pISSN 1598-298X
J Vet Clin 31(6) : 483-489 (2014)

Journal of Veterinary Clinics
www.ksvc.or.kr

Tibial Plateau Leveling Osteotomy for Treatment of Naturally Occurring Cranial Cruciate Ligament Rupture in Small Breed Dogs - Case Series

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(Accepted: December 09, 2014)

Abstract : This study describes a surgical technique and evaluates the clinical outcomes in small breed dogs with cranial cruciate ligament rupture (CCLR) treated with tibial plateau leveling osteotomy (TPLO). Seven skeletally mature dogs weighing less than 15 kg underwent unilateral TPLO to stabilize the stifle joint with CCLR. Clinical evaluation was performed via visual lameness score, range of motion (ROM), and thigh girth circumference (TC). Postoperative complications were recorded. All patients reached a grade 1 score at 1 week and grade 0 at 8 weeks postoperatively. The mean operated limb extension angle was 98.11%, 99.07%, and 98.73% of the mean extension angle of the contralateral limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively. The mean operated limb flexion angle was 98.07%, 95.88%, and 96.35% of the mean flexion angle of the contralateral limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively. The mean TC of the operated limb was 92.95%, 93.68%, and 95.44% of the mean TC of the normal limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively. Our outcomes for TPLO in small breed dogs are not worse than those previously reported for large breed dogs. Based on the result in the present study, CCLR in small dogs can be successfully managed with TPLO, as done in large breed dogs.

***Key words* :** tibial plateau leveling osteotomy, cranial cruciate ligament rupture, small breed, dog.

Introduction

Cranial cruciate ligament rupture (CCLR) is one of the most common causes of hind limb lameness in dogs (12). CCLR causes stifle joint instability, leading to subsequent development of progressive osteoarthritis (OA) and secondary meniscal damage. Goals of treatment for the cruciate deficient stifle include an early return to function, mitigating the progression of OA, and preserving range of motion (6). Treatment of CCLR has led to the development of numerous surgical procedures to provide stability to the stifle joint by neutralizing cranial drawer motion and internal rotation of the tibia (1).

Traditional surgical procedures such as the intraarticular technique, and extracapsular suture repair (ECR), provide stifle joint stability using an autogenous, allogenic, or synthetic material placed within or around the joint to mimic the function of the normal cranial cruciate ligament (1). Although many reports have shown acceptable results, those traditional methods have suboptimal long-term outcomes, because they are unsuccessful in maintaining consistent stability, mitigating the progression of OA, and preventing subsequent meniscal injury (5,8).

Tibial plateau leveling osteotomy (TPLO) was first introduced in 1993 for treatment of CCLR (24). The goal of TPLO is to stabilize a CCLR-affected stifle joint during weight bearing, by neutralizing the cranial tibial thrust, and preventing cranial translation of the tibia (24,25). This is achieved by altering the tibial plateau angle (TPA) with proximal tibial radial osteotomy to allow rotation of the tibial plateau. Current recommendations are to reduce TPA to an angle of 5-6.5° to neutralize cranial tibial thrust and minimize strain on the caudal cruciate ligament (27).

Despite recent evolution in procedures for repair of CCLR in dogs, ECR remains a popular treatment method. An older study reported that TPLO showed an earlier return to function and reduced progression of OA compared with other techniques (25). Recent studies have compared TPLO and ECR because both procedures are now widely used. Some studies have found no significant differences between dogs that underwent TPLO and ECR (2). However, other studies have shown that dogs that underwent TPLO had better outcomes than those that underwent ECR (7,18). Although no single technique is considered superior to others, many veterinary surgeons anecdotally believe that TPLO surgery is better than traditional surgical procedures (2,7,18).

Although many studies have evaluated outcomes of TPLO in large breed dogs (3,6,17), few studies have assessed its results in small breed dogs, which present some technical difficulties to TPLO. Our purpose in this study was to describe the surgical technique in terms of those difficulties with small dogs and evaluate the outcomes of TPLO for the stabilization of CCLR in small dogs. Our hypothesis was that TPLO in small breed dogs would provide results for visual lameness score, stifle range of motion, and thigh girth circumference comparable to TPLO in large breed dogs and superior

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to ECR in small breed dogs.

Materials & Methods

Inclusion Criteria

Dogs were included in the present study if they had hind limb lameness resulting from CCLR, weighed less than 15 kg, and were treated with TPLO at Chonbuk Animal Medical Center between August 2013 and May 2014. Dogs were excluded if they didn't meet the inclusion criteria or had a neurologic dysfunction. The medical records were reviewed for breed, age, weight, sex, body condition score, limb affected, history of lameness, previous medications, method and result of surgery, and condition of the affected limb in the postoperative period. Physical examination, visual lameness score, thigh girth circumference (TC) measurement, measurement of stifle range of motion (ROM), and radiographic examination were performed.

Visual Lameness Score

Patients were evaluated at stance, walk, and trot. Visual lameness was evaluated and graded using a previously described method (9): 0 = no detectable lameness at a walk or trot, no detectable lateral weight shift at a stance; 1 = no detectable lameness at a walk or trot and minor lateral weight shift at a stance; 2 = lameness at a walk or trot without hip hike; 3 = lameness at a walk or trot with hip hike; 4 = non-weight bearing at trot with weight bearing at walk; 5 = non-weight bearing at stance or walk.

Range of Motion

Stifle ROM was measured with each unsedated patient in lateral recumbency. Once the patient relaxed, the uppermost hind limb was manually moved through ROM several times. A plastic goniometer with two-degree increments was used to measure ROM as previously described (10). The mean of the triplicate measures recorded to the nearest degree was used for results. Additionally, the percentages of the affected limb compared to the unaffected limb were assessed. The flexion angles were converted by subtracting measured angle from 180º to calculate the percentage compared to the contralateral limb.

Thigh Girth Circumference

The patient was placed in a normal standing position. TC was measured between the greater trochanter and lateral femoral condyle using a tape measure with a spring tensioned device (GulickII, Country Medical Technology Inc., USA). The mean of the measures, recorded in triplicate to the nearest 0.5 cm, was used for results. The percentages of the affected limb compared to the contralateral limb were assessed.

Radiographic Evaluation

Mediolateral radiographs of the stifle joint were obtained with the stifle and hock positioned at 90º including both joints in the radiographic projection. The beam center of the radiograph was on the stifle. Craniocaudal projection, including hock and stifle joint in the exposure, was obtained also. The beam was centered on the stifle joint. Preoperative radiographs were obtained before surgery, postoperative radiographs were taken immediately following surgery with the patients anesthetized. TPA was measured on preoperative and postoperative radiographs based on a previously described method (22).

Surgical Plan

The surgical plan was performed using a digital templating software program (OrthoView Vet Orthopedic Digital Planning: OrthoView LLC, USA). A TPLO saw blade of appropriate size for each patient was located on the scaled radiographic image and positioned with being centering the saw over the intercondylar eminence (13). Three distances were measured: D1 was the distance from the patellar tendon insertion on the tibial tuberosity to the osteotomy line, measured perpendicular to the tibial crest; D2 was the distance from the tibial tuberosity to the osteotomy line, measured along the proximo-cranial tibia; D3 was measured from the most caudal aspect of the medial tibial plateau to the caudal exit of the osteotomy (Fig 1) (29).

Surgery

The patients were premedicated using butorphanol (Butorphanol tartrate [0.2 mg/kg], Myungmoon Pharm Cl. LTD, Korea), midazolam (Midazolam [0.2 mg/kg], Bukwang, Pharm. CO., LTD., Korea), cefazolin (Cefazolin sodium [22 mg/kg], Chong Kun Dang Pharm, Korea), and tramadol (Tramadol HCl [3 mg/kg], Formenti Farmaceutici S.p.A, Italy). Propo-

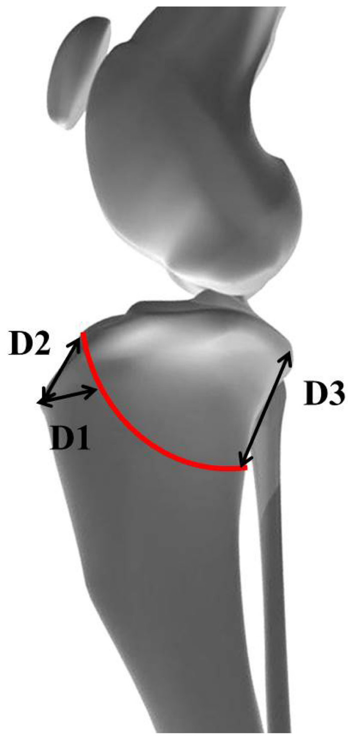

Fig 1. D1: the distance from the patellar tendon insertion on the tibial tuberosity to the osteotomy line, measured perpendicular to the tibial crest. D2 : the distance from the tibial tuberosity to the osteotomy line, measured along the proximo-cranial tibia. D3: measured from the most caudal aspect of the medial tibial plateau to the caudal exit of the osteotomy.

fol (Propofol [6 mg/kg], Claris Lifesciences Limited., India) was used as an induction agent. Inhalation anesthesia was maintained using isoflurane. Epidural analgesia was performed in all patients at L7/S1 using lidocaine (Lidocaine HCl 2% [1 ml / 4.5 kg], Je Il Pharm. CO., LTD, Korea) delivered through a spinal needle.

Arthroscopy was performed first to explore the stifle joint thoroughly. The cranial cruciate ligament remnants were removed. A partial meniscectomy was performed to remove any damaged portion of the meniscus. A meniscal release was performed by transecting the caudal meniscotibial ligament if the meniscus was considered vulnerable to continued damage.

A skin incision was made medially from approximately the center of the stifle joint to the proximal third of the tibia. A TPLO jig (mini TPLO jig, IMEX, USA) was applied to the medial aspect of the tibia using two k-wires located proximally, and distally, respectively (Fig 1A). The medial surface of the tibia was marked for D1, D2, and D3 (Fig 2B). The popliteal muscle was elevated from the caudal aspect of the tibia, and a gauze sponge was placed to protect soft tissue during the osteotomy. A cis-cortex cut of the medial tibia was performed first, and the desired rotational distance was marked on the radial osteotomy line. Then a trans-cortex cut was performed (Fig 2C). A 1.4 mm k-wire was applied on the cranial aspect of the proximal segment, and then the proximal segment was rotated to the desired distance marked on the bone by a k-wire placed before. In those who required tibial tuberosity transposition to realign the quadriceps mechanism, the distal tibial segment was externally rotated along its long axis by bending a distal jig pin cranially until the malalignment between the patella and the tibial tuberosity was eliminated (15). The TPLO jig was removed after applying a temporary fixation pin from the patellar tendon insertion on the tibial tuberosity to the proximal segment (Fig 2D and E). A Y-ULP (BS.Corem, Korea) (Fig 2F) or a TPLO plate (Synthes, USA) was applied and fixed with six screws. The temporary fixation pin was removed. In cases with MPL, patella stability was checked, and traditional methods for MPL correction (trochlear block recession, medial releasing, and lateral imbrication) were performed as necessary. The stifle was checked for absence of cranial tibial thrust. The surgical area was lavaged vigorously, and the closure was performed routinely.

A cold pack was applied to the operated stifle joint during the following 3 days. A Robert Jones bandage was applied for the first 3 postoperative days. Analgesia and antibiotics were provided in all cases with meloxicam (Medicox [0.1 mg/kg], Myungmoon Pharm Cl. LTD, Kyonggi-do, South Korea), tramadol (2 mg/kg two times daily, TRIDOL SOLUBLE TAB®, Grunenthal GmbH, Germany) given orally for 2 weeks, and cephalexin (15 mg/kg two times daily, Methilexin Inj®, Union Korea Pharm, Korea) for 1 week orally. Patients were discharged between 3 and 7 days after surgery. Suture removal was performed 7 to 10 days after surgery.

Follow-up Evaluation

Follow-up evaluation included 4, 8, 12, and 24 weeks reevaluation with visual lameness score, ROM, TC, and radiograph. Three patients had only 12 weeks of follow-up evaluation because their surgery happened less than 24 weeks before our analysis.

Results

Preoperative Findings

Seven client-owned dogs met the inclusion criteria. Dog breeds were Poodle, Maltese, Yorkshire Terrier, Lhasa Apso, Welsh Corgi, Cocker Spaniel, and mixed breed. Sex distribution was 4 neutered male, 2 intact female, and 1 spayed female. Mean age was 7.00 ± 3.65 years (range, 3-12 years); mean weight, 6.94 ± 4.34 kg (range, 3.6-15 kg); and mean BCS, 3.14 ± 0.38 (range, 3-4, out of 0 to 5). Affected limb was 4 right hind limb, 3 left hind limb. Mean preoperative visual lameness score was 3.57 ± 0.79 (range, 2-4). Preoperative TC and ROM were not recorded.

Preoperative mean TPA was 30.29 ± 3.90º (range, 27-38º). Obvious drawer test sign was detected in 5 animals (71.43%). Five cases (71.43%) showed concurrent MPL on the cruciate deficient limb (1 grade I/IV, 1 grade II/IV, 2 grade III/IV,

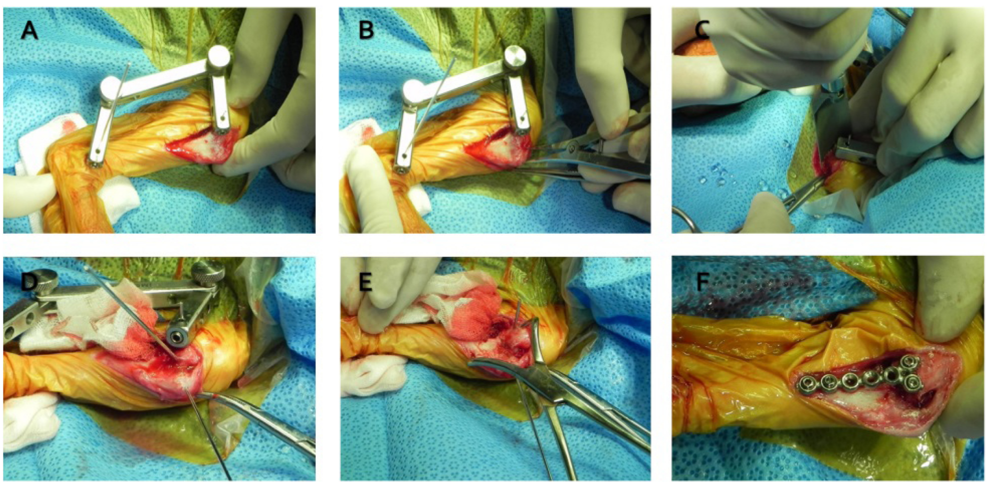

Fig 2. Surgical procedure of TPLO. (A) Application of a TPLO jig. (B) D1, D2, and D3 were marked. (C) Radial osteotomy. (D) Application of temporary fixation pin. (E) Interfragmentary compression provided by pointed reduction forceps. (F) Plate application.

and 1 grade IV/IV). One dog had bilateral hip OA. Various degrees of degenerative joint disease and joint effusion were detected on preoperative radiographs of the stifle joint in all patients.

Intraoperative Findings

The status of the cranial cruciate ligament included 5 complete CCLR (71.43%), 1 partial tear (14.29%), and 1 stretched ligament (14.29%). Conditions of medial meniscus included 3 no damage (42.86%), 2 bucket handle tears, and 2 abrasion regions on the caudal pole of the medial meniscus (42.86%). Damaged menisci were treated by partial meniscectomy or meniscal release, accordingly. Ancillary procedures for management of MPL included trochlear block recession in 5 cases (71.43%) and medial releasing and lateral imbrication in 3 cases (42.86%). Mean postoperative TPA was 6.86 ± 3.13° (range, 3-12°) upon immediate postoperative radiographic examination.

Postoperative Findings

All patients seemed to tolerate the procedure well and were mildly lame at the time of discharge. The function of the affected limb continued to return to normal gradually. The lameness score varied between patients from grade 2 to 4 before surgery. All of the patients reached a grade 1 score at 1 week and grade 0 score at 8 weeks postoperatively (Fig 3). The mean operated limb extension angle was 98.11%, 99.07%, and 98.73% of the mean extension angle of the contralateral limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively (Table 1). The mean operated limb flexion angle was 98.07%, 95.88%, and 96.35% of the mean flexion angle of the contralateral limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively (Table 1). The mean TC of the operated limb was 92.95%, 93.68%, and 95.44% of the mean TC of the normal limb at 4 weeks, 8 weeks, and 12 weeks postoperatively, respectively (Table 1). One dog had superficial wound dehiscence as a complication. This complication was treated by wound management and application of a Robert Jones bandage. Two cases showed MPL postoperatively; 1 grade II/IV and 1 grade I/IV. The patient with grade I/IV MPL didn't require any treatment because the instability of the patella was minimal. The one with grade II/IV MPL recovered spontaneously 2 weeks postoperatively.

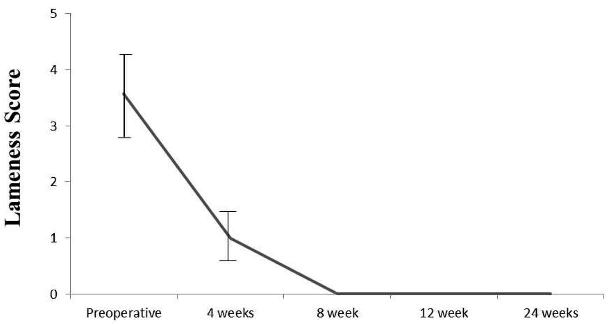

Fig 3. Visual lameness score.

Table 1. Range of motion and thigh girth circumference after surgery expressed as a percentage of that of the contralateral stifle joint

	Extension angle (%)*	Flexion angle (%)*	Thigh girth circumference (%)*
4 weeks	98.11 ± 2.47	98.07 ± 1.89	92.95 ± 2.91
8 weeks	99.07 ± 2.33	95.88 ± 3.63	93.68 ± 2.14
12 weeks	98.73 ± 3.39	96.35 ± 3.04	95.44 ± 1.69

*Mean ± SD

Discussion

The surgical procedures for the treatment of CCLR in the present study were as follows. First, a thorough exploration of the stifle joint was performed using arthroscopy. Remnants of the injured cruciate ligament were identified and removed with grasping forceps. Menisci were checked for injury and treated with partial meniscectomy or meniscal release, if damaged. After arthroscopy, dynamic stabilization of the stifle joint was performed with TPLO.

Meniscal damage presents as a secondary condition in up to 70% of patients with CCLR (19,21). One study suggests that diagnosis of meniscal tears is better with arthroscopy than arthrotomy (21). Considering that joint space is small in small dogs, diagnostic and therapeutic procedures using arthroscopy must be considered optimal. In the present study, medial meniscal injuries were 2 bucket handle tears and 3 cases of abrasion damages on the caudal pole, which was treated by partial meniscectomy to remove the injured portion. If continuing pathology was suspected, meniscal release was performed.

When performing osteotomy during TPLO in small dogs, their small bones must be considered. Tibial tuberosity fracture occurs with a frequency of 4.2% and is associated with the thickness of the tibial tuberosity after osteotomy in a TPLO procedure (4). The smallest commercial TPLO saw blade has a 10 mm diameter of radius. A surgeon must consider other techniques, such as ECR, or cranial tibial wedge osteotomy, if the width of the tibial tuberosity is too narrow to perform an osteotomy with a 10 mm saw blade. However, placing the saw blade anywhere other than over the intercondylar eminences can result in undesirable changes to the tibial mechanical axis and postoperative TPA (13). In this way, TPLO has a limitation in small breed dogs.

Another consideration about small bone size is the accuracy of osteotomy. A small mistake during osteotomy can result in tremendous error in small dogs. Saw blade position during surgery is usually defined by two points on the medial surface of the tibia. One point is on the osteotomy line at a distance from the tibial tuberosity perpendicular to the tibial crest (D1). The other point is on the proximal extent of the tibia at a distance measured from the tibial tuberosity (D2). These distances are measured on the preoperative mediolateral radiograph. To locate the saw blade more accurately, we added one more point on the caudal region of the tibia at a distance from the most caudal aspect of the medial tibial plateau (D3) (Fig 1) (29). Using this method, none of the cases in the present study showed narrow tibial tuberosity or TPA far from the desired angle of 5º, which means that our effort to position the saw blade accurately was successful.

In this retrospective study, all dogs presented their operated limb with a mean 5.56% decrease in TC, 1.27% decrease in extension, and 3.65% decrease in flexion at 12 weeks postoperatively. None were lame 4 weeks postoperatively. Our results show that CCLR correction using TPLO can be performed successfully in small dogs.

The lameness score varied from grade 2 to 4 before surgery. All patients had a grade 1 score at 1 week and a grade 0 at 8 weeks postoperatively. None of the dogs in this study showed clinically observed lameness in either limb 4 weeks postoperatively. In another study, dogs continued to be 2/5 lame at 8 weeks postoperatively and still had 1/5 lameness 18 weeks after TPLO (3). Compared to a report evaluating ECR in small dogs and cats, our result showed faster recovery on the visual lameness score (14). We consider the limb function of our patients to be satisfactory; dogs usually continue to be lame for several months because of the altered biomechanics of the stifle joint after TPLO (16).

A study reported that stifle joints with CCLR treated with TPLO showed 94.8% of flexion and 97.2% of extension one to five years after surgery (17). Jandi and Schulman (2007) suggested that patients had a higher clinical lameness score if they had a ≥ 10º loss of flexion or extension (11). All of our patients showed higher percentage of ROM than previous reports and none of them lost more than 10º of ROM in extension or flexion.

The reported complication rate of TPLO ranges from 19 to 28% (19,20,26). Reported complications include screw loosening, tibial tuberosity fractures, patellar tendon thickening, osteomyelitis, soft tissue infection, subsequent meniscal tears, plate breakage, and patellar luxation (24,25,28). Among these complications, major complications are screw loosening, tibial tuberosity fractures, osteomyelitis, subsequent meniscal tears, and plate breakage requiring continuing treatment or a second surgery. In the present report, one patient (case 4) had wound dehiscence and two (cases 4, 7) had reluxated patella one week after surgery. Those conditions were minor complications and were controlled successfully by wound management and bandage application, and spontaneous recovery, respectively.

Mean postoperative TPA (6.86 ± 3.13º) was slightly different from the recommended TPA of 5º (25). One patient (case 1) here can be considered undercorrected (12º) because of manipulation during reduction and fixation. This patient was not lame at recheck time. In vitro studies consider cranial tibial thrust to be neutralized at 6.5º (27). Overrotation of the tibial plateau can adversely affect the result of surgery and has been related to caudal cruciate ligament injury (24). On the other hand, underrotation of the tibial plateau might not provide the stifle joint with stability due to residual cranial tibial thrust. Good results after TPLO were gained with postoperative TPA ranging from 0 to 14º (23). Therefore, we think a postoperative TPA of 12º in one patient is an acceptable angle to show good clinical outcomes.

In cases with MPL which is necessary to perform tibial tuberosity transposition (TTT), this was carried out by rotating the distal segment to realign the quadriceps mechanism after radial osteotomy as previously described (15). This method might be technically simpler than the combination of TPLO and TTT. In large or giant breed dogs, a broad plate or second plate could be added to the fixation to provide more stability, which isn't possible in smaller patients. However, we found no incidence of fixation failure and an absence of change in the TPA in the present study, suggesting that buttress fixation was satisfactory in small breed dogs.

Some studies have revealed that TPLO showed a better outcome than ECR. Dogs returned to normal loading faster after TPLO than ECR (18). Dogs treated with ECR used their limbs more comfortably in the later recovery period (6 months), but some factors, such as greater progression of OA in dogs treated with ECR, limited recovery to normal function compared with dogs treated with TPLO (18). A recent study revealed no significant differences in result assessed by pressure walkway gait analysis or radiographic OA between dogs treated with ECR or TPLO (2).

In conclusion, technical difficulties associated with the size of small breed dogs can be overcome using arthroscopy and precise osteotomy with saw blade location determined using three measuring distances instead of two. Our outcomes of evaluation for TPLO in small breed dogs are not worse than those previously reported for large breed dogs. Based on our data, CCLR in small breed dogs can be successfully managed with TPLO.

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소형견에서 전 십자인대 단열의 치료를 위한 경골 고평부 평탄 골절단술의 평가

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요 약 : 본 연구는 소형견에서 전 십자인대 단열에서 경골 고평부 평탄 골절단술로 치료된 증례의 예후와 수술적 기법에 대해 보고하고자 한다. 5 kg 미만의 7 마리의 성견에서 편측 전 십자인대 단열에서의 경골 고평부 평탄 골절단술을 이용한 증례를 본 연구에서 이용하였다. 임상적 관찰, 파행 지수, 관절의 운동 범위, 대퇴 둘래 길이를 측정하고 수술 후 부작용에 대해 기록하였다. 모든 환자에서 수술 후 1주에 파행 지수 1을 8주 이후에는 파행 지수 0를 보여주었다. 수술한 다리의 펴짐각은 다른 쪽 정상 다리와 비교하여 4주에 98.11%로 8주에 99.07%로 12주에 98.73%로 측정되었고 굽힘각은 4주에 98.07%로 8주에 95.88%로 12주에 96.35%로 측정되었다. 수술 후 대퇴 둘레 길이는 다른 쪽 정상 다리와 비교하여 4주에 92.95%를 8주에 93.68%를 12주에 95.44%를 보여 주었다. 우리가 수술 한 결과는 이전에 보고된 대형견에서 경골 고평부 평탄 골절단술의 이용 결과들과 비교하여 나쁘지 않은 결과를 보여 주었다. 본 증례를 바탕으로 대형견에서와 같이 소형견에서도 경골 고평부 평탄 골절단술이 전 십자인대 단열에서 성공적으로 사용될 수 있다고 사료된다.

주요어 : 경골 고평부 평탄 골절단술, 전 십자인대 단열, 소형견종, 개