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# Comparison of Tibial Tuberosity Transposition and Anti-rotation Suture for Medial Patellar Luxation in 133 Small-breed Dogs

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**Abstract :** This retrospective study is designed to compare the clinical results of tibial tuberosity transposition (TTT) and anti-rotation suture (ARS) treatments for medial patellar luxation (MPL). Medical records of 133 dogs were reviewed that had undergone surgical correction of MPL between January 2013 and May 2017. MPL correction was performed on 182 stifles, with TTT and ARS being performed on 101 stifles and 81 stifles. The common dog breeds receiving surgical treatment for MPL were Maltese, Pomeranian, Chihuahua and Poodle. Mean age of dogs with MPL was 32.6 months, and their mean body weight was 4.26 kg. Seventy dogs (52.6%) were male and 63 (47.4%) were female. Of the 182 stifles with MPL, grade II, III and IV were 18.7%, 72.0% and 9.3%. Total complications after TTT and ARS were recorded in 16.8% and 29.6%. Major complications after TTT and ARS were recorded in 5.9% and 12.3%, minor complications after TTT and ARS were recorded in 10.9% and 17.3%. The risk of complication and reluxation rate after TTT were significantly lower than that for ARS ($p < 0.05$). However, the rate of reluxation among dogs treated by ARS (1.2%) for grade II MPL was significantly lower than that for dogs treated by ARS (8.6%) for grade III MPL ($p < 0.05$). The TTT group had a shorter recovery period after surgical intervention than that in the ARS group ($p < 0.001$). In conclusion, TTT had a significantly lower incidence of complication and a shorter recovery period than ARS. However, ARS for grade II MPL appears to be a good surgical option for reducing the rate of reluxation after surgery. These results of this study could be used to provide therapeutic guidelines for surgical MPL correction in small-breed dogs.

***Key words* :** patellar luxation, anti-rotation suture, tibial tuberosity transposition, dog.

## Introduction

Patellar luxation (PL) is the most common orthopedic condition affecting the stifle joint in small-breed dogs, but is infrequently reported in cats (1,2,6,40). Small-breed dogs are more commonly affected than large-breed dogs (1,2,9,39). Furthermore, medial patellar luxation (MPL) has been identified as more common than lateral patellar luxation (LPL) in all dog breeds (1,2,32,38). MPL has been reported to account for 95% to 98% of PL cases, with 50% to 93% of small-breed dogs having bilateral luxation (2,22,49). Neutered dogs are reported as more likely to have MPL (32). In addition, PL is reported as a complication of surgical correction for cranial cruciate ligament rupture (CCLR), occurring with a frequency of 0.18%, and is most common in large-breed dogs (3). Although proximal displacement of the patella within the femoral trochlear groove may have a role in MPL in large-breed dogs, this does not apply to small-breed dogs (25,35, 42,48). Moreover, proximodistal malalignment of the patella has been proposed as a predisposing reason for postoperative recurrence of PL, and to avoid patellar reluxation, such malalignment should be corrected through surgical intervention (25,35).

Clinical signs of MPL usually include acute, chronic, intermittent, and weight-bearing pelvic limb lameness (5). Careful physical examination, radiography, and gait analysis are needed to evaluate the grade of PL (36). The quadriceps angle can help to evaluate dogs with MPL when using a radiographic technique (34). Although dogs with PL have various clinical signs, dogs with grades II to IV PL and lameness often benefit from surgical intervention (20). Generally, grades II and III PL have good prognosis, but surgical results for grade IV of PL are poor (32,38,39,47). The majority of dogs with MPL have some structural abnormalities, including lateral bowing of distal femur, medial dislocation of the quadriceps, hypoplastic medial trochlear ridge and medial bowing of the proximal tibia (5,7,14,43). The goal of surgical correction of PL is to neutralize the mechanical forces caused by the underlying structural abnormalities, thereby restoring normal stifle biomechanics, and eliminating repeated trauma to articular cartilage (5,7,9,18,20). Early surgical intervention for PL can promote early return of limb function and potentially reduce progression of osteoarthritis (4,39). Early surgical correction of severe bone deformities undoubtedly has a major role in ensuring good function (36). Typically, small-breed dogs with MPL and concomitant CCLR are older and have a higher MPL grade than dogs with MPL only, because of chronic internal tibial rotation and increased ligament strain (10).

Various common surgical methods for PL have been described, including tibial tuberosity transposition (TTT), tro-

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chlear block recession (TBR), trochlear wedge recession (TWR), anti-rotation suture (ARS), medial retinacular release, lateral retinacular imbrication (19,43,44,47). In addition, new surgical treatments including distal femoral lateral closing wedge osteotomy, medial ridge elevation wedge trochleoplasty, kite shield-shaped wedge recession and TTT-advancement are reported to reduce complications after conventional PL correction surgery and reduce the PL occurrence rate (5,7,20,23,28,29,37.46,50). The suggested primary advantage of TBR over TWR is its maintenance of the depth of the proximal trochlear groove, thus ensuring optimal patellar depth throughout the full range of stifle motion (26,46).

Various complications after PL correction are reported including implant loosening, tibial tuberosity fracture, patellar reluxation, overcorrection, patellar baja, recession wedge displacement, lateral trochlear ridge fracture, soft tissue irritation, infection and lameness (2,9,11,15,16,22,27,30,38,39,45). Risk factors significantly associated with a higher rate of ARS complications in dogs were heavy body weight and young age at the time of surgery (8). Secondary osteoarthritis is a common permanent lesion associated with developmental PL (33,41,51). A higher rate of MPL recurrence and poorer outcomes have been reported for dogs having surgical correction of grade IV MPL, compared with those for dogs with lower grade MPL (49). The majority of dogs with congenital MPL are inspected for cartilage erosion on the articular surface of the patella as cartilage erosion on the articular surface of the patella can cause lameness after corrective MPL surgery (13).

There have been various retrospective studies into complications, outcomes, risk factors, prognosis after PL correction. TTT and trochlear groove deepening techniques for MPL correction are reported to be good surgical methods for reducing the rate of reluxation (1,2,9,15,21,27,38,45,49). Considering the risk of postoperative complication after MPL correction, a combination of soft tissue reconstruction, femoral trochlear groove deepening, and TTT has been recommended. (2,4,9,15,19,21,24,38,39,49).

The results of applying the ARS technique with trochlear groove deepening and soft tissue reconstruction have also indicated a successful prognosis (31). However, other reports have not recommended the ARS technique for mature dogs with MPL, except in cases of mitigation of deformity or of deformity correction with continued growth, because this technique for correcting MPL is insufficient and non-permanent (19,36,43,47). This is study is designed to compare the clinical results of TTT and ARS, and to provide a therapeutic guideline for surgical MPL correction in small-breed dogs.

## Materials and Methods

### Inclusion criteria

Medical records of 133 dogs received TTT or ARS for MPL between January 2013 and May 2017 were reviewed. Medical record data analyzed included breed, age, sex, MPL grade, body weight, recovery period, and complications after surgical intervention. For comparison purposes, dogs weighing greater than 10 kg and those, with CCLR, LPL or severe bone deformity were excluded from the study.

### Group categorization

Data for dogs that underwent TTT or ARS were retrospectively analyzed. Seventy-one dogs (101 stifles) were included in the TTT group, and 62 dogs (81 stifles) were included in the ARS group.

### Patellar luxation grade

The PL was graded as described previously (39) and the grade definitions are presented (Table 1).

### Surgical procedures

All patients were premedicated with butorphanol (0.2-0.4 mg/kg subcutaneous injection) and meloxicam (0.2 mg/kg subcutaneous injection). Propofol (6-8 mg/kg intravenous injection) was used to induce anesthesia with maintenance of via gaseous mixture of oxygen and isoflurane. Cefazolin sodium (22 mg/kg intravenous injection) was administered to all patients at anesthesia induction. The standard TTT and ARS surgical techniques were performed as previously described (17,19,36,43,46,47). In addition to TTT or ARS treatment, all dogs had undergone other corrective surgical techniques including TBR, lateral retinacular imbrications. And medial capsulotomy was performed for grade IV PL only. Cephadroxil (22 mg/kg twice a day) and meloxicam (0.1 mg/kg once a day) were administered during the postoperative period, generally for 10 to 14 days. A Robert Jones bandage was applied to the affected limb for 7 to 10 days. Patient activity was restricted to leash walks only for 4 to 6 weeks, a period when bony healing occurs at the surgical correction sites (47).

### Complications

Major complications were defined as those that required revision surgery and minor complications were those that did not require further surgery (2). Among the study dogs, the major complications were reluxation, overcorrection, implant loosening and tibial tuberosity fracture whereas the minor complications were tissue irritation, bone lysis by implant and lameness without reluxation.

**Table 1.** Patellar luxation grades

| | |
|---|---|
| Grade I | Patella can be manually luxated but returns to normal position when released |
| Grade II | Patella luxated with stifle flexion or on manual manipulation and remains luxated until stifles extension or manual replacement occurs |
| Grade III | Patella luxated continually. Patella can be manually replaced but reluxates spontaneously when manual pressure is removed. |
| Grade IV | Patella luxated continually and cannot be manually replaced. |

**Recovery period**

Recovery period was established as the time from the day of surgical correction to the time when no lameness was observed (51). In the analysis of recovery period, patients were excluded if they exhibited lameness without reluxation after surgery.

**Statistical analysis**

Numbers and percentages are presented and chi-squared testing was conducted for univariable associations between categorical variables. Mean and, standard deviation values are presented and analysis of variance was conducted for continuous variables. Recovery period was analyzed only for patients that exhibited no lameness complication after surgery (n = 169). All analyses were performed by using standard statistical software (SPSS version 23; IBM); statistical significance was set at $p < 0.05$.

## Results

**Analysis of patients**

The common breeds receiving surgical treatments for MPL were Maltese, Pomeranian, Chihuahua and Poodle. Of the 182 stifles, 34 (18.7%) were grade II, 131 (72.0%) were grade III, and 17 (9.3%) were grade IV. Among the 133 dogs undergoing MPL correction, 84 (63.2%) dogs had unilateral PL, 49 (36.8%) dogs had bilateral PL (Table 2).

Mean age of the dogs with MPL was 32.6 months, and their mean body weight was 4.26 kg. Seventy dogs (52.6%) were male and 63 (47.4%) were female (Table 3).

**Table 3.** Distribution of age, body weight and gender by dog breed

| Breed | Mean age (month) | Mean body weight (kg) | Gender | |
|---|---|---|---|---|
| | | | Male | Female |
| Maltese | 35.7 | 4.29 | 31 | 26 |
| Miniature Pinscher | 46.4 | 4.42 | 2 | 3 |
| Spitz | 17.2 | 7.20 | 3 | 2 |
| Yorkshire Terrier | 29.4 | 4.10 | 1 | 4 |
| Chihuahua | 36.0 | 3.30 | 14 | 7 |
| Pomeranian | 26.1 | 3.67 | 9 | 14 |
| Poodle | 28.2 | 4.38 | 8 | 4 |
| Other | 29.0 | 7.60 | 2 | 3 |
| Total | 32.6 | 4.26 | 70 | 63 |

**Complications**

Total complications after TTT were recorded in 17 (16.8%). Among the major complications after TTT, reluxation was recorded in 2 stifles (2.0%), overcorrection in 1 stifle (1.0%), implant loosening in 2 stifles (2.0%) and tibial tuberosity fracture in 1 stifle (1.0%). Among the minor complications,

**Table 2.** Patellar luxation grades and types by dog breed

| Breed | Patellar luxation grades | | | Patellar luxation type | |
|---|---|---|---|---|---|
| | II (n = 34) | III (n = 131) | IV (n = 17) | Unilateral (n = 84) | Bilateral (n = 49) |
| Maltese | 14 | 56 | 11 | 33 | 24 |
| Miniature Pinscher | 1 | 6 | 0 | 3 | 2 |
| Spitz | 1 | 5 | 0 | 4 | 1 |
| Yorkshire Terrier | 3 | 4 | 0 | 3 | 2 |
| Chihuahua | 1 | 27 | 2 | 12 | 9 |
| Pomeranian | 7 | 21 | 2 | 16 | 7 |
| Poodle | 6 | 8 | 0 | 10 | 2 |
| Other | 1 | 4 | 2 | 3 | 2 |

**Table 4.** Major and minor complications associated with TTT and ARS

| | Complication | TTT (n = 101) | | | ARS (n = 81) | | |
|---|---|---|---|---|---|---|---|
| | | G II | G III | G IV | G II | G III | G IV |
| Major | Reluxation | | 2 (2.0%) | | 1 (1.2%) | 7 (8.6%) | |
| | Overcorrection | | 1 (1.0%) | | | 1 (1.2%) | |
| | Implant loosening | | 1 (1.0%) | 1 (1.0%) | | 1 (1.2%) | |
| | Tibial tuberosity fracture | | 1 (1.0%) | | | | |
| Minor | Soft tissue irritation | 1 (1.0%) | 3 (3.0%) | 1 (1.0%) | | 1 (1.2%) | 1 (1.2%) |
| | Bone lysis by implant | | | | | 2 (2.5%) | 3 (3.7%) |
| | Lameness without reluxation | | 3 (3.0%) | 3 (3.0%) | | 3 (3.7%) | 4 (4.9%) |
| Total complications | | | 17 (16.8%) | | | 24 (29.6%) | |

TTT: tibial tuberosity transposition, ARS: anti-rotation suture, G: grade of patellar luxation

**Table 5.** Recovery period associated with TTT and ARS

| | TTT (n = 95) | ARS (n = 74) | Total (n = 169) |
|---|---|---|---|
| Recovery Period (weeks)* | 4.0 ± 1.41* | 5.8 ± 1.30* | 4.8 ± 1.62 |

TTT: tibial tuberosity transposition, ARS: anti-rotation suture
*Indicates $p < 0.001$ for the difference between treatments.

soft tissue irritation was recorded in 5 stifles (5.0%), and lameness without reluxation in 6 stifles (5.9%). The incidence of reluxation after TTT was significantly lower than that after ARS. And the incidence of total complications after TTT was also significantly lower than that after ARS.

Total complications after ARS were recorded in 24 (29.6%). Among the major complication after ARS, reluxation was recorded in 8 stifles (9.9%), overcorrection in 1 stifle (1.2%), and implant loosening in 1 stifle (1.2%). Among the minor complications, soft tissue irritation was recorded in 2 stifles (2.5%), bone lysis by implant in 5 stifles (6.2%), and lameness without reluxation in 7 stifles (8.6%). Among the 8 stifles (9.9%) that showed reluxation, 7 stifles (8.6%) had grade III PL and 1 stifle (1.2%) had grade II PL. Among the ARS group, the rate of reluxation for grade II PL (1.2%) was significantly lower than that (8.6%) for grade III PL (Table 4).

**Recovery period**

Patients who underwent surgical correction for MPL visited the hospital once a week for 10 weeks to evaluate the condition of their gait. The TTT group had a significantly shorter recovery period (mean 4.0 weeks) after surgical intervention than that (mean 5.8 weeks) of the ARS group (Table 5).

## Discussion

Maltese, Pomeranian, Chihuahua and Poodle were the common breeds that underwent surgery for correction of MPL in this study. Many previous studies describing the distribution of MPL among breeds have been reported. One study reported that Poodles and Yorkshire Terriers were at increased risk for PL, whereas Rottweilers, Dachshunds, German Shorthaired Pointers, and mixed breeds had a decreased risk, while another study reported that an over-representation of PL was observed in Chihuahua, Poodle, Bull Terrier, Maltese, Pomeranian, Papillon, Silky Terrier, Labrador Retriever, Australian Cattle Dog, Staffordshire Bull Terrier, and Yorkshire Terrier breeds (1,22). Because of the trend in small breed preference, especially Maltese could be the most common breed in this study.

The mean age of dogs with MPL in this study was 32.6 months, which is similar to results presented in previous reports (1,2,21,22). There may be differences between the age of diagnosis and that of the corrective operation, because the operations took place in patients with grades III, IV, and grade II with lameness. In addition, the stifle PL progression can be examined through regular checkups in dogs with grade I or grade II with no lameness.

Mean body weight of the subjects in this study was 4.26 kg. The data selected for analysis in this study were from small-breed dogs, therefore mean body weight in this study is different from those in other studies that examined all-breed dogs.

Studies into MPL have reported various results related to the PL grade distribution (1,2,21,22,33,41). In this study, the predominant PL grade of dogs undergoing surgical intervention was grade III. The timing of corrective surgery can vary depending on the surgeon as well as PL grade. In the present study, grade II cases with no lameness were excluded but may have been monitored for PL progress through regular checkups. Regardless dogs with grade II with lameness, grade III and grade IV are recommended for corrective surgery.

Seventy dogs (52.6%) were male and 63 (47.4%) were female. However, it is commonly reported that the incidence of MPL is higher in female dogs than in males. Therefore, the result of this study do not correspond with those in previous reports in which PL is more common in female than in male dogs (1,22,24,45).

Among the 133 dogs with MPL corrective surgery, 49 (36.8%) dogs had bilateral PL. Other authors have reported that bilateral PL occurs in more than 50% of MPL patients (2,22,49). The high incidence of bilateral PL might be related to the reason why many dog owners want their dogs to have surgery for unilateral PL with lameness as such owners may think that single-session bilateral surgery would have more serious complications than unilateral surgery even in the presence of bilateral PL. However, there was no significant difference in complication rates between single-session bilateral surgery and unilateral surgery. It has been reported that single-session bilateral surgery can promote early improvement in limb use and a quick return of limb function (4,12).

Total complications occurred in 17 (16.8%) dogs of the TTT group which was less than the 24 (29.6%) complications in the ARS group, and the difference was statistically significant. Furthermore, reluxation occurred in 2 (2.0%) dogs in the TTT group, which was less than the 8 (9.9%) occurrences in the ARS group. This relatively high reluxation rate in the ARS group might reflect the observation that ARS tension might be insufficiently permanent to maintain a consistent outward force in dogs with severe tibial crest torsion or in those that are highly active dogs (19,36). Among the 8 stifles (9.9%) showing reluxation in the ARS group, 7 (8.6%) had grade III and 1 stifle (1.2%) had grade II. The ARS group with grade II had a low frequency of postoperative reluxation, which might be because low-grade PL may require less force to correct for tibial torsion. Although ARS suture tension is thought to have sufficient force to correct grade II, ARS is not recommended for mature dogs with MPL (19,36). Regardless, the results of the present study showed that the ARS is effective correction technique of grade II in small-breed dogs.

Overcorrection occurs when excessive force is exerted in the lateral direction. To prevent overcorrection, surgeons should checked extension, flexion and external rotation of stifles following TTT and ARS (21).

Implant loosening following TTT and ARS, as well as tibial tuberosity fracture can appear in highly active patients. After corrective surgery for MPL, uncontrolled exercise should be restricted to leash walks only for 4 to 6 weeks, a period in which bony healing occurs at the surgical site (19,47). Based on these recovery concerns, the patients in this study had a soft padded bandage applied for 3 weeks, and were restricted to leash walks. None of the dogs, developed complications such as patellar alta or severe lameness.

Soft tissue irritation, present in 5 (5.0%) stifles in the TTT group, was more common than that in the ARS group (2 stifles, 2.5%). Some patients were very sensitive at the surgical site. Most of the patients had thin skin, and the soft tissue irritation might be explained by self-licking of the skin. This complication disappeared by removing the implants at three months after the surgery.

Bone lysis by implant indicates that the hole on the tibial crest that was used for correction of tibial torsion was widened by the continuous suture tension. Such a complication was observed only in the ARS group, but that complications disappeared after removing the suture at three months after surgery. If the hole on the tibial crest widens, ARS tension can decrease and the reluxation rate increase. Thus, it is important to check, by using X-ray imaging, for bone lysis after ARS.

Six stifles (6.0%) in the TTT group and 7 stifles (8.6%) in the ARS group showed intermittent slight lameness but did not experience reluxation. There are some studies indicating a possible reason for this result. One study indicated that pre-operative factors such as a higher body condition score grade, a high pre-operative lameness grade, or longer pre-operative lameness duration were associated with lameness without reluxation (30). In another report, dogs with congenital MPL were inspected for cartilage erosion on the articular surface of the patella, and such cartilage erosion could cause lameness after corrective MPL surgery (13). It is suggested that a long pre-operative lameness duration and the presence of chronic arthritis could cause lameness. However, the causes of the intermittent slight lameness in this study are unclear.

All the cases in this study underwent a weekly evaluation for 10 weeks to determine the time at which post-operative lameness disappeared. The TTT group had a significantly shorter recovery period (mean 4.0 weeks) after surgical intervention than that in the ARS group (mean 5.8 weeks), suggesting that postoperative lameness can disappear after 6 weeks regardless of the surgical method used. It is suggested that the initial tension of the suture in ARS surgery decreases at about 6 weeks post-surgery, and at that time, the associated pain would be reduced.

## Conclusion

The use of TTT to treat MPL had a significantly lower incidence of complication, especially reluxation rate, and a significantly shorter recovery period than those for ARS treatment. However, the use of ARS for grade II MPL was an acceptable surgical option for reducing the rate of reluxation after corrective surgery for MPL.

## References

1. Alam MR, Lee JI, Kim IS. Frequency and distribution of patellar luxation in dogs: 134 cases (2000 to 2005). Vet Comp Orthop Traumatol 2007; 20: 59-64.
2. Arthurs GI, Langley-Hobbs SJ. Complications associated with corrective surgery for patellar luxation in 109 dogs. Vet Surg 2006; 35: 559-566.
3. Arthurs GI, Langley-Hobbs SJ. Patellar luxation as a complication of surgical intervention for the management of cranial cruciate ligament rupture in dogs. Vet Comp Orthop Traumatol 2007; 20: 204-210.
4. Balogh DG, Kramek B. Clinical results of single-session bilateral medial patellar luxation repair in 26 small breed dogs. Can Vet J 2016; 57: 427-430.
5. Bevan JM, Taylor RA. Arthroscopic release of the medial femoropatellar ligament for canine medial patellar luxation. J AM Anim Hosp Assoc 2004; 40: 321-330.
6. 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.
7. 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 indogs. Vet Comp Orthop Traumatol 2017; 30: 20-27.
8. Casale SA, McCarthy RJ. Complications associated with lateral fabellotibial suture surgery for cranial cruciate ligament injury in dogs: 363 cases (1997-2005). J Am Vet Med Assoc 2009; 234: 229-235.
9. Cashmore RG, Haclicek M, Perkins NR, James DR, Fearnside SM, Marchevsky AM, Black AP. Major complications and risk factors associated with surgical correction of congenital medial patellar luxation in 124 dogs. Vet Comp Orthop Traumatol 2014: 27: 263-270.
10. 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; 236: 887-891.
11. Chase D, Farrell M. Fracture of the lateral trochlear ridge after surgical stabilization of medial patellar luxation. Vet Comp Orthop Traumatol 2010; 23: 203-208.
12. Clerfond P, Huneault L, Dupuis J, Moreau M, Auger J. Unilateral or single-session bilateral surgery for correction of medial patellar luxation in small dogs: short and long-term outcomes. Vet Comp Orthop Traumatol 2014; 27: 484-490.
13. Daems R, Janssens LA, Beosier YM. Grossly apparent cartilage erosion of the patellar articular surface in dogs with congenital medial patellar luxation. Vet Comp Orthop Traumatol 2009; 22: 222-224.
14. 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.
15. Dunlap AE, Kim SE, Lewis DD, Christopher SA, Pozzi A. Outcome and complication following surgical correction of grade IV medial patellar luxation in dogs: 24 cases (2008-2014). J Am Vet Med Assoc 2016; 249: 208-213.
16. Edwards GA, Jackson AH. Use of a TTA plate for correction of severe patella baja in a chihuahua. J Am Anim Hosp Assoc 2012; 48: 113-117.
17. Fischer C, Cherres M, Grevel V, Oechtering G, Bottcher P. Effects of attachment sites and joint angles at the time of lateral suture fixation on tension in the suture for stabilization of the cranial cruciate ligament deficient stifle in dogs. Vet Surg 2010; 39: 334-342.

18. Fitzpatrick CL, Krotscheck U, Thompson MS, Todhunter RJ, Zhang Z. Evaluation of tibial torsion in yorkshire terriers with and without medial patellar luxation. Vet Surg 2012; 41: 966-972.
19. Fossum TW. Diseases of the Joints. In: Small animal surgery, 4th ed. St. Louis, Missouri: Mosby Elsevier. 2013; 1353-1360.
20. Fujii K, Watanabe T, Kobayashi T, Hayashi K. Medial ridge elevation wedge trochleoplasty for medial patellar luxation: a clinical study in 5 dogs. Vet Surg 2013; 42: 721-726.
21. Gibbons SE, Macias C, Tonzing MA. Patellar luxation in 70 large breed dogs. J Small Anim Pract 2006; 47: 3-9.
22. 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.
23. Jeong B, Jung J, Park J, Jeong SM, Lee H. 3D-pringting bone model for surgical planning of corrective osteotomy for treatment of medical patellar luxation in a dog. J Vet Clin 2016; 33: 385-388.
24. Jeong MB, Jeong SW, Kim JY, Han HJ, Kim JS. Evaluation combination of retinacular imbrication, trochleoplasy and tibia tuberosity transposition in dogs with patellar luxation. J Vet Clin 2003; 20: 96-103.
25. Johnson AL, Broaddus KD, Hauptman JG, Marsh S, Monsere J, Sepulveda G. Vertical patellar position in large-breed dogs with clinically normal stifles and large-breed dogs with medial patellar luxation. Vet Surg 2006; 35: 78-81.
26. Johnson AL, Probst CW, Decamp CE, Rosenstein DS, Hauptman JG, Wwaver BT, Kern TL. Comparison of trochlear block recession and trochlear wedge recession for canine patellar luxation using a cadaver model. Vet Surg 2001; 30: 140-150.
27. Kang BJ, Cho S, Kim Y, Lee S, Yoon D, KIM WH, Kweon OK. Postoperative complication associated with tibial tuberosity transposition surgery for medial patellar luxation in dogs: 77 cases (2007-2011). J Vet Clin 2014; 31: 11-14.
28. Kang BJ, Rhew D, Kim Y, Lee S, Yoon D, Kim WH, Kweon OK. Treatment of grade IV medial patellar luxation by femoral shortening osteotomy in three small-breed dogs. J Vet Clin 2014; 31: 421-424.
29. Katayama M, Ogaya H, Shunsuke S, Uzuka Y. Kite shield-shaped wedge recession for treatment of medial patellar luxation in seven small-breed dogs. Vet Surg 2016; 45: 66-70.
30. Kwon GB, Analysis of factors associated with postoperative lameness in dogs undergoing medial patella luxation repair: 124 cases (2012-2015). A thesis the faculty of graduate studies of Konkuk University, 2015.
31. Kwon I, Medial patellar luxation in 198 dogs: A retrospective study for prevalence and prognosis of surgical correction. A thesis the faculty of graduate studies of Konkuk University, 2011.
32. LEplattenier H, Montavon P. Patellar luxation in dogs and cats: pathogenesis and diagnosis. Compend Contin Educ Pract Vet 2002; 24: 234-239.
33. Linney WR, Hammer DL, Shott S. Surgical treatment of medial patellar luxation without femoral trochlea groove deepening procedures in dogs: 91 cases (1998-2009). J Am Vet Med Assoc 2011; 238: 1168-1172.
34. Mortari AC, Rahal SC, Vulcano LC, Silva VC, Volpi RS. Use of radiographic measurements in the evaluation of dogs with medial patellar luxation. Can Vet J 2009; 50: 1064-1068.
35. Mostafa AA, Griffon DJ, Thomas MW, Constable PD. Proximodistal alignment of the canine patella: radiographic evaluation and association with medial and lateral patella luxation. Vet Surg 2008; 37: 201-211.
36. Perez P, Lafuente P. Management of medial patella luxation in dogs: what you need to know. Ir Vet J 2014; 4: 634-640.
37. Pinna S, Venturini A, Tribuiani AM. Rotation of the femoral trochlea for treatment of medial patellar luxation in a dog. J Small Anim Pract 2008; 49: 163-166.
38. Remedios AM, Basher AW, Runyon CL, Fries CL. Medial patellar luxation in 16 large dogs: a retrospective study. Vet Surg 1992; 21: 5-9.
39. Roush JK. Canine patellar luxation. Vet Clin North Am small Anim Pract 1993; 23: 855-868.
40. Rotherford L, Langley-Hobbs SJ, Whitelock RJ, Arthurs GI. Complications associated with corrective surgery for patellar luxation in 85 feline surgical cases. J Feline Med Surg 2015; 17: 312-317.
41. Roy RG, Wallace LJ, Johnston GR, Wickstrom SL. A Retrospective evaluation of stifle osteoarthritis in dogs with bilateral medial patellar luxation and unilateral surgical repair. Vet Surg 1992; 21: 475-479.
42. Segal U. Or M, Shani J. Latero-distal transposition of the tibial crest in cases of medial patellar luxation with patella alta. Vet Comp Orthop Traumatol 2012; 25: 281-285.
43. Slatter D. Stifle joint. In: Textbook of small animal surgery, 3rd ed. Philadelphia PA: Saunders Elsevier Science. 2003; 2122-2133.
44. Slocum B, Slocum TD. Trochlear wedge recession for medial patellar luxation: an update. Vet Clin North Am Small Anim Pract 1993; 23: 869-875.
45. Stanke NJ, Stephenson N, Hayashi K. Retrospective risk factor assessment for complication following tibial tuberosity transposition in 137 canine stifles with medial patellar luxation. Can Vet J 2014; 55: 349-356.
46. Talcott KW, Goring TL, Haan JJ: Rectangular recession trochleoplasty for treatment of patellar luxation in dogs and cats. Vet Comp Orthop Traumatol 2000; 13: 39-43.
47. Tobias KM, Johnston SA. Stifle Joint. In: Veterinary surgery small animal, 1st ed. St. Louis Missouri: Saunders Elsevier. 2012; 973-982.
48. Wangdee C, Theyse LFH, Hazewinkel HAW. Proximo-distal patellar position in three small dog breeds with medial patellar luxation. Vet Comp Orthop Traumatol 2015; 28: 270-273.
49. Wangdee C, Theyse LFH, Techakumphu M, Soontornvipart K. Evaluation of surgical treatment of medial patellar luxation in Pomeranian dogs. Vet Comp Orthop Traumatol 2013; 26: 435-439.
50. Yeadon R, Fitzpatrick N, Kowaleski MP: Tibial tuberosity transposition-advancement for treatment of medial patellar luxation and concomitant cranial cruciate ligament disease in the dog. Vet Comp Orthop Traumatol 2011; 24: 18-26.
51. Yoon DY, Kang BJ, Kim Y, Lee SH, Rhew D, Kim WH, Kweon OK. Degenerative joint disease after medial patellar luxation repair in dogs with or without trochleoplasty. J Vet Clin 2015; 32: 22-27.