnaire (Appendix A) required responses regarding the severity and duration of lameness preoperatively and at the time of survey completion, the current need for anti-inflammatory medication, and overall owner satisfaction. The clients were instructed to circle the most appropriate categorical response for each question. Returned surveys were grouped according to the time elapsed from...
surgery: group 1, < 3 months; group 2, 3–6 months; group 3, 6–9 months; group 4, > 9 months.

Statistical analysis

Descriptive statistics were calculated using the MEANS procedure of the SAS System (ver 9.12, SAS Institute Inc., Cary, NC 27513), and mean values with standard deviations are given for parametric data. Median values and ranges are given for non-parametric data. The Wilcoxon Signed rank test was calculated using the UNIVARIATE procedure of the SAS System to test for change from before to after surgery for the lameness scores and the continuous radiographic measures. The Cochran Mantel Haenszel test was calculated using the FREQ procedure of the SAS System to test for change from before to after surgery in the DJD scores.

Results

Sixty-five TTA procedures were performed in 57 dogs between March 2004 and February 2005. Eight of these dogs had bilateral procedures with half of them having both procedures done under the same anesthetic episode. Thirty-six left TTAs were done, while 29 were right TTAs. Mean age at the time of surgery was 5.2 ± 2.5 years (range 1.3 to 9.8 years), while mean body weight was 39.7 ± 11.9 kg; (range, 10.4 to 81.8 kg). Eighteen different dog breeds were represented with Labrador retrievers (29%) and mixed breed dogs (23%) predominating. Of the group, 55% were female spayed, 35% were male neutered, 6% were intact male and 3% intact females. The median duration of lameness prior to surgery was 4.0 months (range 0.3 to 36 months), with a median lameness score of 3/4.

Surgery duration lasted a mean of 125 ± 37 minutes per operated leg (range 70 to 225 minutes). Fifty-one percent of stifles had meniscal damage, including one dog with a lateral meniscal tear; damage was treated by partial or complete meniscectomy. In the stifles without meniscal injury, no releasing procedure was performed. The cranial cruciate ligament was completely ruptured in 69% of stifles, and only partially damaged in the remaining 31%. Fifty-eight percent (38) of the 65 stifles received 9 mm cages, while 37% (24) received 6 mm cages, and 5% (12 mm cages were placed in two great Danes and one bull mastiff. In 77% (50) of the cases, either a 5 or 6 tine fork was used. The median postoperative lameness score was 3/4.

A total of 27 distinct complications and observations were recorded (Table 1). The majority were minor including incisional swelling and bruising. Intraoperative complications were noted in two dogs. While performing the osteotomy with an oscillating saw in one dog, the tendon of the long digital extensor was inadvertently transected. No attempt at repair was made and recovery seemed unimpeded. The other involved intra-articular screw placement that was not seen until follow-up. Perioperative complications were generally mild and included incisional swelling, diarrhea and inappetence. These occurred in 59%, 14% and 10% of cases, respectively. The most notable early post-operative complication encountered, occurring within two weeks of discharge, was incisional dehiscence and superficial infection in three dogs (5%). More long-term complications, seen greater than two weeks after discharge, were considered serious. The most common were joint pain and effusion, medial meniscal injury and joint crepitus. These were observed in six (10%), three (5%) and two (4%) dogs, respectively. The most catastrophic complication was a complete implant failure with fork fracture, broken cage and tibial crest displacement that occurred in one dog six weeks post-operatively (Fig. 4A, B). This dog received bilateral TTAs under the same anaesthetic episode. The fracture was repaired using a pin and tension band technique to reattach the tuberosity, while the cage was left in place. The owner admitted that the dog was not controlled in his activity postoperatively. This dog subsequently developed a draining fistulous tract from the revised surgical site and was euthanatized at the request of the owners. Another serious complication seen in a different dog was focal lysis of the lateral femoral condyle due to the aforementioned intra-articular screw placement. This dog eventually had the implants removed. On follow up physical examination, one additional dog was noted to have a grade II/IV medial patellar luxation which had not been noted pre-operatively.
Many observations were noted, mostly on post-operative radiographs, relating to procedural deviations and unexpected findings. Common procedural errors included the osteotomy extending distal to the proximal plate screw (22%), an improperly fitted plate (26%), variations from ideal screw placement (17%) and poorly contoured plates (5%) (Table 2). One of the more interesting of the late post-operative observations were several areas of periosteal proliferation seen on recheck radiographs at the level of the medial, lateral, and caudal tibial diaphysis associated with the osteotomy and soft-tissue manipulation (Fig. 5). All dogs had complete sets of pre- and post-operative radiographs except for two, which were subsequently excluded from the radiographic comparison portion of the study. Due to the template design, those sets of radiographs that included any films that were not made with the stifle within 5° of 135° were excluded from analysis. A total of 57 sets of pre- and post-operative radiographs were available for comparison. The mean preoperative α was 100.0° (range 91 to 107°), while the mean postoperative α was 95.5° (range 89.5 to 101.5°). The mean distance of advancement required on the preoperative radiographs was 9.0 mm (range 0.5 to 17.5 mm), while the mean postoperative measured distance from the theoretical 90° α was 4.1 mm (range –1 to 9 mm).

Thirty studies (58%) were radiographs made by referring veterinarians and mailed to the VMRCVM while 22 studies (42%) were performed by the VMRCVM radiology department. Of the 52 sets of follow-up radiographs, 49 (94%) were made six or more weeks post-operatively. The mean follow-up time was just over eight weeks with the longest being 34 weeks. Healing of the osteotomy gap was deemed complete (grade 4) in only five (10%) cases at the time of recheck. The mean follow-up time for this group was 11.4 weeks. Those with healing graded as three (29%), two (48%) and one (13%) had mean follow-up times of 9, 7.7 and 5.4 weeks, respectively. Eighty-seven percent (45) of cases had healing scores of 2 or higher (Fig. 6). The average age and weight for the remaining 13% that had lower healing scores were 6.9 years and 39.3 kg. Patient age and weight were not significantly different in these animals from those that had scores of 2 or higher (p=0.18, p=0.46). In 51 cases, there were pre-operative and recheck radiographs to compare osteoarthrosis. OA scores preoperatively had a mean of 2.1 (median 2, range 0 to 4), while the two month recheck OA scores averaged 2.5 (median 2, range 1 to 4), representing significant progression (p=0.005). Osteoarthrosis was also significantly worse in a side to side comparison. Thirty-four (67%) of the cases showed progression when pre-op and follow-up radiographs were directly compared while none was observed in 17 (33%) (p<0.001).

Forty (70%) completed questionnaires were returned by owners. All were received by the owner no earlier than eight weeks post-operatively. The earliest follow-up was eight weeks, the latest was 42 weeks, and the median was 24 weeks. There were five (12%) dogs that had follow-up greater than nine months, 14 (35%) were six to nine months, 13 (33%) were three to six months...
and eight (20%) were between eight weeks and three months (Table 3). Owners assessed the overall outcome of the procedure to be excellent in 75% (30) of cases and good to excellent in 90% (36). Seventy-eight percent (31) of owners thought that the lameness frequency was a category 3 (lame after short walks) or less at the time of the survey. This is opposed to 15% (6) that were category 3 or less pre-operatively. Lameness severity at the time of survey was a category 2 or 1 (limps only after heavy exercise or never) in 95% (38) of cases, whereas pre-operatively only 32% (13) of patients were considered category 2 or 1. The overall activity level was improved according to 90% (36) of owners.

Evaluating by follow-up time category yielded similar results. Overall outcome was assessed to good to excellent in 100%, 93%, 77% and 100% for the time frames of nine or more months, six to nine months, three to six months and less than three months, respectively. Lameness frequency was perceived to be a category 1 or 2 (limping never or only after heavy exercise) in 40%, 72%, 62% and 62% of the cases at the time of evaluation, with respect to the previously listed follow-up times. This was opposed to 40%, 0% 16% and 0% pre-operatively, respectively. The severity of lameness followed a similar pattern. At the time of follow-up, severity was assessed to be a category 1 or 2 (limps never or uses leg with each step) in 100%, 100%, 92% and 87% of the cases with the same time categories as before. The respective pre-operative lameness scores of category 1 or 2 were 40%, 50%, 23% and 15%.

### Table 2

<table>
<thead>
<tr>
<th>Description</th>
<th>Frequency</th>
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<tr>
<td>Osteotomy extends beyond proximal plate screw</td>
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<td>21.5</td>
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<tr>
<td>Plate extends beyond crest</td>
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<td>18.5</td>
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<tr>
<td>Empty drilled hole</td>
<td>8</td>
<td>12.3</td>
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<tr>
<td>Monocortical plate screw</td>
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<td>10.8</td>
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<tr>
<td>Poor plate contouring</td>
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<td>4.6</td>
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<tr>
<td>Screw near joint</td>
<td>3</td>
<td>4.6</td>
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<tr>
<td>Fork not flush with plate</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>Distal plate extends beyond caudal cortex of tibia</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>Cage upside down</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>Fissure caused by proximal plate screw</td>
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<td>1.5</td>
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<tr>
<td>Transected long digital extensor tendon</td>
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</table>

### Discussion

In this study, the tibial tuberosity advancement procedure was performed in 65 stifles in dogs that had signalments comparable to other cranial cruciate repair studies (15–17). Young, large breed dogs, particularly Labrador retrievers, predominated. Other patient factors, including partial ver-
susc complete CCL rupture and meniscal damage at the time of surgery, were similar to other reports of CCL treatment techniques (14, 16–19). The TTA procedures in this study were performed by experienced orthopaedic surgeons or by residents under their direct supervision. The average surgery duration of 125 minutes is subjectively similar to the duration of other cruciate repair procedures at our teaching hospital and elsewhere (17). The prevalence of medial meniscal injury and partial versus complete cranial cruciate tears in this series are also similar to previous reports (17, 20).

The relatively new TTA procedure has had very few reported cases of complications. One or more complications occurred in 33 of 57 dogs (59%). When minor incisional swelling and bruising are removed from the list of complications, only 12 of 57 dogs (21%) had more serious complications. Studies of other cranial cruciate ligament repair techniques report overall complication rates of 20% to 28% (16, 17, 21, 22). The most serious complication reported previously for TTA included tibial tuberosity fracture associated with fork placement and tibial fracture in two cases where the osteotomy extended distal to the plate (10). The number of serious complications in this series was similarly few. The historical activity allowed in the dog with implant failure underscores the importance of exercise restrictions after surgery to allow for adequate bone healing. Optimal time has not been established, but radiographic healing of the osteotomy gap was observed to be at least partially complete by about seven to eight weeks postoperatively and fully complete by as early as eight to 10 weeks.

Eighty-seven percent of cases observed had some degree of of radiographic healing (grade 2 or higher) evident at an average follow-up of 8.6 weeks. Undoubtedly the quality and quantity of cancellous graft impacts the time to radiographic union as does surgical technique and a variety of patient factors including age (23). A postoperative restricted activity regimen for eight to 10 weeks with gradual return to normal activity after recheck seems reasonable.

The dog with complete implant failure developed a fistulous tract, which is suggestive of implant-associated infection, but no bacterial cultures were performed for confirmation. No other cases were found to have clinical or radiographic evidence of implant infections or osteomyelitis. Superficial incisional infections did occur in three dogs. Studies of other CCL repair techniques report infection rates to be low, ranging from <1% up to 7% (16, 17).

Intra-articular screw placement occurred in one dog. This could be seen on the postoperative radiographs, but was deemed non-pathogenic at the time. Subsequently, the dog recovered with persistent lameness, and six months after the procedure the implants were removed, resulting in clinical improvement (Fig. 7A, B). It is supposed that normal joint motion of the femoral condyle against the screw tip is the cause of bone lucency observed on follow-up radiographs (Fig. 8). Every attempt should be made to direct the cage screws away from the joint surface, and if noted on postoperative radiographs, immediate revision to a shorter screw is advised. In one other case with no postoperative problem, the caudal cage screw was too long and the tip was located within the stifle joint.

In the case of postoperative medial patellar luxation, luxation secondary to the TTA is suspected. One of the proposed benefits of this procedure (10), and the original human application of patellar advancement is to reduce the articular pressure between the femur and patella (24). This reduced force between the two bones could predispose the patella to luxation. Alternately, movement of the tibial tuberosity medially during the procedure as a result of improper plate contouring could also predispose for medial patellar luxation (25). Neither of these could be documented in the case reported here, and the dog did not require further treatment.

The long digital extensor tendon was iatrogenically severed in one dog. This can be avoided by adhering to the designers’ recommendation of creating the osteotomy gap.
cranial to the level of the tubercle of Gerdy, located on the cranialateral proximal tibia (10, 11). The dog in which this occurred did not experience any observable deficiencies, which has been reported elsewhere (21).

Importantly, 3/32 stifles (nearly 10%) having no meniscal damage at the time of the TTA procedure subsequently developed medial meniscal tears requiring a second operative procedure. It is stated that due to the biomechanical considerations of the TTA, no meniscal damage is anticipated, nor has such damage been documented until now (9). Meniscal releasing procedures have been used routinely in tibial plateau leveling procedures to protect the medial meniscus from future damage and perhaps should be considered in TTA procedures as well (17). Clearly TTA has an effect on the function of the medial meniscus postoperatively. This may be due to a change in the direction of physiologic thrust to the caudal direction, the inability of TTA to control cranial drawer during different portions of limb motion, or underadvancement was performed and thus tibiofemoral shear force was not eliminated. The small number of cases may be biased. Further research will be necessary to determine what factors may contribute to meniscal damage after TTA.

Radiographically, the mean preoperative \( \alpha \) was 100°. It is unknown at this time if this angle is significantly different between dogs with and without cruciate ligament disease. The mean postoperative \( \alpha \) was only 95.5°. The theoretical goal for tuberosity advancement is to obtain a 90° angle between the tibial plateau and the patellar ligament at 90° of stifle flexion in order to neutralize cranial cranial translation inducing shear forces across the femorotibial joint (26). Radiographs were not taken at 90° but closer to 135° of flexion. According to theory, alpha is directly proportional to the degree of stifle flexion which may explain the discrepancy (26).

The question still remains as to how much deviation from this is physiologically acceptable to control cranial tibia thrust during weight bearing. Further studies are needed to determine the significance of and deviation possible from this theoretical ideal in the clinical setting. The remaining 4.1 mm average of advancement distance required to reach the ideal \( \alpha \) is encompassed by the 5° variation from 90°. The TTA system is limited somewhat by the cage sizes available (6, 9, and 12 mm in width). Perhaps instead of relying on the manufacturer’s template for measurements preoperatively, the actual \( \alpha \) should be measured, in which case a larger variety of cage widths may help to individually achieve the ideal postoperative advancement.

The mean duration of lameness prior to presentation for TTA was six months, which can partially be attributed to the two to three month waiting period for appointments to our orthopedic service. This length of time undoubtedly contributed to the 2.1 mean osteoarthrosis (OA) score on the preoperative films (1). The recheck radiographs had a mean OA score of 2.5 and side-to-side comparison revealed OA progression in 67% of the cases. Osteophytosis was seen to be significantly greater at six months (14) and at >12 months (18) with multiple other CCL repair techniques. Radiographic progression may not be linear and it has been shown that osteoarthrosis progresses with CCL rupture despite treatment (18). The manufacturer’s suggestion of reduced OA progression compared to other cranial cruciate repair methods cannot be supported by our short-term results. Long-term follow-up studies are required to assess the degree of OA advancement in TTA cases as compared with other procedures.
At a median of six months follow-up, 90% of the owners stated the overall outcome was good to excellent. Improvements in the majority of cases were seen in the frequency and severity of lameness. Owner assessment was used in this study due to the small number of patients available for re-check physical and radiographic examination. Undoubtedly, reassessment by the operating surgeon would be ideal, but useful and valid information can be obtained by owner assessment (27).

The retrospective nature of this study limited the entire data set in each case dependent on the completeness of the record, radiograph set, and owner evaluations. A controlled prospective study would obviate these problems. The lameness scores and owner evaluation data were necessarily subjective in nature and could have introduced some bias into our analysis. Differences in the completeness of the surgery report also precluded individual assessments of intra- and post-operative stifles stability, but in general cranial drawer was not improved by TTA, while cranial tibial thrust was in the awake patient.

Tibial tuberosity advancement is the latest in a vast array of procedures designed to stabilize the canine stifle affected by cranial cruciate ligament rupture. Some similar complications and observations were seen with the TTA as with other CCL repair techniques. No direct comparisons to other procedures can yet be made. Subjectively, stifle stabilization with TTA in our hospital provided identical, if not slightly better, early outcomes as the tibial plateau leveling osteotomy. This descriptive report, including owner assessment, and clinical experience suggest that patients benefit, at least in the short-term, with respect to subjectively improved ambulation and decreased discomfort post-operatively. Advancement of OA was noted in most, but was generally mild. Prospective, long-term clinical trials and biomechanical research are needed to evaluate the efficacy of this procedure for long-term stifle joint stabilization after cranial cruciate ligament rupture. This research is currently underway at this institution.

References