The Journal of Veterinary Medical Science

FULL PAPER

Surgery

Preoperative planning for tibial plateau leveling osteotomy based on proximal tibial width

Hiroko FUJINO[1)#], Muneki HONNAMI[1)#*] and Manabu MOCHIZUKI[1,2)]

[1)]Veterinary Medical Center, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

[2)]Laboratory of Veterinary Emergency Medicine, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

J. Vet. Med. Sci.
82(5): 661–667, 2020
doi: 10.1292/jvms.19-0501

Received: 6 September 2019
Accepted: 19 March 2020
Advanced Epub:
31 March 2020

ABSTRACT. The purpose of this study was to evaluate the applicability and feasibility of a novel preoperative planning method for tibial plateau leveling osteotomy (TPLO) based on the width of the proximal tibia. All TPLO procedures were performed by the same surgeon. In preoperative planning, the width of the tibial crest to the caudal edge of the medial tibial plateau (W) was measured, and the saw blade size that was closest to the distance between the point of the cranial third W and the intercondylar tubercles was selected. The postoperative tibial plateau angle (TPA), distance of eccentricity (DOE), and minimum thickness of the tibial tuberosity remaining cranial to the osteotomy (tibial tuberosity width; TTW) were documented. Complications in the perioperative and follow-up periods were documented. Thirty-one TPLO procedures were performed in 28 dogs, including both small and large breeds. The postoperative TPA was 8.4 ± 2.0° and the DOE was 3.55 ± 2.88 mm. The ratio of the TTW to the preoperative W was 0.27 ± 0.06. There were no major complications, such as fractures of the tibial tuberosity or implant breakage. This preoperative planning method allowed appropriate planning for TPLO with a clear index that was based on the size of the tibia rather than the breed or weight of the dog. This method should be of benefit to the surgeon, whether an expert or a novice, and contribute to the success of TPLO.

KEY WORDS: cranial cruciate ligament, dog, preoperative planning, tibial plateau leveling osteotomy

Cranial cruciate ligament rupture is a common cause of pelvic limb lameness in dogs and results in joint instability and progressive osteoarthritis [10]. Tibial plateau leveling osteotomy (TPLO) is a common surgical treatment for cranial cruciate ligament rupture in both small and large dog breeds [5, 8, 19].

TPLO is a modified osteotomy of the proximal tibia intended to neutralize cranial tibial thrust and involves a cylindrical proximal tibial osteotomy, rotation of the tibial plateau segment, and internal fixation of the osteotomy [16]. Reported complication rates after TPLO range from 14.8% to 28% and include implant breakage, infection, patellar tendonitis, fracture of the tibial tuberosity, fracture of the tibia and fibula, and implant-associated sarcoma [3, 7, 11, 13, 14, 16, 17]. Meticulous preoperative planning is necessary to achieve the desired postoperative tibial plateau angle (TPA) and to reduce the risk of complications [4].

The tibial tuberosity width (TTW) is one of the most important factors in preoperative planning. If the radius of the tibial osteotomy is too large or its position is too cranial or distal, the thickness of the remaining tibial tuberosity becomes thin and there is a high risk of avulsion fracture. It has been shown that a TTW of <10 mm increases the risk of tibial tuberosity fracture in a cohort of large dogs with a mean body weight of approximately 40 kg [2]. Furthermore, in a retrospective study of small dogs weighing <15 kg, the mean TTW was 7.7 (range, 5.4–9.9) mm and there were no tibial tuberosity fractures [19]. The TTW values in previous reports are often used to determine the appropriate radius (i.e., an appropriate saw blade size) and position of the osteotomy. However, no standard method for selection of the saw blade size has been established. The reported TTW values are based mainly on body weight, and do not consider the size and shape of the proximal tibia of the individual dog. In routine cases, a TTW of 10 mm is a reasonable goal in large dog breeds, however, it is generally much smaller in giant breeds and greater in small and toy breeds. Therefore, the saw blade size and osteotomy position should be finally determined according to the discretion of the surgeon to secure "enough" TTW and to ensure that the shape of the tibial tuberosity gradually becomes wider from proximal to distal [12]. Furthermore, the osteotomy position should not damage tissues in the stifle joint, in particular the meniscus and

*Correspondence to: Muneki, H.: m.honnami@gmail.com
#These authors contributed equally to this work.

cruciate ligaments, and the proximal bone segment should be large enough for adequate implant setting. We have devised a preoperative planning method for selection of a saw blade of adequate size, the position of the osteotomy, and the implant that is based not on body weight but on the size of the proximal tibia of the individual dog. The purpose of this prospective study was to evaluate the applicability and feasibility of our method in dogs undergoing TPLO.

MATERIALS AND METHODS

Case selection

Dogs that were diagnosed with unilateral or bilateral cranial cruciate ligament rupture and presented for TPLO at The University of Tokyo, Veterinary Medical Center between June 2015 and September 2016 were included in the study. The age, sex, breed, body weight, and operated limb were recorded in all cases. Dogs were excluded if the radiographs obtained preoperatively and immediate postoperatively showed that the mediolateral stifle was not correctly positioned. The position was deemed to be correct if the separation of the superimposed femoral condyles was ≤2 mm on the radiographs [9].

Preoperative planning

Mediolateral radiographs were obtained with the stifle and tarsocrural joints each positioned at 90° of flexion. First, the TPA was measured as previously reported [15]. Second, the TPLO saw blade was selected as follows (Fig. 1A). The width of the tibial crest to the caudal edge of the medial tibial plateau (W) was measured and the point of the cranial third W (1/3W) was marked. The distance between the 1/3W and the intercondylar tubercles (R) was measured. The radius of the TPLO saw blade that was closest to R was selected from the 12, 15, 18, 21, 24, 27, and 30 mm sizes, manufactured by Johnson & Johnson K.K. (Depuy Synthes Japan, Tokyo, Japan) or New Generation Devices (Glen Rock, NJ, USA) which was selected either one of devices in random manner.

Next, an osteotomy line with a radius that was the same as that of the selected saw blade was drawn at the middle point of the tibial intercondylar tubercles. Two distances (D1 and D2) were measured as previously reported [18] to determine the intraoperative landmarks. D1 is the distance from the insertion of the patellar tendon to the osteotomy perpendicular to the cranial border of the tibia. D2 is the distance between the insertion of the patellar tendon and the exit of the cranioproximal osteotomy from the tibia (Fig. 1B).

Finally, a maximally sized TPLO plate for placement on the proximal bone segment was selected from the 2.0, 2.4, 2.7, 3.5 mm, and 3.5 mm Broad LCP™ system manufactured by Johnson & Johnson K.K. (Depuy Synthes Japan, Tokyo, Japan) or the 2.5 mm Fixin™ mini system manufactured by TraumaVet SRL (Rivolito, Italy).

Surgical procedure and postoperative care

All dogs were induced with intravenous propofol (veterinary propofol injection 1% "Mairan", MSD Animal Health K.K.,

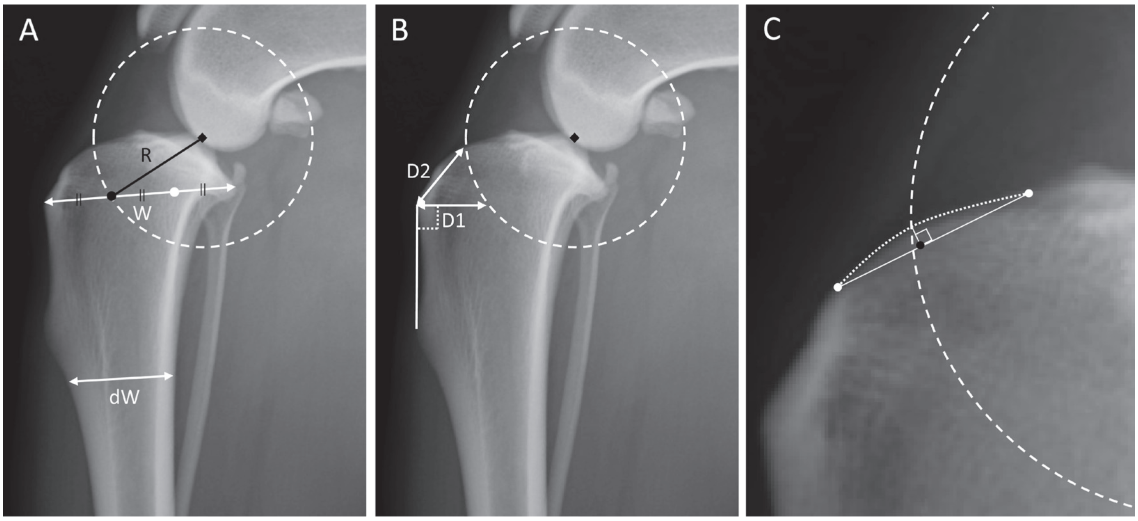

Fig. 1. Preoperative measurements recorded on a mediolateral radiograph of the proximal tibia. The width of the tibial crest to the caudal edge of the medial tibial plateau (W) was measured. The point of the cranial third W (1/3W) was marked. The distance between the 1/3W and the intercondylar tubercles (R) was measured. The radius of the saw blade closest to R was selected. The tibial width of the diaphysis at the distal end of the tibial tuberosity (dW) was measured. (A). The osteotomy template was centered on the tibial intercondylar tubercles. The distance between the insertion of the patellar tendon and the osteotomy was measured perpendicular to the cranial border (D1) and along the cranioproximal border (D2). (B). The bone cutting point at the proximal tibial surface where no ligaments were attached, i.e., between the caudal attachment of the patellar tendon and the cranial attachment of the cranial tibial ligament of the medial meniscus, was identified. The data were then plotted and the ratio of the bone cutting point to the width of this area was then calculated (C).

doi: 10.1292/jvms.19-0501

Tokyo, Japan). General anesthesia was maintained using 1–2% isoflurane (Isofuru®, Zoetis Japan K.K., Tokyo, Japan) in oxygen. For analgesia, 0.25% bupivacaine (Marcaine®, 0.1 ml/kg; Aspen Japan K.K., Tokyo, Japan) was administered for sciatic and femoral nerve block, and ketamine (Ketalar®, 1 mg/kg/hr; Daiichi Sankyo Propharma Co., Ltd., Tokyo, Japan) and fentanyl (Fentanyl Injection 0.5 mg "Janssen", 10 μg/kg/hr, Janssen Pharmaceutical K.K., Tokyo, Japan) were infused at a constant rate perioperatively. Antibiotic agents were administered intravenously (cefazolin sodium 20 mg/kg; Nichi-Iko Pharmaceutical Co., Ltd., Toyama, Japan) 40 min. before surgery and every 2 hr thereafter during the perioperative period. An oral non-steroidal anti-inflammatory drug, i.e., firocoxib (Previcox®, 5 mg/kg every 24 hr; Boehringer Ingelheim Animal Health Japan Co., Ltd., Tokyo, Japan) or robenacoxib (Onsior®, 2 mg/kg, every 24 hr; Elanco Japan K.K., Tokyo, Japan), was administered for 3–5 days after surgery. Arthroscopy or subpatellar arthrotomy was performed in all cases for debridement of the remnants of the cranial cruciate ligament tissue and injured portion of the meniscus.

The surgical procedure was performed as previously described without an alignment jig [16]. A medial surgical approach to the proximal tibia was used. D1 and D2 were measured, and the positions marked using electrocautery. A TPLO saw, the size of which had been predetermined from the preoperative radiographs, was used for the osteotomy. After the osteotomy, a Steinmann pin (2.0 mm or 2.5 mm in diameter) was placed through the proximal bone segment and used to rotate the proximal segment until the distance required to create a postoperative TPA of 5 degrees was reached. Next, a Kirschner wire (1.0 mm or 1.25 mm in diameter) was inserted through the proximal part of the tibial tuberosity to the proximal bone segment for temporary fixation. The proximal bone segment was stabilized with a predetermined TPLO plate, locking head screws, and cortical screws. After the plate setting, Steinman pin and Kirschner wire were removed.

Radiographic assessment

Using preoperative mediolateral radiographs, the ratio of the width of the tibia at the level of the distal end of the tibial tuberosity (dW) (Fig. 1A) to the width of the remaining proximal bone segment (2/3W) was calculated. The bone cutting point at the proximal tibial surface where no ligaments were attached, i.e., between the caudal attachment of the patellar tendon and the cranial attachment of the cranial tibial ligament of the medial meniscus, was also evaluated. The data were then plotted and the ratio of the bone cutting point to the width of this area was then calculated (Fig. 1C).

Postoperative radiographs of the stifle and tibia were obtained immediately after surgery under anesthesia. The postoperative TPA was measured on these radiographs, and the osteotomy site, apposition, implant position, and limb alignment were evaluated.

The accuracy of the osteotomy site was evaluated by measuring the distance of eccentricity (DOE). The intended center of the osteotomy (ICO) was determined as previously described. The actual center of the osteotomy (ACO) was identified using a circular template (as in preoperative planning) that was aligned with the tibial osteotomy. The distance between the ICO and ACO was measured and deemed to be the DOE. The direction of eccentricity was determined by measuring the inaccuracy relative to the cranio-caudal (x-axis; L1) and proximal-distal (y-axis; L2) directions (Fig. 2A). The ratio of the DOE to the preoperative W was calculated to standardize the distance by the bone size. The minimum TTW from the insertion of the patellar tendon to the osteotomy was measured and the ratio of the TTW to the preoperative W was calculated (Fig. 2B). All radiographic measurements

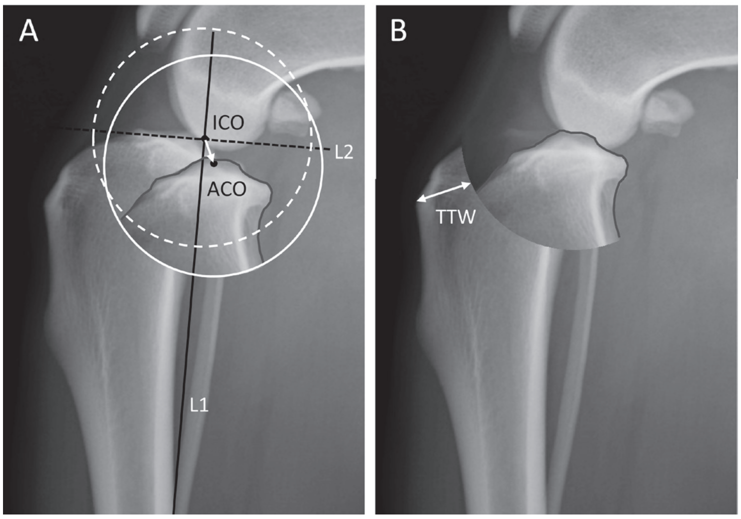

Fig. 2. (A) The actual center of the osteotomy (ACO) was identified during preoperative planning using a circular template that was aligned with the tibial osteotomy. The distance between the intended center of the osteotomy (ICO) and the ACO was measured and defined as the distance of eccentricity (DOE). The tibial mechanical axis (solid line, L1) was identified and a perpendicular line (dotted line, L2) that intersected at the ICO was drawn. Lines L1 and L2 were used as the y-axis and x-axis, respectively. (B) The minimum width of the tibial tuberosity between the insertion of the patellar tendon and the osteotomy was measured. The ratio of the width of the tibial tuberosity to the preoperative width of the tibial crest to the caudal edge of the medial tibial plateau (W) was calculated.

were made by the same observer (HF). Follow-up radiographs were obtained at 6–8 weeks postoperatively and as necessary thereafter to evaluate osteotomy healing and complications.

Complications

Complications in the perioperative period and during follow-up were documented. Complications associated with the surgical procedure were classified as major if reoperation was required and minor if manageable without further surgery.

RESULTS

Thirty-one TPLO procedures were performed by the same surgeon (MH) in 28 dogs (Table 1). The dog breeds included Toy Poodle (n=5), Shiba (n=4), mix breeds (n=4), Jack Russell Terrier (n=2), Border Collie (n=2), and one dog of each of the following breeds: Chihuahua, Bernese Mountain Dog, Cavalier King Charles Spaniel, Beagle, Dogo Argentino, German Shepherd, Rottweiler, Whippet, and Dalmatian. The mean age was 7.6 ± 3.4 (range, 1.6–12.8) years and the mean body weight was 19.2 ± 14.3 (range 3.9–60) kg. The dogs included 10 neutered males, 9 neutered females, 2 males, and 7 females. The operated limb was on the left side in 16 dogs and on the right side in 15.

The mean TPA was 28.3 ± 3.2 (range, 22–36) degrees preoperatively and 8.4 ± 2.0 (range 5.1–12) degrees postoperatively. The following saw blade sizes were selected: 12 mm (n=3), 15 mm (n=10), 18 mm (n=3), 21 mm (n=6), 24 mm (n=3), 27 mm (n=4), and 30 mm (n=2). The size of the TPLO plate used was 2.0 mm (n=2), 2.4 mm (n=4), 2.5 mm (n=4), 2.7 mm (n=6), 3.5 mm (n=13), or 3.5 mm broad (n=2).

The mean dW to 2/3W ratio was 1.24 ± 0.15 (range 0.82–1.59). In all cases, the cutting point at the proximal tibial surface was within the area without any ligaments. The ratio of the bone cutting point to the width of this area was 0.40 ± 0.12 (range 0.08–0.65; Fig. 3).

The mean DOE was 3.55 ± 2.88 mm. In 13 (42%) of 31 TPLO procedures, the ACO was located caudal and distal to the ICO (Fig. 4A). The mean DOE/W was 0.10 ± 0.06 (range 0–0.24) and classified by saw blade size. There were no obvious differences

Table 1. Summary of Tibial plateau leveling osteotomy (TPLO) procedures and postoperative measurements

Total number of dogs	28
Total number of stifles	31
Age (years)	7.6 ± 3.4
Weigh (kg)	19.2 ± 14.3
Sex (male/ female/ casted/ spayed)	2 / 7 / 10 / 9
Pre TPA (degree)	28.3 ± 3.2
Post TPA (degree)	8.4 ± 2.0
Operated limb (left/right)	16 / 15
Ratio of dW to 2/3W	1.24 ± 0.15
Ratio of the proximal bone cutting point to the area without any ligaments	0.40 ± 0.12
DOE (mm)	3.55 ± 2.88
Ratio of DOE to W	0.10 ± 0.06
Ratio of TTW to W	0.27 ± 0.06

The data are shown as the mean ± standard deviation or number as appropriate. TPA, tibial plateau angle; dW, tibial width of the diaphysis at the distal end of the tibial tuberosity; W, width of the tibial crest to the caudal edge of the medial tibial plateau; DOE, distance of eccentricity; TTW, tibial tuberosity width.

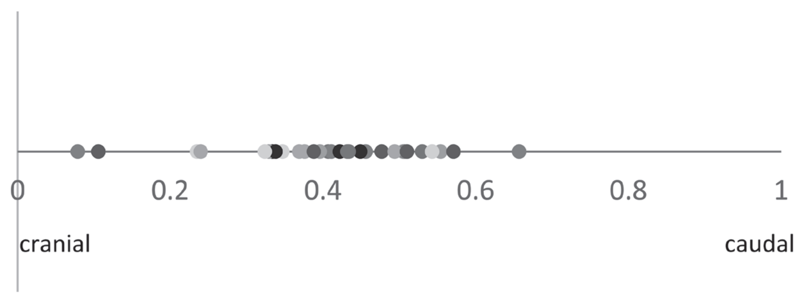

Fig. 3. The ratio of the bone cutting point to the width of that proximal tibial surface without any ligaments attaching. The ratio was plotted on the line that defined the caudal attachment of the patellar tendon as 0 and the cranial attachment of the cranial tibial ligament of the medial meniscus as 1. The mean ratio was 0.40 ± 0.12 (range 0.08–0.65).

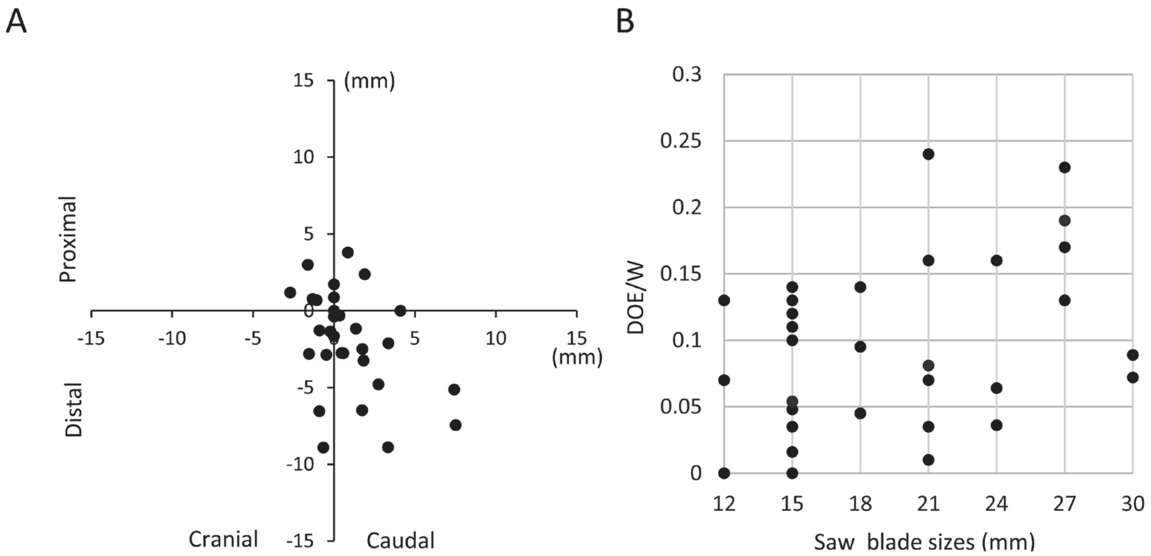

Fig. 4. (A) Distance and direction of eccentricity for the tibial plateau leveling osteotomy procedures. The y-axis represents the tibial mechanical axis and the x-axis is perpendicular to the y-axis. Each datum point represents the actual center of the osteotomy in relation to the intended center of the osteotomy (0, 0). The mean distance of eccentricity was 3.55 ± 2.88 mm, and the actual center of the osteotomy was located caudal and distal to the intended center of the osteotomy in 13 (42%) of 31 tibial plateau leveling osteotomy procedures. (B) The ratio of distance of eccentricity to the preoperative W classified by saw blade size.

between the groups (Fig. 4B). The mean TTW/W was 0.27 ± 0.06 (range 0.19–0.42).

The mean follow-up duration was 157 ± 85.3 (range 55–413) days. Minor complications occurred in five cases (16.1%) during the perioperative and follow-up periods. These complications included superficial wound dehiscence (n=2), tissue swelling (n=1), fibular fracture (n=1), and patellar tendonitis (n=1). Superficial wound dehiscence caused by self-trauma with skin suture in two cases was successfully treated by wound irrigation and administration of oral antibiotic medication (cefalexin, 20 mg/kg, every 12 hr). In one case, a proximal fibular fracture without fragment displacement was detected on the immediate postoperative radiograph that had healed without treatment by 4 weeks after surgery. In another case, patellar tendonitis was detected 3 weeks after surgery and treated with a prolonged course of oral non-steroidal anti-inflammatory medication (firocoxib, 5 mg/kg, every 24 hr); resolution was achieved by 8 weeks after surgery. There were no major complications, such as tibial tuberosity fracture or breakage of the implant.

DISCUSSION

Preoperative planning for TPLO is important to ensure a successful procedure and to reduce the risk of complications. The saw blade size influences the size of the remaining TTW and proximal bone segment. In a previous report, it was shown that the ideal TTW was >10 mm in large dog breeds [2]. In another two reports on small dog breeds, the mean TTW values were 7.7 mm and 5.9 mm with no tibial tuberosity fractures in either study [1, 19]. We typically refer to these TTW values according to body weight and physical constitution when selecting a saw blade size. However, it is difficult to apply these values to all dogs. In this study, we determined the saw blade size based on the 1/3W, preserving the ratio of the width of the tibial tuberosity to the width of the tibia of the individual dog in all cases. Appropriate TPLO procedures were performed and there were no major complications, such as tibial tuberosity fracture. In a report that investigated the risk factors for tibial tuberosity fracture after TPLO, the TTW/W of a group with tibial tuberosity fractures was 0.19 and that of a group without was 0.26 [2]. The mean TTW/W in the present study was 0.27, which is approximately equivalent to the value in the group without tibial tuberosity fracture in the previous report. Therefore, the value of 1/3W used in this study can be considered reasonable.

The advantage of our method is that it is also able to keep the size of the proximal bone segment constant according to the size of the individual dog. One of the important elements of TPLO is to fix the proximal bone segment with suitable implants. If the proximal bone segment is too small, while it is possible to ensure a wide tibial tuberosity, the selection of appropriately sized plates becomes difficult. Using our method, the width of the proximal bone segment was 2/3W and the maximum plate that could span this segment was selected. Therefore, there were no implant-related complications, which indicates that the appropriate implant was able to be selected. The mean dW to 2/3W ratio was 1.24 (range 0.82–1.59). Generally, the implant is selected such that the screw size is <1/3 of the bone width. However, in TPLO, given that two or more screws are inserted in the proximal bone side by side, when determining the screw size from the width of the diaphysis of the tibia, it is difficult to install a plate in a proximal bone segment that is smaller than twice the diaphysis of the tibia. Therefore, our method of taking into account the placement of the plate in the proximal bone segment when selecting the size of the implant is considered clinically acceptable.

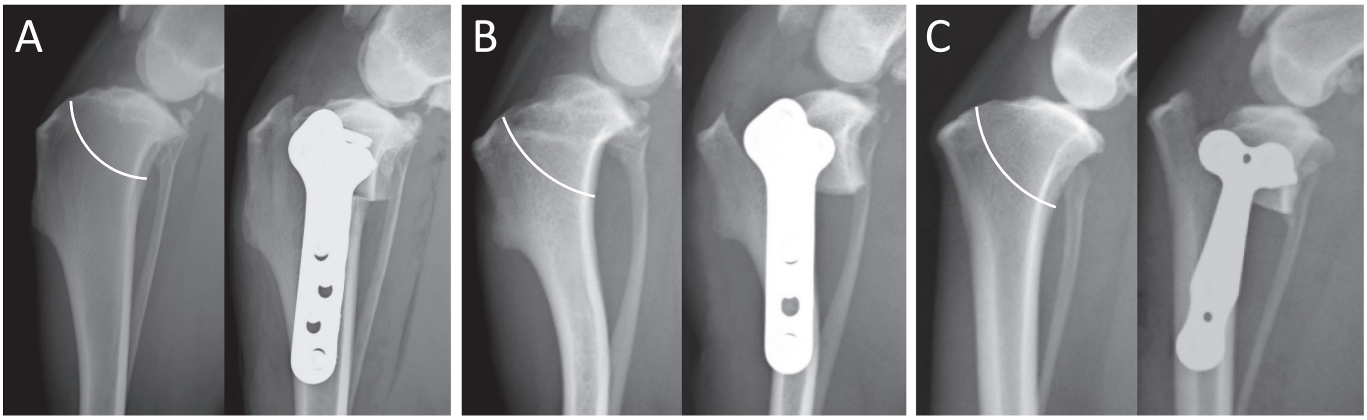

Fig. 5. Preoperative and postoperative mediolateral radiographs of the proximal tibia in a German Shepherd (A), Pembroke Welsh Corgi (B), and Toy Poodle (C). The shape of the proximal tibia varied depending on the dog breed.

When setting the osteotomy line, it is also important not to damage the structures present in the proximal tibial surface, including the patellar tendon, cranial tibial ligament of the medial meniscus, and the attachment of the cranial cruciate ligament. Using our method, the cutting position for the proximal tibia was set in the area without these ligaments in all cases, which allowed for a safe osteotomy. The risk of damage to the attachment of the patellar tendon is more likely if the bone cutting position is close to the cranial edge, and there is also a risk of damage to the cranial tibial ligament of the medial meniscus if the cutting position is close to the caudal edge. In this regard the ratio of 1/3 can be considered reasonable. However, the cutting position was on the cranial side in two of our cases (0.08/0.11), both of which were toy poodles. The shape of the proximal tibia in toy poodles is such that the top of the tibial tuberosity tends to be located proximally, so a more appropriate setting ratio would be required in this breed.

The complication rate in this study was equivalent to that in previous reports and all complications were minor. We also measured DOE using methodology similar to that in earlier reports [6, 18]. The mean DOE in this study was 3.55 mm, which is similar to that reported previously. These findings indicate that a slight gap between the preoperative planning and the actual surgical procedure, which was not associated with serious complications. Furthermore, DOE was standardized by tibial width and classified by saw blade size. Although the number of cases in each group was small, there were no obvious differences between the groups. The DOE/W ratio tended vary more widely when the blade size was larger than when it was smaller.

Our preoperative planning method is simple. When using the conventional method to determine the saw blade size and osteotomy position, some elements should be considered concurrently, including the residual TTW, the center of the osteotomy, the size of the proximal bone segment, and the implants used for fixation of the osteotomy. In contrast, our method proceeds step by step. First, we determine the saw blade size depending on the distance between the 1/3W and the intercondylar tubercles (R). Second, the osteotomy line is drawn at the middle point of the tibial intercondylar tubercles. Finally, a TPLO plate of maximum size is used to cover the proximal bone segment. The simplicity of the preoperative planning should be of benefit to the surgeon, whether an expert or a novice, when devising an appropriate plan and contribute to the success of TPLO.

This study has some limitations. The first is the small number of cases, and future studies should include more cases of various sizes and breeds. The second limitation is that we provisionally applied the value of "one-third" to the ratio of the osteotomy line and TTW. However, the result was that there were no major complications, such as tibial tuberosity fracture or implant breakage. As already mentioned, a ratio of 1/3 can be considered reasonable because it allows a safe bone cutting line to be set. However, the shape of the proximal tibia in dogs depends on the breed. Our impression is that the form of the tibia in Toy Poodle and Pembroke Welsh Corgi are different to that in large breeds (Fig. 5). There is likely to be a more appropriate ratio for these breeds.

In conclusion, our method allows appropriate preoperative planning with a clear index that is not dependent on the breed or weight of the dog but is based on the size of the individual proximal tibia.

CONFLICT OF INTEREST. The authors declare no conflicts of interest related to this report.

REFERENCES

1. Barnes, D. C., Trinterud, T., Owen, M. R. and Bush, M. A. 2016. Short-term outcome and complications of TPLO using anatomically contoured locking compression plates in small/medium-breed dogs with "excessive" tibial plateau angle. *J. Small Anim. Pract.* **57**: 305–310. [Medline] [CrossRef]
2. Bergh, M. S., Rajala-Schultz, P. and Johnson, K. A. 2008. Risk factors for tibial tuberosity fracture after tibial plateau leveling osteotomy in dogs. *Vet. Surg.* **37**: 374–382. [Medline] [CrossRef]
3. Boudrieau, R. J., McCarthy, R. J. and Sisson, R. D. Jr. 2005. Sarcoma of the proximal portion of the tibia in a dog 5.5 years after tibial plateau leveling osteotomy. *J. Am. Vet. Med. Assoc.* **227**: 1613–1617, 1591. [Medline] [CrossRef]
4. Collins, J. E., Degner, D. A., Hauptman, J. G. and DeCamp, C. E. 2014. Benefits of pre- and intraoperative planning for tibial plateau leveling

osteotomy. *Vet. Surg.* **43**: 142–149. [Medline] [CrossRef]
5. Cosenza, G., Reif, U. and Martini, F. M. 2015. Tibial plateau levelling osteotomy in 69 small breed dogs using conically coupled 1.9/2.5 mm locking plates. A clinical and radiographic retrospective assessment. *Vet. Comp. Orthop. Traumatol.* **28**: 347–354. [Medline] [CrossRef]
6. Craig, A., Witte, P. G. and Scott, H. W. 2017. Sagittal accuracy of tibial osteotomy position during in vivo tibial plateau levelling osteotomy performed without an alignment jig and cutting guide. *Vet. Comp. Orthop. Traumatol.* **30**: 37–45. [Medline] [CrossRef]
7. Fitzpatrick, N. and Solano, M. A. 2010. Predictive variables for complications after TPLO with stifle inspection by arthrotomy in 1000 consecutive dogs. *Vet. Surg.* **39**: 460–474. [Medline] [CrossRef]
8. Garnett, S. D. and Daye, R. M. 2014. Short-term complications associated with TPLO in dogs using 2.0 and 2.7 mm plates. *J. Am. Anim. Hosp. Assoc.* **50**: 396–404. [Medline] [CrossRef]
9. Grierson, J., Sanders, M., Guitan, J. and Pead, M. 2005. Comparison of anatomical tibial plateau angle versus observer measurement from lateral radiographs in dogs. *Vet. Comp. Orthop. Traumatol.* **18**: 215–219. [Medline] [CrossRef]
10. Johnson, J. M. and Johnson, A. L. 1993. Cranial cruciate ligament rupture. Pathogenesis, diagnosis, and postoperative rehabilitation. *Vet. Clin. North Am. Small Anim. Pract.* **23**: 717–733. [Medline] [CrossRef]
11. Kergosien, D. H., Barnhart, M. D., Kees, C. E., Danielson, B. G., Brourman, J. D., DeHoff, W. D. and Schertel, E. R. 2004. Radiographic and clinical changes of the tibial tuberosity after tibial plateau leveling osteotomy. *Vet. Surg.* **33**: 468–474. [Medline] [CrossRef]
12. Kowaleski, M. P., Apelt, D., Mattoon, J. S. and Litsky, A. S. 2005. The effect of tibial plateau leveling osteotomy position on cranial tibial subluxation: an in vitro study. *Vet. Surg.* **34**: 332–336. [Medline] [CrossRef]
13. Pacchiana, P. D., Morris, E., Gillings, S. L., Jessen, C. R. and Lipowitz, A. J. 2003. Surgical and postoperative complications associated with tibial plateau leveling osteotomy in dogs with cranial cruciate ligament rupture: 397 cases (1998–2001). *J. Am. Vet. Med. Assoc.* **222**: 184–193. [Medline] [CrossRef]
14. Priddy, N. H. 2nd., Tomlinson, J. L., Dodam, J. R. and Hornbostel, J. E. 2003. Complications with and owner assessment of the outcome of tibial plateau leveling osteotomy for treatment of cranial cruciate ligament rupture in dogs: 193 cases (1997-2001). *J. Am. Vet. Med. Assoc.* **222**: 1726–1732. [Medline] [CrossRef]
15. Reif, U., Dejardin, L. M., Probst, C. W., DeCamp, C. E., Flo, G. L. and Johnson, A. L. 2004. Influence of limb positioning and measurement method on the magnitude of the tibial plateau angle. *Vet. Surg.* **33**: 368–375. [Medline] [CrossRef]
16. Slocum, B. and Slocum, T. D. 1993. Tibial plateau leveling osteotomy for repair of cranial cruciate ligament rupture in the canine. *Vet. Clin. North Am. Small Anim. Pract.* **23**: 777–795. [Medline] [CrossRef]
17. Stauffer, K. D., Tuttle, T. A., Elkins, A. D., Wehrenberg, A. P. and Character, B. J. 2006. Complications associated with 696 tibial plateau leveling osteotomies (2001–2003). *J. Am. Anim. Hosp. Assoc.* **42**: 44–50. [Medline] [CrossRef]
18. Tan, C. J., Bergh, M. S., Schembri, M. A. and Johnson, K. A. 2014. Accuracy of tibial osteotomy placement using 2 different tibial plateau leveling osteotomy jigs. *Vet. Surg.* **43**: 525–533. [Medline] [CrossRef]
19. Witte, P. G. and Scott, H. W. 2014. Tibial plateau leveling osteotomy in small breed dogs with high tibial plateau angles using a 4-hole 1.9/2.5 mm locking T-plate. *Vet. Surg.* **43**: 549–557. [Medline] [CrossRef]