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Cranial Cruciate Ligament Rupture in Dogs - Evaluation of Postoperative Results of the CBLO Technique

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ABSTRACT

***Background*:** A major cause of osteoarthritis (OA) in dogs is cranial cruciate ligament (CCL) rupture. Currently, many intra- and extra-articular treatment techniques are used for dogs with CCL tears. However, biomechanically based methods (Tibial Plato Levelling Osteotomy-TPLO, Tuberositas Tibia Advancemet -Standard TTA, TTA-Rapid) are often preferred. It has been suggested that it may be an alternative technique to prevent complications of the most commonly used TPLO, TTA and TTA-Rapid. The aim of this study was to evaluate the post-operative results of the Cora Base Levelling Osteotomy (CBLO) technique in dogs with cranial cruciate ligament (CCL) rupture.

***Materials, Methods & Results*:** Ten dogs of different breeds, ages and weights were used as material. The operation was started from the medial surface of the tibia. The injector needles were used to locate the joint for placement of the biradial saw. The medial collateral ligament was visualised. The popliteal muscle was reflected and the popliteal artery was protected. The osteotomy was stopped when 1/3-1/2 complete and the appropriate millimetre measurements were marked for osteotomy rotation. In the pre-operative planning, D1, the distance from the patellar tendon to the tibia, D2 and the caudal extension of the area where the saw was placed. The osteotomy was started. The osteotomy was completed, the desired rotation achieved and maintained with a stabilising pin. The plate was fixed. The bone plates used were a standard 3.5 mm CBLO (Intrauma, Fixin, Italy) and in some cases a wide TPLO plate. Progress in walking and running tests was noted in 7 cases (70%) compared to the preoperative period. Mild lameness after exercise was observed in 3 cases (30%). Surgery took an average of 30-40 min. It was also observed that the tibial plateau angle (TPA) decreased individually in the post-operative period. According to the results of the force plate gait analysis, there was an improvement in 5 cases (50%). No post-operative change was observed in 5 cases (50%). Radiographs of the A.genu in the medio-lateral and cranio-caudal positions were taken in the cases. The criteria used in the evaluation; the radiographs were interpreted taking into account criteria such as narrowing of the joint space, displacement of the "fat pad" in the joint, cranial rotation of the tibia, especially as a result of cranial cruciate ligament rupture, and osteophytic growth in the subchondral areas of the joint. Post-operative radiographs at day 1 and day 45 were compared. It was observed that the placement of the plate was good in all cases.

***Discussion*:** Therefore, the CBLO technique is an alternative technique to the TPLO and TTA techniques for CCL ruptures. The CBLO technique is an adjunct to the TPLO technique by preserving the proximal tibial epiphysis. Even in small breeds, a large amount of bone is available for stabilization in the proximal area. The compression screw and implant provide excellent bone contact. This ensures proper fixation and early function in recovery. Correction of the axis in the centre of the CORA has been observed to improve after proximal and distal rotation. There was no balcony effect as seen with TPLO. The joint was not damaged by the CBLO technique. However, there are some difficulties with the CBLO technique; learning the technique and handpieces. In particular, good preparation for the preoperative period for TPA and plate selection. A larger group of dogs is also needed for further studies and additional complications could be expected in the long-term evaluation.

Keywords: CBLO, Force Plate Gait Analysis, Tibial Plateau Angle.

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INTRODUCTION

Cranial cruciate ligament (CCL) ruptures are among the most important causes of osteoarthritis (OA) in dogs [2]. Osteoarthritis is one of the most crucial joint diseases seen in dogs. It is reported that approximately 37% of lameness in dogs is caused by OA [1,3,27]. It's described as a complex condition involving alterations in bone and soft tissue, along with gradual deterioration of the synovial joint's articular cartilage.

Today, many intraarticular and extra capsular treatment techniques are used for dogs with CCL rupture [34]. But, biomechanical based methods (Tibial Plato Levelling Osteotomy-TPLO, Tuberositas Tibia Advancemet -Standard TTA, TTA-Rapid) are frequently preferred [2,3]. Each of these techniques have some advantages and disadvantages [12,13].

The proximal tibia in dogs exhibits procurvatum. A corrective technique involves reducing the tibial plateau angle (TPA) by rotating the proximal tibia at the center of rotation of angulation (CORA) using the CBLO method [23,35]. This osteotomy procedure is performed proximally on the tibia, considering the CORA point for accurate angulation. By rotating semi-circularly at the CORA point, this technique corrects the mechanical axis, preventing procurvatum progression and addressing tuberositas tibia issues. CORA localization is determined via medial and lateral radiography, with the intersection of proximal and distal anatomic axes serving as the starting point. Post-operative TPA is recommended to fall within the range of 9-12°, or ideally around 10°, to alleviate stress on the joint [12,13,24].

The aim of the study was to investigate the post-operative prognosis (Clinical, Radiological, Tibial Plateau Angle, Force Plate Analysis) of the CBLO technique in dogs with CCL rupture.

MATERIALS AND METHODS

Materials

Ten dogs of different breeds, ages and weights with the complaint of lameness in A. genu were used as the study material (Table 1) at the Department of Surgery, Faculty of Veterinary Medicine, University of Selcuk (Table 1). Routine systemic, clinical (walking, running ext.) and radiographic examination (craniocaudal (CrCa) and medio-lateral (ML)) were carried out in dogs. Cranial cruciate ligament rupture was diagnosed in dogs. Examination results were recorded. Excessive tibial plateau angle (TPA) was selected at the end of radiological examinations for the cases with bilateral problems.

Pre-operative (Pre-op) planning

Pre-op planning for TPA was done according to Reif & Probst [26]. A. genu was positioned the tibiotarsal joint forming 90 degrees. The cranial and caudal extents of the tibial plateau was drawn to determine the tibial plateau slope. A 2nd line was drawn from the center of the intercondylar eminences to the center of the talus. Other line is the long axis of the tibia on sagittal plane. A 3rd line was drawn perpendicular to the tibial long axis at the intersection of lines 1st and 2nd. After identification of the tibial axis and the tibial plateau, the TPA between the medial tibial plateau and a line perpendicular to the functional axis of the tibia was measured with manually. The anatomic CORA was detected with the proximal tibial anatomic axis and distal tibial anatomic axis by radiographic evaluation. A radial osteotomy was centered at this point and after the proximal segment turned. The correction of CORA size results in the wanted post-operative TPA of 9°-12° [14]. The saw guidance was based on the following measurements. The distance from the adjacent of the patellar tendon at the tibial crest to the point where the saw blade is to cross the cranial cortex was measured on the pre-op radiograph (D1). The distance from the joint line to the point where the saw blade cut off the caudal cortex (D2) was also measured on pre-op radiographs. The saw blade was placed at D1/D2 perpendicular to the plane of the CORA and a circular osteotomy begun (Figure 1 and Figure 2).

Surgical procedure and osteotomy

The patients were fasted 12 h before the preoperative period. Preoperative flunixin meglumine [Flumed®[1] - 0.5-2 mg/kg BW, i.v.] was given before the operations. Anesthesia was induced with xylazine hydrochloride [Alfazyne[2] 2% - 20 mg/mL, i.v.] and propofol [Propofol-Lipuro 1%[3] - 4 mg/kg, i.v.]. Anesthesia was maintained with isoflurane (2%-4%) in oxygen (AErrane)[4]. Operative processing was started from the medial surface of the tibia. The places of the joint were determined with the injector needles in order to place the biradial saw. The medial collateral ligament was visualized. The popliteal muscle

reflected and the popliteal artery was protected. The osteotomy was stopped when 1/3-1/2 complete and appropriate millimeter measurements were marked for osteotomy rotation. In pre-op planning, D1, the distance of the patellar tendon to the tibia, D2, and the caudal extension of the area where the saw was placed. Osteotomy procedure was started. The osteotomy was completed, desired rotation achieved, and maintained with a stabilization pin. The plate was fixed (Figure 3). Bone plates used were a 3.5 mm standard CBLO and some cases for broad TPLO plate. The stabilization pin was inserted through the patellar tendon at its point of insertion at the tibial crest. Selection of the saw blade[5] size was slightly larger than the diameter of the bone at the CORA point. Post-operative penicillin G [Devapen[6] - 22,000 IU/kg, 2 days, i.v.], flunixin meglumine [Flumed®[1] - i.m. or Meloksikam[7] - 20 mg, 0.4cc/10 kg, s.c.] were administered after the surgery.

Table 1. Distribution of cases undergoing Cora Base Levelling Osteotomy (CBLO) operation.

No.	Breed	Gender	Age	Weight	Extremity
1	Mix	♂	3	25	Right
2	Mix	♂	2	28	Right
3	Mix	♂	3	32	Left
4	Mix	♀	2	21	Left
5	Mix	♀	3	30	Right
6	Mix	♂	1	23	Right
7	Mix	♂	2	18	Left
8	Mix	♀	2	25	Right
9	Mix	♀	1.5	21	Right
10	Pitbull	♂	2	26	Right

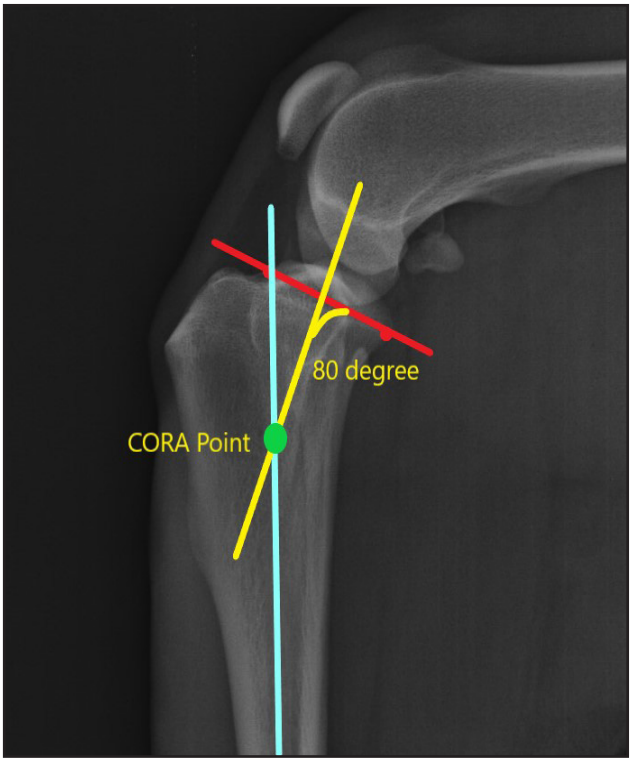

Figure 1. The tibial axis and the tibial plateau was identificated. The anatomic CORA was detected with the proximal tibial anatomic axis and distal tibial anatomic axis.

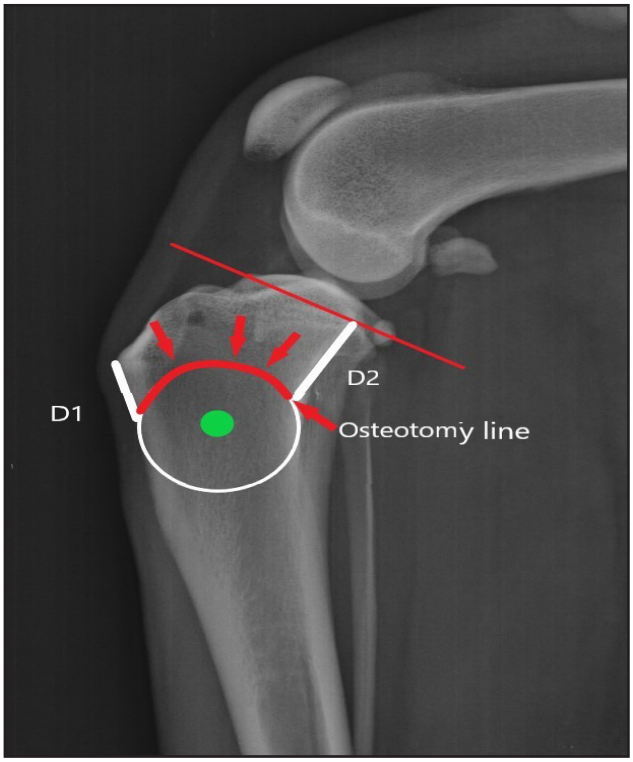

Figure 2. D1, the distance of the patellar tendon to the tibial tuberosity, D2, and the caudal extension of the area where the saw would be placed.

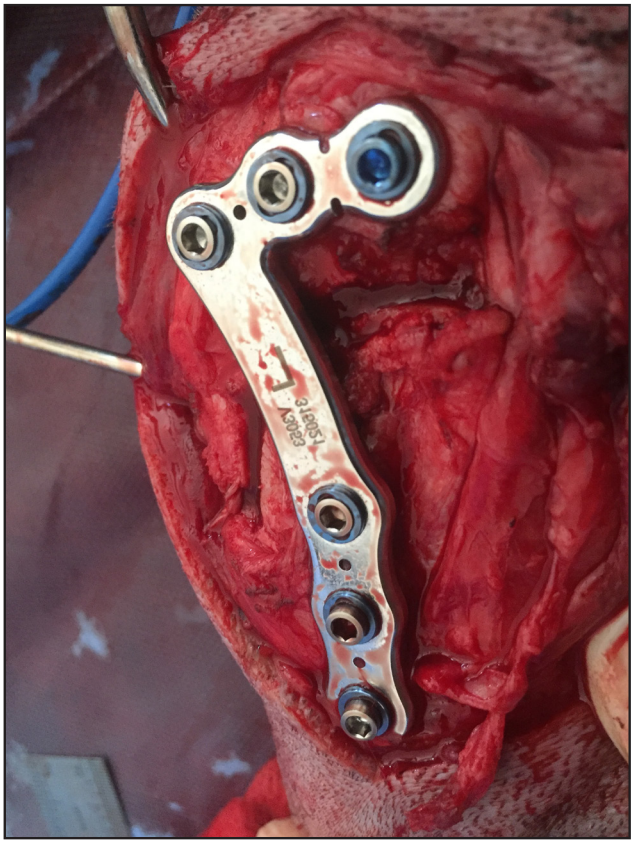

Figure 3. The plates used were a 3.5 mm standard and some cases for broad TPLO plates.

Radiological examinations

Radiological examinations[8] of the dogs were performed on pre-op and post-op. The 1st day (0) and 45th day (recovery period of osteotomy line 6 weeks). Neutral 135° mediolateral radiographs of the stifles were acquired. Radiographic examinations were recorded in study forms.

Force plate analysis

Lameness assessment was used with force plate gait analyzer[9] to measure postoperatively to assess weight-bearing in dogs. The degree of using the extremities of the cases was measured by force plate analysis. In practice, before the cases were examined, the analyzer was made ready by weight calibration. Subsequently, the subjects were placed on the analyzer one by one and fixedly held with one extremity in each square compartment. Meanwhile, by taking weight measurements (at least 15 times) from an auxiliary analyzer control, the average pressures were automatically recorded in the computer.

Pre-Op tibial plateau angle

The tibial plateau angle (TPA) was measured as the angle between lines both above. Then, according to the diameter of the saw blade to be used, the "Rotation Template" was used and after the osteotomy of the tibial plateau, how many mm of rotation (shift) would be calculated.

Statistical analysis

Outcome was assessed through recheck examinations by the clinician at the 45th day post-op. The result was considered excellent if limb use was normal, good if there was mild lameness after exercise, fair if there was continuous lameness, and poor if the limb was not used to support weight.

RESULTS

Clinical findings

In order to follow up the clinical findings, activities such as walking, running, climbing, and jumping were performed in the post-operative period. Progress was recorded in 7 cases (70%) of the cases compared to the pre-operative period for walking and running tests. It was observed that there was mild lameness after exercise for 3 cases (30%).

Operation findings

Operation times in the cases took an average of 30-40 min. No complications (bleeding, meniscus damage, tendon damage) were encountered in the approach to the operation area in 9 cases. In only one case, bleeding occurred depending on the position of the saw and the bleeding was stopped immediately. It was recorded that this case had a good post-operative prognosis. After rotation from the CORA point, no difficulty was encountered while fixing the ideal plate to the dorsal part of the tibia and the distal part of the osteotomy line.

Radiological findings

Radiographs of the A.genu in the mediolateral and cranio-caudal positions were taken in the cases (Figures 4 and 5). The criteria considered in the evaluation; radiographic images were interpreted by considering criteria such as narrowing of the joint space, displacement of the "Fat Pad" in the joint, cranial rotation of the tibia, especially as a result of cranial cruciate ligament rupture, and osteophytic growth in the joint subchondral areas. Post-operative 1st and 45th day radiographic views were compared. It was observed that the placement of the plate was good in all cases.

Force plate analysis findings

Pre-op and post-op 45th day results were compared individually (Table 2). According to the weight-bearing findings, there is an improvement in 5 cases (50%). In 5 cases (50%), no post-operative change was observed. Force Plate Analysis findings did not support clinical findings of 3 cases.

Post-operative (Post-op) tibial plato angle (TPA)

Pre-op and post-op TPA results (Table 3) are given. It was observed that the TPA angle decreased in the post-operative period in all cases individually. However, the TPA angle suggested by the CBLO system should be 9-120. It was found above these values in 4 (40%) of the cases, and close in of the other 6 cases (60%).

Figure 4. Medio-lateral radiographic projections were taken post-op examination.

Figure 5. Cranio-caudal radiographic projections were taken post-op examination.

Table 2. Force Plate analysis findings Pre-Operative (Pre-Op) and Post-Operative (Post-Op) pressure results.

Case No.	Pre-Op Pressure	Post-Op Pressure
1	33	15
2	10	15
3	14	20
4	20	20
5	3	13
6	24	10
7	19	12
8	2	10
9	12	7
10	16	10

Table 3. Pre-Operative (Pre-Op) and Post-Operative (Post-Op) Tibial Plato Angle (TPA) results.

Case No.	Pre-Op TPA	Post-Op TPA	Pre-Op Period calculatec TPA Angle (X 0.3)
1	33	12	10
2	25	15	8
3	28	14	9
4	30	12	9
5	25	14	8
6	28	10	9
7	30	10	9
8	30	15	9
9	32	16	10
10	28	15	9

DISCUSSION

Partial or complete CCL ruptures are very common in dogs [4,33]. Injury in CCL ruptures is characterized by instability in the knee joint and lameness as a result of the displacement of the tibia to the cranial [33]. The knee joint does not prevent the tibia from moving forward. The muscle strength in extremity does not support enough. Conservative treatments are generally unsuccessful and surgical methods are preferred [19]. Many intraarticular and extra capsular techniques have been developed [15-17,25]. Today, biomechanical based methods (Tibial Plato Levelling Osteotomy - TPLO, Tuberositas Tibia Advancement - Standard TTA, TTA-Rapid) are popular CCL treatment methods [3].

Studies conducted in recent years have reported animal owner satisfaction in 90% of cases where TTA and TPLO techniques were applied [28-30,36]. The remaining 10% of the owners reported that they were not satisfied with the osteotomy techniques performed. The occurrence of cartilage degeneration in the caudal part of the joint in the post-operative arthroscopic examination was considered as the most important complication. The excessive pressure on this region has been demonstrated [14,17]. The TPLO technique is designed to bring the tibial plateau angle to 6°. However, this situation brings A. genu to permanent flexion and dogs seem to be walking down the hill [12,13,20]. For this reason, it is necessary to change the osteotomy technique to correct the mechanical tibial axis and to distribute the pressure regularly. Thus, the load on the caudal meniscus would be reduced [12,13]. Especially TPA is preferred at 30° and above. It has been reported that TTA is less effective in correcting this angle with the osteotomy method [15].

Hulse *et al*. [12,13], mentioned about the osteotomy technique performed at the proximal level of the tibia, which was performed considering the CORA point. Anatomical CORA level osteotomy is the deformity correction [22]. The dog's proximal tibia is normal procurvatum. It is the proximal anatomical CORA point. The localization of the CORA is determined by medial and lateral X-rays. For this, it is the intersection point of the proximal anatomic axis with the distal anatomic axis. It has been suggested that the tibial plateau angle should be between 9-12^0. Measurement is absolutely important in partial rupture or cases undergoing meniscectomy [12-14]. In this project, if the preparation for the pre-op. is done correctly. The operation procedure is done serially. Operation times in the cases took an average of 30-40 min. No complications (bleeding, meniscal damage, tendo damage) were encountered in the approach to the operation area in 9 cases. In only 1 case, bleeding occurred depending on the position of the saw and the bleeding was stopped immediately. It was recorded that this case had a good post-operative prognosis. After rotation from the CORA point, no difficulty was encountered while fixing the ideal plate to the dorsal part of the tibia and the distal part of the osteotomy line. The technique is a helpful technique by protecting the proximal tibial epiphysis. In addition, intra-articular reconstruction and extra articular displacement of the bone are possible. The head compression screw and implant provide excellent bone contact and it helps for proper fixation and early function in recovery. It was seen that correction of the axis in the center of the CORA appears to improve after proximal and distal rotation [28]. This center is the epiphysis part of the proximal tibia. For this reason, there was no "balcony" effect. Maybe the most important issues were an osteotomy that does not damage the joint. The joint cartilage in A. genu would not be damaged and the joint fluid would be prevented from reaching the osteotomy line. Because, high concentrations of MMP and Interleukin were found in the joint fluid in CCL ruptures [22]. In studies conducted in humans, joint fluids inhibit osteoblasts and effect the retention of collagenase in the fracture side [9,10]. In addition, joint fluids are prevented creation of bone production in the rabbit joint [5,31].

The presence of a natural procurvatum in the canine tibia causes the tibial plateau angle to be inclined [25]. This physiological situation causes the formation of the procurvatum axis. This provides the CORA (Center of rotation of the angulation) point, that is, the angulation rotation point. Semicircular rotation at the CORA point prevents the procurvatum by correcting the mechanical axis and progression of the tibial crest [35]. Bringing the tibial plateau angle to 6° would be increase the pressure on the caudal part of the joint, while the tibial plateau angle would be (between 9-12°, or tpa x 0.3). It is claimed that it provides less pressure to get on the joint. The osteotomy technique performed on the CORA point is based on Paley's principles [22]. The tibial plateau angle should be around 10°. Therefore, the mechanical axis is not perpendicular to the tibial plateau, but only 80°. Complication rate (10-34%) after TPLO surgery has been reported [12,13,25]. The incidence of minor and

major complications associated with TPLO is 28%. Major complications (tibial crest avulsion, meniscal injury, intraarticular screw placement, and implant failure) account for 2-6% and usually occur between 2 weeks and 3 months after surgery. Radiographically, degenerative joint disease could be progressed after TPLO [13,24,25]. In the presented study, it was determined post-operative angle was found between 10-15^0 in most of the cases. It was observed that slight fluctuations in TPA angle were not very effective in clinical observations in cases with good results from the operation.

The most important complication reported for the TTA method is bone fracture (1-5.1%) [7,11,18,21]. Implant loss or loosening (0.8-2%) [16,30,36]. Patellar luxation (0.8-1%) [11,16,30], meniscal tear (3.1-25.4%) [7,8,29,30,36] and infection (0.5-5.3%) [7,11,21,30]. Complication rates are pronounced in some breeds [18], poor implant position and narrow width of distal osteotomy and controversial results have been reported between the increase in body weight [21,30]. No statistical difference was noted between unilateral TTA application (11.7%) and bilateral (17.6%) [11]. Complications were reported in 18% of dogs who underwent TTA operation (12%) [6,18,21]. But in the presented study, If the literature data are evaluated for TTA results. There was no bone fracture and meniscus injury in CBLO. Then, no difficulty was encountered while fixing the ideal plate to the dorsal part of the tibia and the distal part of the osteotomy line.

Radiographic examination findings of the CBLO technique were compared with the 1st and 45th day radiographic views in the post-operative period. While it was observed that the placement of the plate was good in all cases, the steinmann pin was placed long in order to reduce the osteotomy line in some cases. In these cases, plate and pin were removed at the end of the 45th day.

In this study, lameness assessment was used with force plate analyzer. Pre-op and post-op 45th day results were compared individually. According to the force plate findings, there is an improvement in 5 cases (50%). In 5 cases (50%), no post-operative change was observed. But, force plate findings did not support clinical findings in 3 cases. The reason for not using the extremity well was attributed to the opening of the operation wound for various reasons and the pain process and the prolongation of the rehabilitation period in some cases. Because, radiographically, no problem was observed in the osteotomy line.

The tibial plateau angle was measured at the post-operative 45th day. It was observed that the TPA angle decreased in the post-operative period in all cases individually. However, the TPA angle suggested by the CBLO system should be 9-12^0. But, 10^0 is the acceptable for TPA angle. It was found above these values in 4 (40%) of the cases, and close of the other 6 (60%) cases. One of the reasons for this is that the measurements were not made digitally and the measurements were made with a manually. As explained above, it was observed that slight fluctuations in TPA angle in clinical observations were not very effective in cases with good results from the operation [23].

CONCLUSION

CBLO technique is an alternative technique to TPLO and TTA techniques for CCL rupture. CBLO technique is an auxiliary technique by preserving the proximal tibial epiphysis when compared with the TPLO technique. Even in small breeds, there is a large bone part for stabilization in the proximal area. Compression screw and implant provide excellent bone contact. This ensures proper fixation and early function in recovery. Correction of the axis in the center of the CORA is observed to improve after proximal and distal rotation. There was no "balcony" effect as in TPLO. The joint was not damaged by CBLO technique. But there are some difficulties of CBLO technique; learning process of technique and hand pieces. Especially, good preparation for pre-operative period for TPA and plate selection. A larger group of dogs is also needed for further studies and additional complications could be expected in the long-term evaluation.

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***Ethical approval*.** The study was performed with approval from and under the guidelines of the Institutional Laboratory Animal Care and use Committee of Veterinary Faculty (2019/25).

***Declaration of interest*.** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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