pISSN 1598-298X / eISSN 2384-0749
J Vet Clin 37(3) : 135-140 (2020)
https://doi.org/10.17555/jvc.2020.06.37.3.135

Journal of Veterinary Clinics
www.ksvc.or.kr

Clinical Results of Distal Femoral Osteotomy for Treatment of Grade 4 Medial Patella Luxation with Concurrent Distal Femoral Varus in Small Breeds Dogs: 13 Cases

Yoon-Ho Roh[†], Jin-Ho Jung[†], Je-Hun Lee, Jae-Min Jeong, Seong Mok Jeong and HaeBeom Lee[1]

College of Veterinary Medicine, Chungnam National University, Daejeon 34134, Korea

(Received: March 15, 2020 / Revised: May 20, 2020 / Accepted: June 08, 2020)

Abstract : The purpose of this study was to determine the outcome of distal femoral osteotomy for distal femoral varus and medial patellar luxation (MPL) grade 4 in small-breed dogs. Radiographs and medical records were reviewed to collect data and plan the surgery in small-breed dogs with MPL grade 4. Computed tomography (CT) imaging was also performed in cases of severe bone deformities. Signalment, weight, medial patellar luxation and lameness grade, radiographic bone union, complications, pre- and postoperative femoral varus angle, passive range of motion, static weight bearing distribution and visual analogue scale scores were recorded. Thirteen corrective distal femoral osteotomies were performed with ancillary and additional procedures in 9 dogs; 4 dogs had staged bilateral procedures; and four stifles were suspected to have partial or complete rupture of the cranial cruciate ligament. One stifle underwent patellar groove replacement. The mean ± SD pre- and postoperative femoral varus angles were 109.15° ± 3.71° and 96.30° ± 2.97°, respectively. Significant improvements in passive range of motion, thigh circumference and visual analogue scale (VAS) scores were observed. There was no reluxation of the patella. This study suggests that distal femoral osteotomy with traditional and additional procedures provided satisfactory outcomes in patient healing and functional recovery in small-breed dogs with excessive femoral varus angles.

***Key words* :** distal femoral osteotomy, Femoral varus angle, Medial patellar luxation, Small-breed dogs.

Introduction

Medial patellar luxation (MPL) is one of the most common orthopedic diseases causing lameness in small and large-breed dogs (14,27). MPL often presents bilaterally, occurring in 50% of cases (34). A recent study reported that 93% of Pomeranian dogs presenting with MPL were affected bilaterally (35). Some small-breed dogs, including Chihuahua, Pekingese, Pomeranians, Miniature and Toy Poodles and Yorkshire Terriers, are 12 times more likely to develop MPL than large-breed dogs (3,25).

Although the exact etiology of MPL has not been clarified so far, several results have been published in various papers. Alignment of the quadriceps extensor mechanism, which comprises the quadriceps muscle group, and the patellar ligament has been implicated in the pathogenesis of MPL (13,27). The MPL stage is divided into four classes. In grade 4 patellar luxation, the patella is permanently luxated and cannot be returned to its anatomically original position by hand (28). Malalignment-associated skeletal abnormalities, including coxa vara, decreased femoral neck anteversion, genu varum, distal femoral varus or external torsion and tibial valgus or internal torsion, also tend to be present (32). It has been reported that skeletal abnormalities are related to the severity of MPL grade (4,35).

The re-luxation rate in MPL surgery ranges from 8% to 12% (3,10), with a lower rate achieved with the use of more advanced current surgical techniques. However, surgical correction of grade 4 MPL is still very challenging, and the prognosis is poor to guarded (27). In one study, it was found that the reluxation rate was 36% after grade 4 MPL surgery in small-breed dogs, specifically Pomeranians (35). In grade 4 MPL, not only internal rotation of the tibial tuberosity and shallow or absent trochlea ridge of the femur but also femoral varus or angular deformity may also be present (8,16,20). Therefore, although tibial tuberosity transposition (TTT) and wedge or block trochleoplasty are common operations for correcting grade 4 MPL, currently, distal femoral osteotomy (DFO) is gaining attention in the correction of excessive femoral varus, a contributor to malalignment of the quadriceps mechanism (8,30). When the femoral varus angle (FVA) is greater than 10-12 degrees, which corresponds to an anatomic lateral distal femoral angle (aLDFA) that is greater than 100-102 degrees, DFO is recommended (29,30).

However, these surgical standards are based on empirical facts and applied to large dogs, such as Labrador retrievers (29). The results of DFO application have been reported in various studies. However, most cases have been applied to large-breed dogs with variable MPL grades, and cases in which DFO is applied to small dogs only are extremely rare (5,9,12,26,30).

The purpose of this study was to determine the clinical outcome of DFO for grade 4 MPL with femoral varus deformity in small-breed dogs as a component of surgical treat-

[†]These authors contributed equally to this work.
[1]Corresponding author.
E-mail : seatiger76@cnu.ac.kr

ment combined with traditional methods. We hypothesized that DFO with traditional surgical methods would provide satisfactory and improved outcomes in the function of patients.

Materials and Methods

Case selection

The medical records revealed 9 dogs: 13 stifles that had undergone surgical treatment for nontraumatic medial patellar luxation at Chungnam National University Veterinary Medicine Teaching Hospital, Daejeon, Republic of Korea, from 2014 to 2018. Dogs were selected according to the following criteria: (1) grade 4 MPL; (2) DFO surgery was performed; (3) weight ≤ 9 kg; and (4) over 6 months of follow-up after surgery.

Procedure

Medical records and radiographs were reviewed to collect data. The information collected included breed, sex, body weight, general physical and orthopedic exam findings, date of surgery, age at surgery and surgery procedure. Follow-up data were obtained from medical records or telephone conversations with owners. A standard craniocaudal radiograph (hip-extended view) was obtained as well as craniolateral and mediolateral projections of the femur and tibia. In cases of severe angular deformity in the femur and tibia, computed tomography (CT) imaging was also performed. Femoral varus was obtained by measuring the aLDFA. Correction of concurrent diseases such as cranial cruciate ligament insufficiency or tibial torsion was planned using preoperative radiographs or CT images.

The drug used for premedication was administered appropriately according to the condition of each patient, and propofol (Anepol, Hana Pharm Co, Korea) (2-6 mg/kg IV) was used for induction. Isoflurane (Ifran, Hana Pharm Co, Korea) was given as the maintaining inhalant gas, and cefazoline (Cefazoline, CKD Pharm Co, Korea) (22 mg/kg IV) was administered every 90 min perioperatively for prophylaxis. Remifentanil (Remiva, Hana Pharm Co, Korea) (0.1-0.3 mcg/kg/min IV) was used mainly for peri- and postoperative pain control.

The DFO surgery was performed according to the standard procedure, and a locking plate was used after osteotomy at the site of the center of angulation of rotation (CORA). In all DFO surgery cases, lateral closing wedge ostectomy was used. The reduction angle was determined as planned prior to surgery (32). Surgical procedures, such as trochlear block recession, tibial tuberosity transposition, medial releasing and lateral imbrication, were also applied to all stifles. Antirotational suturing was applied to two stifles. The ancillary procedures were carried out according to the preference of the surgeon, and the degree of coverage was also adjusted appropriately according to the surgical site situation and the patient's condition. Usually, the patients were discharged one week after surgery, and the dogs were rehabilitated at least twice a week for a month or more.

Radiographic evaluation and data analysis

Standard stifle radiographic images (craniocaudal and mediolateral views) were taken pre- and postoperatively to compare aLDFA. We also assessed bone union 0, 4, 8, 12 and 24 weeks after surgery and osteoarthritis (OA) progression 0 and 24 weeks after surgery (7,17). Subsequent images were taken every 6 months. Based on these radiographs, OA progression was assessed by scoring based on synovial effusion, osteophyte presence, and intra-articular mineralization of the stifle joint. Synovial effusion and intra-articular mineralization were graded as 0-2 by subjective rating (0 - normal, 1 - mild, 2 - severe). Osteophytes generated around the stifle joint were graded as 0-3 by subjective rating (0 - normal, 1 - mild, 2 - moderate, 3 - severe). A single observer performed the radiographic scoring. Postoperative outcomes were assessed using data including radiographic evaluation, lameness scoring, thigh girth analysis, static weight bearing evaluation and a questionnaire.

Passive range of motion (PROM) was used to measure the flexion and extension angle of the affected stifle using a universal plastic goniometer (UPG). Measurements using a UPG (IMEXX Veterinary, Inc., Longview, USA) were performed as previously described 0 and 24 weeks after surgery (22). A measuring tape with a spring tension device (Gulick II: Country Medical Technology Inc., Gays Mills, WI, USA) was used to measure thigh circumference on the affected limb. The assessment was divided into unilateral and bilateral groups. The technique used to perform the thigh circumference measurement was based on a previous report, and readings were made in triplicate (22). Thigh circumference was measured 0 and 24 weeks after surgery. And the increase in thigh circumference in 24 weeks was measured in percentage. For the visual lameness score, a numerical rating scale (NRS) with 6 grades was used for lameness severity classification, and it was evaluated under walking, standing and trotting conditions (0 = no lameness detected; 1 = barely detectable lameness; 2 = mild lameness; 3 = moderate lameness; 4 = severe lameness but carries limb when trotting; 5 = non-weight bearing). The evaluation of lameness was performed before surgery and 4, 8, 12, and 24 weeks after surgery.

Static weight bearing distribution was measured when the dogs held their head and neck in a relaxed, neutral position and stared straight ahead on a force sensing resistor mattress (Snowforce Matrix Sensor 1610, Kitronyx, Korea); they maintained the same posture for 3 to 5 seconds in a quiet place. These measurements were performed 0 and 24 weeks after surgery.

A visual analogue scale questionnaire consisting of 12 questions were obtained either directly or by telephone interview before and after surgery by the owner (15,30). The postoperative response was at least 6 months postsurgery.

Statistical analysis

All statistical analyses were done using the SPSS software version 24.0 (IBM SPSs statistics 24.0, IBM Corp., Chicago, IL). Shapiro-Wilk tests were used to determine the normality of the data. The data are summarized as the means ± standard deviation (SD). The Wilcoxon signed rank test was performed to compare the data for aLDFA, PROM, lameness score and static weight bearing distribution. Values of $p < 0.05$ were considered statistically significant.

Results

Nine dogs with 13 stifles were included in this study. The distribution of dog breeds was as follows: 5 Maltese, 3 Chihuahua and 1 Pomeranian. All dogs were castrated males. The mean body weight and age at the time of surgery were 3.75 ± 0.75 kg (range: 2.85-5 kg) and 3.2 ± 2.34 years (range: 0.8-9.3 years), respectively. The mean follow-up period was 550.38 ± 310.39 days (range: 207-1,215 days). Of the 9 dogs, only 5 underwent unilateral surgery, and 4 underwent staged bilateral surgery (Table 1). Four stifles were suspected to have partial or complete rupture of the cranial cruciate ligament. One of the dogs had a tibial plateau levelling osteotomy, and the others had cranial closing wedge osteotomies. Tibial valgus was identified in 2 stifles and corrected with a single tibial osteotomy. Femoral torsion was found in two cases and was corrected with a DFO. One stifle that underwent patellar groove replacement (PGR) showed impingement between the PGR and patella. This was thought to be due to the small size of the PGR. Therefore, revision surgery was performed with larger prosthetics. The problem did not occur after revision surgery. In two cases, friction was felt on the side of the DFO during manipulation. However, lameness was not observed.

The results of the statistical analysis were summarized (Table 2). The mean preoperative aLDFA of the stifle joint that had femoral correction was 109.15° ± 3.71° (range: 104°-115°). The mean postoperative aLDFA was 96.30° ± 2.97° (Fig 1). Radiographic bone union of the DFO occurred after 92.22 days ± 22 days (range: 61-141). No other side effects, such as implant failure, were observed. In the OA progress assessment, synovial effusion was 1.75 ± 0.45 (range: 1-2) preoperatively and 1.50 ± 0.52 (range: 1-2) 24 weeks after the operation ($p = 0.18$). The mean osteophyte score was 1.90 ± 0.88 (range: 1-3) preoperatively and 2.00 ± 0.82 (range: 1-3) 24 weeks postoperatively ($p = 0.32$). The intra-articular mineralization score was 0 before and after surgery ($p = 1$). There were no significant changes in any OA evaluations. The mean flexion degree in the PROM of the affected limb was 30.11° ± 4.04° and 41.56° ± 2.30° 0 and 24 weeks post-

Table 1. Summary data for 9 dogs (13 stifles) with grade 4 medial patellar luxation treated with distal femoral osteotomy (DFO)

Limb	Breed	Age (years)	Sex	Weight (kg)	Side	Pre-Op aLDFA (°)	Post-Op aLDFA (°)	Imaging modality	Concurrent diseases	Other procedures
1[a]	Chihuahua	3.4	MC	2.85	R	115	97	Rad, CT	Femoral torsion, CCLR	TBR, TTT CCWO
2[a]	Chihuahua	3.8	MC	2.6	L	113	87	Rad, CT	CCLR	TBR, TTT CCWO
3[b]	Maltese	1.7	MC	5	L	113	94	Rad	Trochlear ridge abnormality	PGR, TTT
4[b]	Maltese	2.3	MC	4.8	R	108	94	Rad	None	TBR, TTT
5	Maltese	1.8	MC	4.6	L	112	99.4	Rad	None	TBR, TTT
6	Chihuahua	1.3	MC	3.9	L	109.8	99	Rad	None	TBR, TTT
7	Maltese	5	MC	3.3	L	104	94	Rad, CT	CCLR	TBR, TTT, TPLO
8[c]	Maltese	0.8	MC	3.1	R	111	91	Rad	Tibial valgus	TBR, TTT, Tibial osteotomy
9[c]	Maltese	0.8	MC	3.1	L	104	92	Rad	Tibial valgus	TBR, TTT, Tibial osteotomy
10[d]	Chihuahua	3	MC	3.75	R	104	93	Rad	Femoral torsion	TBR, TTT
11[d]	Chihuahua	3	MC	3.75	L	107	100	Rad	Femoral torsion	TBR, TTT
12	Pomeranian	9.3	MC	3.95	R	109.1	95.7	Rad	None	TBR, TTT
13	Maltese	5.4	MC	4	R	107.1	96.3	Rad, CT	CCLR	TBR, TTT CCWO

aLDFA, anatomic lateral distal femoral angle; CCLR, cranial cruciate ligament rupture; CCWO, cranial closing wedge osteotomy; CT, computed tomography; L, left; MC, male castrated; Pre-Op, pre-operation; Post-Op, postoperation R, right; Rad, radiography; TBR, trochlear block recession; TTT, tibial tuberosity transposition.

Table 2. aLDFA, PROM (flexion and extension angle), lameness score, thigh circumference and static weight bearing distribution in presurgery group and postsurgery group (24 weeks)

	aLDFA (Deg)	Flexion angle (Deg)	Extension angle (Deg)	Lameness score (number)	Thigh circumference unilateral (%)	Thigh circumference bilateral (%)	Static weight bearing distribution (%)
Presurgery group	109.15 ± 3.71	30.11 ± 4.04	156.89 ± 2.30	3.07 ± 0.71	-	-	9.31 ± 5.71
Postsurgery group (24 weeks)	96.30 ± 2.97	41.56 ± 2.30	162.78 ± 2.91	0.32 ± 0.61	13.24 ± 5.05	12.26 ± 3.43	18.63 ± 2.02
p value*	0.01	0.008	0.007	0.001	-	-	0.0001

aLDFA, anatomic lateral distal femoral angle; Deg, degree; PROM, passive range of motion.
*Denotes significant difference ($p < .05$).

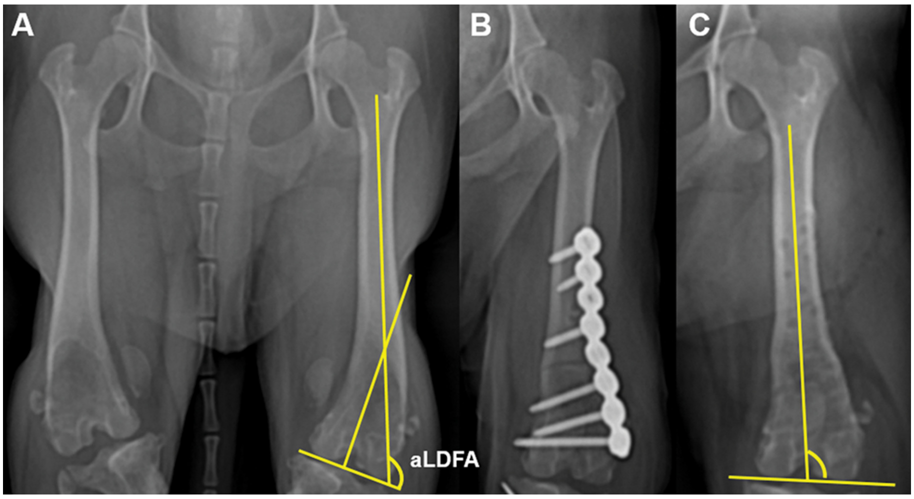

Fig 1. Pre- and postoperative craniocaudal femoral projection from case 4 showing reference lines for the radiographic measurement of the distal femoral varus deformity (A and B). Case 4 performed 2 staged bilateral DFO, and the plate on the left limb was removed 8 months later (C). Note the improved limb alignment and patellar location with aLDFA 96.3° postoperavely compared to the preoperative radiograph with aLDFA 110° (C). aLDFA, anatomic lateral distal femoral angle; DFO, distal femoral osteotomy.

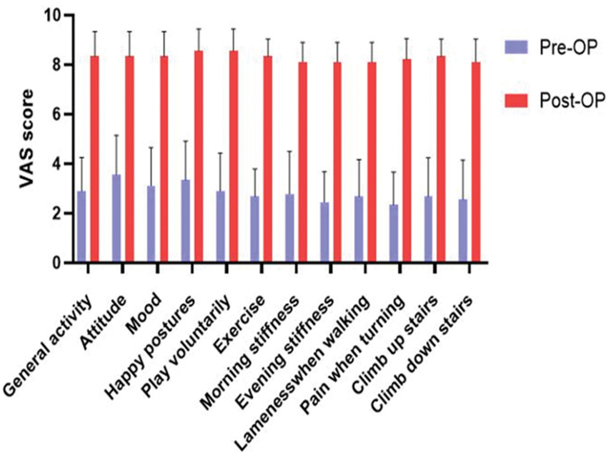

Fig 2. Mean ± SD visual analogue scale (VAS) scores. Significant improvement in the scores for all questions was observed postoperatively.

operatively. The mean degree of extension in the PROM of the affected limb was 156.89° ± 2.30° and 162.78° ± 2.91° at 0 and 24 weeks postoperatively, respectively. The mean lameness score was 3.07 ± 0.71 and 0.32 ± 0.61 at 0 and 24 weeks postoperatively. Significant improvement was observed postoperatively. The mean difference of thigh circumference of the affected limb between the 0 and 24 weeks postoperatively was 13.24% ± 5.05% in unilateral group and 12.26% ± 3.43% in bilateral group. Both groups showed a significant increase in thigh circumference after surgery compared to before surgery. The mean static weight-bearing distribution of the affected limb was 9.31% ± 5.71% and 18.63% ± 2.02% at 0 and 24 weeks postoperatively, respectively ($p < 0.0001$). The questionnaire responses were obtained before the surgery, and those from the most recent follow-up were obtained by direct contact or a phone call. The results of the visual analogue scale scores were summarized graphically. There was a significant increase in the scores for all questions (Fig 2).

Discussion

In this study, DFO surgery in all patients with MPL 4 led to satisfactory results regarding postoperative alignment and function without any reluxation. There was no reluxation after surgery, and median osteotomy union was achieved at 92.22 days of follow-up with no other side effects.

The reported rate of reluxation after conventional surgery was 8%, with an increased incidence for higher grades (3). One of the causes for this is thought to be related to excessive femoral varus conformation (8,29). DFO has been recommended as a surgical correction of medial patellar luxation with excessive femoral varus (30). Several reports have shown good results after performing a DFO; however, there are still controversies over the application and prognosis, and these reports were based on large-breed dogs. To the authors' knowledge, there are no specific reports about DFO application in small-breed dogs with MPL grade 4 only.

A previous study advocated the correction of a femoral varus deformity when the femoral varus angle is greater than 10°-12° or aLDFA ≥ 100°-102°. These figures are based on Labrador retrievers, and the recommended aLDFA at which to perform a distal femoral osteotomy is still controversial (26,29). The normal aLDFA value was considered to be 94°-98°. However, these values were difficult to apply to small dogs because the previous study was based on large breeds of dogs (33). The current literature suggests 94.21° ± 3.48° and 94.5° ± 2.9° as the aLDFA for small-breed dogs (21,23). The aLDFA reference values for Toy Poodles, Chihuahuas and Yorkshire terriers with normal and grade 4 MPL stifle joints have been reported, and DFO was recommended for the treatment of MPL in those breeds (24,36,37). In this study, the mean preoperative and postoperative aLDFA was 109.2° and 96°, respectively. The mean preoperative aLDFA was higher than 102°, a recommended aLDFA for DFO in large-breed dogs. But, it is reported that the measurement aLDFA for the femur in small-breed dogs with MPL grade 4 is 110.5° ± 5.5° in radiography and 108.1° ± 8.0° in CT (36). Intraoperatively, when a DFO was performed in small-breed dogs with an aLDFA larger than 109°, we could not find a medially directed force from the quadriceps mechanism while performing flexion and extension of the stifle joint (within the normal ROM of the stifle joint). In addition, accompanying diseases must all be corrected during the DFO to obtain good results. Patients with grade 4 MPL with distal femoral varus are more likely to have concurrent diseases than other patients (6,9). Examples include femur or tibia torsion, cranial cruciate ligament rupture (CCLR) and stifle cartilage damage, including a worn-out trochlear ridge.

Accurate preoperative planning should be used to increase the success rate of DFO. A well-positioned radiograph view is especially important to accurately measure the aLDFA and CORA. Currently, rather than the location of the fabella bisecting the femoral cortices, the positions of the walls of the intercondylar fossa and femoral trochlear ridges are considered to be the markers for well-positioned views (1,18). In the case of distal femoral varus and other angular deformities, a preoperative plan was established through 3D reconstruction after a CT scan, and the operation was successfully completed. If the patient has multiple deformities, 3-dimensional (3D) imaging is highly recommended.

In our study, the mean time to bone union was 92.22 ± 22.38 days. This is longer than what is reported in other papers (5,30). The longer bone union time in this study may have been influenced by the long interval of follow-up compared to that used in a previous study (5). The radiographic evaluation, PROM, lameness score, thigh circumference and static weight bearing distribution were used to compare the pre- and postoperative status. A positive significance was confirmed in almost all evaluation criteria, which may indicate functional recovery after surgery. Satisfaction on the parental questionnaire was also high. There was no significant change in OA assessments, such as synovial effusion, osteophyte status and intra-articular mineralization. The PROM using a goniometer is an objective measurement of joint and muscle problems, and the angle gradually increases as the stifle is restored (31). However, the normal angle reference value is based on large dogs, and there are no articles on normal small dogs yet (11,19). Therefore, unilateral patients might have be compared with their contralateral limb if it is normal, and bilateral patients should be compared with normal small dogs of similar weight. The evaluation of thigh circumference measurement is usually assessed by the percentage of the affected limb compared to the normal contralateral limb. However, because of the bilaterally affected patient, we evaluated pre- and postoperative values rather than using the method mentioned above. Additionally, the postoperative static weight-bearing distribution was 18.63% ± 2.02%, which is close to the normal value of 20% and indicated complete recovery.

There was one case of a major complication, which was not a side effect of DFO but of a revision surgery for impingement between the patella and PGR due to the application of a small implant size. It was replaced by a larger PGR. In two cases, a little friction around the implant was felt during flexion or extension. It seems that the muscle or joint capsule was stimulated by the implant on the lateral femur epicondyle. There was no pain or lameness, and no problem was found within the radiographic image; however, implant removal might be needed if there is a complication within the continuous follow-up period. The reported rate of reluxation was 0% after applying DFO to a mixed-size dog group with variable MPL grade (5). The most common complications in this paper were infection and delayed union (5). The reluxation rate in this study was similar to that in a previous report, and complications were not found until now. However, latent infection caused by biofilms must be fully recognized and periodically inspected (2).

Limitations of this study include its retrospective nature and that it did not have a normal distribution due to the small population. Therefore, if more cases are gathered, it would be possible to draw conclusions about the most effective angle at which surgery would be indicated. The application of DFO in small-breed dogs should be cautioned, and further studies are warranted.

The results of the study reported here may provide other surgeons with information on the optimal angle for DFO in small-breed dogs.

Conclusion

It is common to see small-breed dogs that have grade 4 MPL with concurrent bone abnormalities. When evaluated subjectively and objectively, these dogs, which were surgically treated with DFO, showed good results.

A cut-off value of aLDFA has not been still settled to provide a basis for DFO in small-breed dogs due to the variation of the muscles thickness and the sizes of the bone. Further studies about this cut-off value will be needed to accurately diagnose abnormal FVA in small-breed dogs. Nevertheless, it seems that the results and considerations in this paper could be a cornerstone to the further studies.

Acknowledgements

This study was supported by research fund of Chungnam National University.

References

1. Aiken M, Barnes D. Are the fabellae bisected by the femoral cortices in a true craniocaudal pelvic limb radiograph? J Small Anim Pract 2014; 55: 465-470.
2. Arciola CR, Campoccia D, Montanaro L. Implant infections: adhesion, biofilm formation and immune evasion. Nat Rev Microbiol 2018; 16: 397-409.
3. Arthurs GI, Langley-Hobbs SJ. Complications associated with corrective surgery for patellar luxation in 109 dogs. Vet Surg 2006; 35: 559-566.
4. Bound N, Zakai D, Butterworth SJ, Pead M. The prevalence of canine patellar luxation in three centres. Clinical features and radiographic evidence of limb deviation. Vet Comp Orthop Traumatol 2009; 22: 32-37.
5. Brower BE, Kowaleski MP, Peruski AM, Pozzi A, Dyce J, Johnson KA, Boudrieau RJ. Distal femoral lateral closing wedge osteotomy as a component of comprehensive treatment

of medial patellar luxation and distal femoral varus in dogs. Vet Comp Orthop Traumatol 2017; 30: 20-27.
6. Campbell CA, Horstman CL, Mason DR, Evans RB. Severity of patellar luxation and frequency of concomitant cranial cruciate ligament rupture in dogs: 162 cases (2004-2007). J Am Vet Med Assoc 2010; 136: 887-891.
7. Chuang C, Ramaker MA, Kaur S, Csomos RA, Kroner KT, Bleedorn JA, Schaefer SL, Muir P. Radiographic risk factors for contralateral rupture in dogs with unilateral cranial cruciate ligament rupture. PLoS One 2014; 9: e106389
8. Dudley RM, Kowaleski MP, Drost WT, Dyce J. Radiographic and computed tomographic determination of femoral varus and torsion in the dog. Vet Radiol Ultrasound 2006; 47: 546-552.
9. Dunlap AE, Kim SE, Lewis DD, Christopher SA, Pozzi A. Outcomes and complications following surgical correction of grade IV medial patellar luxation in dogs: 24 cases (2008-2014). J Am Vet Med Assoc 2016; 249: 208-213.
10. Gibbons SE, Macias C, Tonzing MA, Pinchbeck GL, McKee WM. Patellar luxation in 70 large breed dogs. J Small Anim Pract 2006; 47: 3-9.
11. Hady LL, Fosgate GT, Weh JM. Comparison of range of motion in Labrador Retrievers and Border Collies. J Vet Med Anim Health 2015; 7: 122-127.
12. Hans EC, Kerwin SC, Elliott AC, Butler R, Saunders WB, Hulse DA. Outcome following surgical correction of grade 4 medial patellar luxation in dogs: 47 stifles (2001-2012). J Am Anim Hosp Assoc 2016; 52: 162-169.
13. Hayashi K, Lansdowne J, Dejardin L. Patellar luxation in dogs. In: Mechanism of Disease in Small Animal Surgery, 3rd ed. Jackson, Wyoming: Teton NewMedia. 2010: 655-661.
14. Hayes AG, Boudrieau RJ, Hungerford LL. Frequency and distribution of medial and lateral patellar luxation in dogs: 124 cases (1982-1992). J Am Vet Med Assoc 1994; 205: 716-720.
15. Hudson JT, Slater MR, Taylor L, Scott HM, Kerwin SC. Assessing repeatability and validity of a visual analogue scale questionnaire for use in assessing pain and lameness in dogs. Am J Vet Res 2004; 65: 1634-1643.
16. Hulse DA. Pathophysiology and management of medial patellar luxation in the dog. Vet Med Small Anim Clin 1981; 76: 43-51.
17. Innes JF, Costello M, Barr FJ, Rudorf H, Barr ARS. Radiographic progression of osteoarthritis of the canine stifle joint: a prospective study. Vet Radiol ultrasound 2004; 45: 143-148.
18. Jackson GM, Wendelburg KL. Evaluation of the effect of distal femoral elevation on radiographic measurement of the anatomic lateral distal femoral angle. Vet Surg 2012; 41: 994-1001.
19. Jaegger G, Marcellin-Little DJ, Levine D. Reliability of goniometry in Labrador Retrievers. Am J Vet Res 2002; 63: 979-986.
20. Kaiser S, Cornely D, Golder W, Garner MT, Wolf KJ, Waibl H, Brunnberg L. The correlation of canine patellar luxation and the anteversion angle as measured using magnetic resonance images. Vet Radiol Ultrasound 2001; 42: 113-118.
21. Kim J, Heo S, Na J, Kim N, Kim M, Jeong S, Lee, H. Determination of femoral and tibial joint reference angles in small-breed dogs. J Vet Clin 2016; 33: 340-345.
22. Millis DL, Levine D, Taylor RA. Range of motion and stretching exercise. In: Canine rehabilitation and physical therapy, 2nd ed. St Louis: Elsevier Saunders. 2013: 220-225.
23. Olimpo M, Piras L, Peirone B. Pelvic limb alignment in small breed dogs: a comparison between affected and free subjects from medial patellar luxation. Vet Ital 2016; 52: 45-50.
24. Phetkaew T, Kalpravidh M, Penchome R, Wangdee C. A comparison of angular values of the pelvic limb with normal and medial patellar luxation stifles in Chihuahua dogs using radiography and computed tomography. Vet Comp Orthop Traumatol 2018; 31: 114-123.
25. Priester WA. Sex, size, and breed as risk factors in canine patellar dislocation. J Am Vet Med Assoc 1972; 160: 740-742.
26. Roch SP, Gemmill TJ. Treatment of medial patellar luxation by femoral closing wedge ostectomy using a distal femoral plate in four dogs. J Small anim Pract 2008; 49: 152-158.
27. Roush JK. Canine patellar luxation. Vet Clin North Am Small Anim Pract 1993; 23: 855-868.
28. Singleton WB. The surgical correction of stifle deformities in the dog. J Small Anim Pract 1969; 10: 59-69.
29. Slocum B, Slocum TD. Surgical repair of patellar luxations. In: Current Techniques in Small Animal Surgery, 5th ed. Jackson, Wyoming: Teton NewMedia. 2014: 1064-1069.
30. Swiderski JK, Palmer RH. Long-term outcome of distal femoral osteotomy for treatment of combined distal femoral varus and medial patellar luxation: 12 cases (1999-2004). J Am Vet Med Assoc 2007; 231: 1070-1075.
31. Thomovsky SA, Chen AV, Kiszonas AM, Lutskas LA. Goniometry and limb girth in miniature Dachshunds. J Vet Med. 2016; 2016: 1-5.
32. Tobias KM, Johnston SA. Stifle joint. In: Veterinary surgery: Small animal, 2nd ed. St Louis: Elsevier Saunders. 2018: 1071-1168.
33. Tomlinson J, Fox D, Cook JL, Keller GG. Measurement of femoral angles in four dog breeds. Vet Surg 2007; 36: 593-598.
34. Trotter EJ. Medial patellar luxation in the dog. Compend contin Educ Vet 1980; 2: 58-68.
35. Wangdee C, Theyse LFH, Techakumphu M, Soontornvipart K, Hazewinkel HAW. Evaluation of surgical treatment of medial patellar luxation in Pomeranian dogs. Vet Comp Orthop Traumatol 2013; 26: 435-439.
36. Yasukawa S, Edamura K, Tanegashima K, Seki M, Teshima K, Asano K, Nakayama T, Hayashi K. Evaluation of bone deformities of the femur, tibia, and patella in Toy Poodles with medial patellar luxation using computed tomography. Vet Comp Orthop Traumatol 2016; 29: 29-38.
37. Žilinčík M, Hluchý M, Takáč L, Ledecký V. Comparison of radiographic measurements of the femur in yorkshire terriers with and without medial patellar luxation. Vet Comp Orthop Traumatol 2018; 31: 17-22.