

Clinical results of triple tibial osteotomy treatment in cranial cruciate ligament-deficient dogs

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Abstract: Canine cranial cruciate ligament ruptures have become common with improved nutrition and nonselective breeding strategies. This study assessed 7 dogs of various breeds and ages with the diagnosis of cranial cruciate ligament ruptures. The triple tibial osteotomy (TTO) method was used to treat the rupture. All of the dogs were admitted to the clinic for varying degrees of lameness. Diagnosis was confirmed using both clinical and radiologic examinations. Body weights of the dogs were between 12 and 65 kg. Informed consent was given by the owners prior to surgery. Postoperatively, early evaluations were made using periodic radiographs and clinical examinations, but long-term evaluations were performed by phone interviews due to economic and other limitations by the owners. The TTO operation method was completed successfully in all of the cases and only with Case 5 was a major complication encountered (tibial tuberosity fracture from the distal pivot hole). In 3 cases, the minor complication of wound contamination occurred due to poor wound care by the owners of the dogs. Owners were advised to restrict mobilization for a week following cast removal. Early, mid-, and long-term postoperative results showed functional recovery in all of the cases. All of the dogs returned to their pretrauma lives and those that had chronic symptoms had a significant increase in their mobility when compared to their previous states after cranial cruciate ligament rupture.

Key words: Dog, cranial cruciate ligament, rupture

1. Introduction

Cranial cruciate ligament (CrCL) ruptures are commonly seen in dogs. CrCL ruptures cause the dislocation of the tibia in the cranial direction from the functional ligament during a step movement, resulting in articular degenerative changes and osteoarthritis. Many intra- and extracapsular treatment methods have been reported. Over time, biomechanical problems were overcome and the factor causing subluxation during the step movement was understood to be cranial tibial thrust (CTT) force [1]. Today, the idea of neutralizing the CTT has become the basis of current surgical practices [2]. The methods began with a pioneering study using a cranial wedge osteotomy by Slocum et al. [3], but was modified into a more advanced tibial plateau leveling osteotomy (TPLO) in 1993 by the same researchers. Next, Montavon [4] developed the tibial tuberosity advancement (TTA) method in 1998. The latest method is the triple tibial osteotomy (TTO) developed by Bruce et al. [5] in 2007, which is a unique combination of both of the abovementioned methods. There have been a limited number of studies conducted on this subject in Turkey [6,7].

This study examined the TTO method to share the treatment results on dogs and contribute to the current scientific literature in Turkey.

2. Materials and methods

Herein, 7 dogs diagnosed with CrCL deficiency were assessed using clinical and radiological examinations. The study was performed at the Animal Health Management and Research Hospital of Afyon Kocatepe University. Dogs were chosen from those that qualified for surgical treatment for CrCL rupture. They varied in weight, breed, age, and sex. Ethical permission was granted by the Afyon Kocatepe University Ethical Commission for Animal Experiments under verification number 49533702/105.

2.1. Preoperative planning

X-rays were taken at a 135° knee joint mediolateral projection by extending the joint. Simultaneously, ventrodorsal hip-extended radiographs and additional possible diseases were examined. The images were stored and evaluated using computer software for wedge angle (WA) calculations. X-rays were evaluated for the angle measurement between the patellar ligament and tibial

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plateau axis, preoperatively and postoperatively, for the comparison of surgical changes, as seen in Figure 1.

Care was taken to obtain a proper lateral view of the stifle radiographs. For the precise measurement and determination of the extent of tibial tuberosity, the correction angle (CA) was measured using a combination of the 3 radiographic methods of Warzee et al. [1] Kergosien et al. [8], and Warrick et al. [9]. The angle between the tibial plateau slope and patellar ligament was recorded and the line between the center of the talus and tibial crest was measured. Both results were used for finding the angle of the tibial slope between the functional tibial axis and patellar ligament as well as the CA. The WA was calculated using the CA, as presented by Warrick et al. [9] ($WA = 0.6 \times CA + 7^\circ$) and seen in Figure 1.

2.2. Surgical procedure

The fundamental aim of the TTO intervention was the remodeling of the tibia bone in the construction of 2 planes, so that the tibia plateau and patellar ligament were perpendicular to each other.

The dogs were anesthetized using 2–3 mg/kg of xylazine hydrochloride (Rompun 23.32 mg/mL; Bayer, Leverkusen, Germany) in combination with 5–7 mg/kg of ketamine hydrochloride (Ketalar, 50 mg/mL; Parke-Davis, MI, USA) by intramuscular injection and maintained using 2.5% isoflurane inhalation following tracheal intubation and artificial ventilation. Their fur was clipped and the medial tibial aspect was prepared for aseptic surgery. Skin and subcutaneous layers were dissected and the incision was extended between the medial para-patellar region and the proximal one-third of the tibia. Crystalloid solutions were infused intravenously during surgery at 10 mL/kg/h together with 20 mg/kg cephazoline. Following medial arthrotomy, the joint structures were evaluated for the formation of arthritis, synovitis, and meniscus damage. CrCL remnants were removed and the joint was lavaged to flush out extra debris. The arthrotomy was closed with simple sutures. Proximally, the tibial periosteum was elevated at the medial side and the bone surface was prepared for osteotomy. Osteotomy landmarks were determined as in Warrick et al. [9] using an angled surgical goniometer and ruler. A sagittal bone saw was used for osteotomies and predetermined angles were cut from the bone for osteosynthesis (Figure 2a). The bone plate was recontoured for the best compliance to the medial tibial bone surface. For plate fixation osteosynthesis, regular TPLO plates or T-plates (1259-031/032-00004, Polmed, İstanbul, Turkey) were used and implanted using cortical and cancellous screws, as seen in Figure 2b.

The surgical wound was closed in a routine way and a rigid Robert-Jones cast was applied encompassing the stifle joint to the tarsal joint, leaving the toes outside for the inspection of swelling and any adverse reactions. Dog

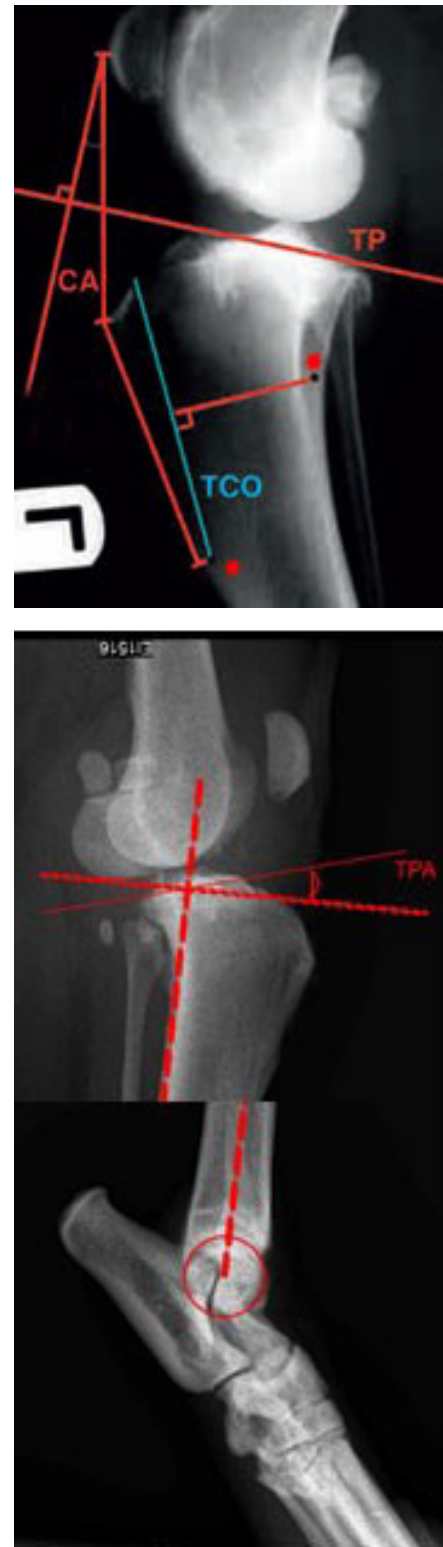


Figure 1. Angle measurements. Methods of (a) Warrick et al. [9], (b) Warzee et al. [1], and Kergosien et al. [8] in combination. CA: correction angle, TP/TPA: tibial plateau slope, PL: patellar ligament, dashed line: tibia functional axis and its perpendicular, TCO: tibial crest osteotomy, *: anchor/maquet holes.

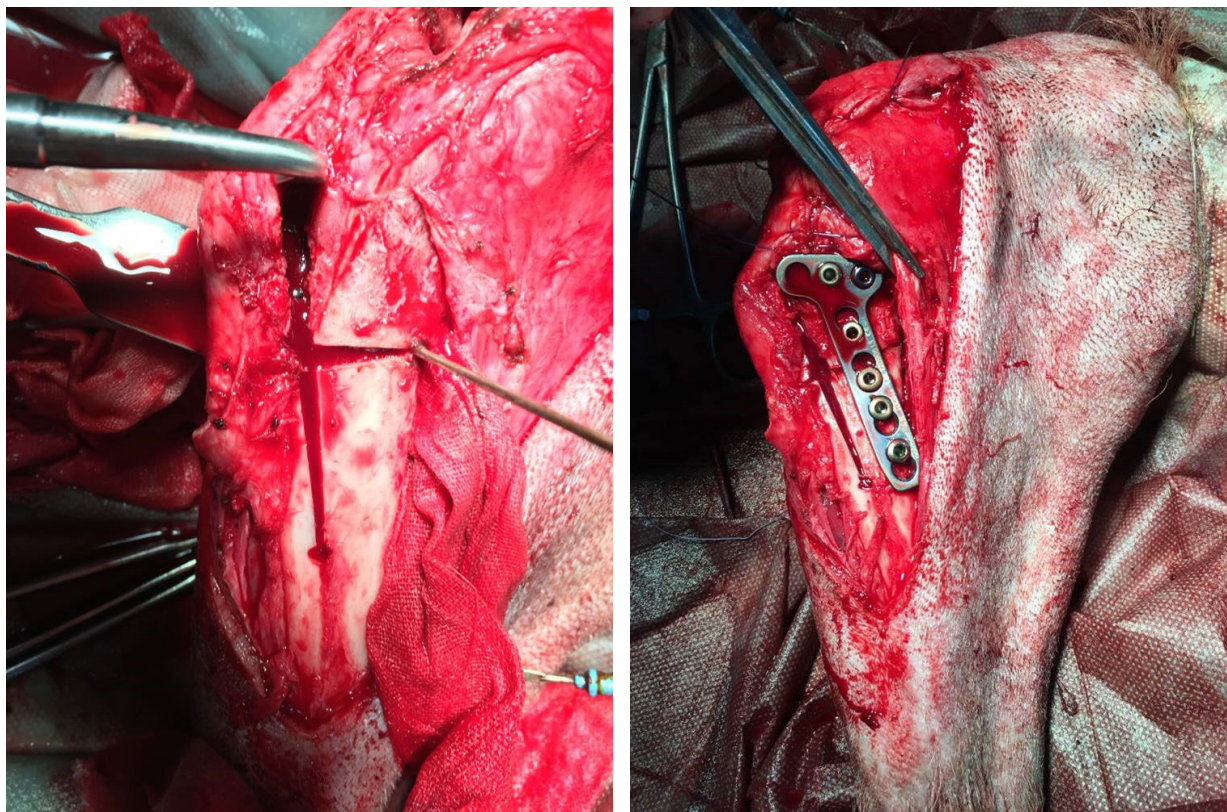


Figure 2. Intraoperative view of Cases 6 and 7.

owners provided postoperative care and pain was managed with 2 mg/kg/day of carprofen (Rimadyl, Zoetis) as needed for 3–5 days. Antibiotic prophylaxis was provided with 20 mg/kg/day of amoxicillin/clavulonic acid (Synulox, 50 mL; Zoetis, NJ, USA) intramuscularly. A Robert-Jones bandage was maintained at the region for a minimum of 3–4 weeks to ensure complete bone healing and movement was restricted for 6 weeks. Bone healing status was followed up by periodic examinations with bilateral view X-rays, as seen in Figures 3a and 3b, and clinical visits when possible. Phone interviews were conducted when owners could not attend clinical visits or radiology examinations.

3. Results

The age, weight, lameness scores, lesion side, further identification, and operational outcomes of the dogs are seen in Table 1.

The evaluations showed that 2 dogs (28%) had CrCL ruptures on the right side, while 5 dogs (72%) had ruptures on the left. The mean body weight of the study group was 33.2 kg. Of the dogs, 2 were older than 3 years (Cases 3 and 5), whereas the others were under 3 years old. Case 1 comprised a dog that had been in a traffic accident with multiple fractures at the contralateral femur bone and was operated on concomitantly with cruciate ligament

intervention. In Case 5, the dog was diagnosed with bilateral mild degree canine hip dysplasia (CHD) during preoperative clinical examinations. The owner of the dog in Case 5 reported no disability due to CHD; therefore, the case was included.

The preoperative and postoperative tibial slope calculations were compared, as shown in Table 2. The preoperative tibial plateau slope was 13.5° and the postoperative one was 3.3°, with a resulting change of 10.3° among the study cases.

The dog in Case 5 had an increase in mobility after the operation and muscle mass gain was noted. CHD was at a mild degree and functional loss due to the operational process was tolerated easily in the postoperative term.

When the cases were evaluated intraoperatively and postoperatively, 3 of the dogs had wound infections postoperatively and 1 had an intraoperative tibial tuberosity fracture. At the same time, in Case 5, the dog showed excessive mobility and compliance by the owner to postoperative directions was poor; therefore, bandage complications were encountered.

In Cases 4 and 6, mid- and long-term postoperative clinical follow-ups were not possible due to limitations of owners (economic restrictions, distance of the hospital to the home of the owner). Short- and mid-term follow-ups

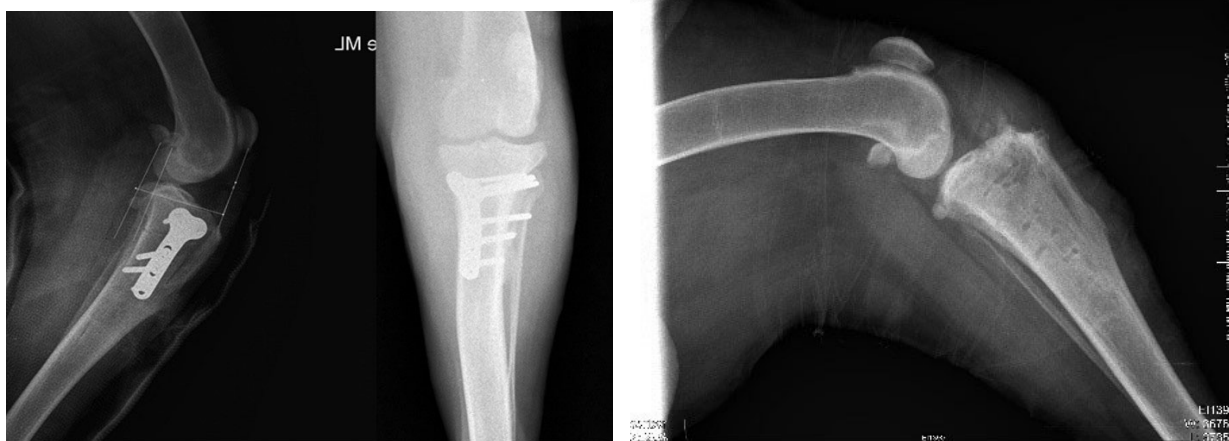


Figure 3. Postoperative radiographs of Case 3.

were performed via a phone interviews with the owners, who recorded videos that were used for case inspections. In Cases 4 and 6, the dogs were evaluated for lameness over shared video. Postoperative radiographs and clinical examinations of the dogs in Cases 1, 2, 3, 5, and 7 were completed via both clinical visits and phone interviews with the owners. On the day 16 follow-up, the dog in Case 2 showed a slight lameness in its gait when walking, but the owner reportedly noticed no discomfort, as shown in Figures 4a and 4b.

The owner of the dog in Case 6 reported that the patient recovered and healed completely from the wound infection and the gait abnormality had been resolved. In acute cases (Cases 1, 2, 4, 6, and 7), the mean time until mobility gain (toe touch to ground or stepping with lameness) of the extremity was 7.4 days (5–10 days) and effective gait (stepping without hesitation) was 19.8 days (18–20 days). In chronic cases (Cases 3 and 5), the mean time was 13 days and 40 days, respectively.

4. Discussion

CrCL ruptures continue to be a disease that negatively affects the lives of dogs who share our homes, as well as in working and sporting breeds. Advancing technology and facilities have reduced the costs of tests for the diagnosis of genetic and environmental components leading to CrCL rupture [10,11]. Although some studies [12] have reported a direct proportion between the incidence of CrCL rupture and increasing age, an increase in body weight and neutering rate have caused this disease to appear at an earlier age [13]. In this study, 71% of the dogs ($n = 5$) with CrCL ruptures were 3 years of age or younger. However, neutering, which is reported to increase the incidence of CrCL rupture [12,13], was not present in any of the cases in this study. A body weight of 15–22 kg or above leads to an increase in the rate of CrCL rupture incidence

[14,15]. In this study, the average weight of the dogs was 33.2 kg (21–44 kg), which was consistent with existing literature findings. Early postoperative and radiograph findings were obtained during the clinical visit in all of the cases. For the mid-term follow-up, 5 dogs (71%) continued with clinical visits, although in the long-term follow-up, the postoperative assessments of 2 dogs (28%) occurred via telephone interviews with their owners. Radiographic signs of primary healing were observed at the end of 1 month in all of the cases and healing of the created bone defect in the tibia was completed in 6–7 months.

All of the dogs could use their extremities without any problems during the recovery period. The dogs began to place their extremities on the ground after an average of 9 days and they were able to step on the ground after an average of 25 days.

The average tibial slope angle change obtained in this study was much less than the changes reported in the literature [2,16–23]. Complications encountered in the treatment of CrCL fractures can be major or minor [24–27]. The complication rate increased as a result of changes between 10 and 20° with the proximal tibial wedge osteotomy operation, which was applied in 100 cases at Zurich University [4]. The complication rate was 25% in the proximal tibial intraarticular osteotomy technique [27]. In this study, the complication rate was 14% ($n = 1$). In other studies, complication rates were similar or higher to that herein [3,4,16,17,27–31]. Kergosien et al. [8] reported tibial tuberosity fracture as a major complication classified, as nondisplaced (7.3%) and caudally displaced (1.4%). Another study about tibial plateau leveling osteotomy reported tibial tuberosity fracture as one of the most seen complications [8]. Fracture of the tibial tuberosity a result of radical changes in the tibial plateau slopes in recent osteoplasty methods for CrCL treatments.

Table 1. Properties of the case studies.

Case Number	Race	Sex	Age (year)	Body weight (kg)	Lameness degree	Accompanying lesions	CrCL lesion side	Complications	Postoperative healing duration (days)		Owner-assessed outcome of the operation
									Stepping	Walking	
1	Mixed	M	1.5	21	Severe	Contralateral Femur Fracture (complicated) + Gun Shot Injury	Left	Skin wound infection	10	20	Very good
2	Aksaray Malaklısı	M	3	42	Moderate	X	Right	X	5	18	Very good
3	Anatolian Shepherd	M	7	37	Mild	X	Left	Skin wound infection	6	35	Very good
4	Aksaray Malaklısı	M	2.5	33	Severe	X	Left	X	8	26	Very good
5	Golden Retriever	M	6	29	Moderate	Bilateral canine Hip dysplasia	Left	Bandage wound, tuberositas tibia fragmentation	20	45	Very good
6	Aksaray Malaklısı	M	2	44	Severe	x	Left	Wound complication	5	20	Very good
7	Mixed	M	3	27	Severe	x	Right	x	9	15	Very good

Table 2. Preoperative and postoperative tibial plateau slopes.

Case number	1	2	3	4	5	6	7	Mean
Preoperative tibial plateau slope (degrees)	14.7	12.7	7.7	7.2	15	12	13.3	13.5
Postoperative tibial plateau slope (degrees)	5.6	2	2.3	4.9	4	4.4	0.3	3.3
Change	9.1	10.7	5.4	2.3	11	7.6	13	10.2

**Figure 4.** (a) Case 2 on day 16 postoperatively; clinical view (left figure). (b) Case 6 on day 25 postoperatively (on the right). Gait statuses are shown.

The basic principal of the TTO operation is the division of change in the tibial slope into 2 components, the tibial plateau (TPLO method) and tuberositas tibia (TTA method). Because of the aforementioned division, a major complication of other methods was substantially decreased. Warzee et al. [32] reported that excessive rotation of the tibial slope might cause a considerable increase in adverse results. The differences between the techniques have given rise to many discussions [33,34]. Many current CrCL repair techniques require special instruments and equipment. TPLO requires a sectoral angle saw and guide pin [3,22,35,36], and the TTA technique uses a cutting guide and cage for advancing tuberositas tibia at the

Maquet hole [19,21,33]. However, TTO utilizes a straight cutting guide with a standard sagittal bone saw to make the osteotomy, which can be used apart from specialized equipment [9].

Biomechanical repair techniques have resulted in 75% or more satisfaction in CrCL fracture treatment in dogs [37]. In this study, the dog owners reported 100% satisfaction in the results of the operational method.

Using the TTO technique in the treatment of CrCL, 7 clinical cases were evaluated in large breed dogs, regardless of age, sex, or breed. The TTO technique should be studied further using more cases and longer follow-ups to investigate minor and major complications. More

diagnostic tests and radiographic methods are needed for the evaluation of the operational outcome of the TTO method.

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Conflict of interest

The authors declare no conflicts of interest for the present study that may have influenced either the conduct or the presentation of the research.

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