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# Table of Contents

Abstract .....	2
Introduction .....	4
Materials and methods .....	8
Results .....	11
Discussion .....	15
Conclusion .....	20
References .....	21
Abstract in Korean .....	28

# 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 relaxation rate after TTT were significantly lower than that for ARS ( $p<0.05$ ). However, the rate of relaxation 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 relaxation after surgery. These results of this study could be used to provide therapeutic guidelines for surgical MPL correction in small-breed dogs.

## 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 relaxation, 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), trochlear 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 luxation, 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 relaxation (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 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 10kg 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).

**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.

### **Surgical procedures**

All patients were premedicated with butorphanol (0.2–0.4mg/kg subcutaneous injection) and meloxicam (0.2mg/kg subcutaneous injection). Propofol (6–8mg/kg intravenous injection) was used to induce anesthesia with maintenance of via gaseous mixture of oxygen and isoflurane. Cefazolin sodium (22mg/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 (22mg/kg twice a day) and meloxicam (0.1mg/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 relaxation, overcorrection, implant loosening and tibial tuberosity fracture whereas the minor complications were tissue irritation, bone lysis by implant and lameness without relaxation.

### **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 relaxation 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).

### Complications

Total complications after TTT were recorded in 17 (16.8%). Among the major complications after TTT, relaxation 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, soft tissue irritation was recorded in 5 stifles (5.0%), and lameness without relaxation in 6 stifles (5.9%). The incidence of relaxation 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, relaxation 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 relaxation in 7 stifles (8.6%). Among the 8 stifles (9.9%) that showed relaxation, 7 stifles (8.6%) had grade III PL and 1 stifle (1.2%) had grade II PL. Among the ARS group, the rate of relaxation 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).

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 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
<b>Total</b>	<b>32.6</b>	<b>4.26</b>	<b>70</b>	<b>63</b>

**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
Reluxation		2		1	7	
		(2.0%)		(1.2%)	(8.6%)	
Overcorrection		1			1	
		(1.0%)			(1.2%)	
Major Implant loosening		1	1		1	
		(1.0%)	(1.0%)		(1.2%)	
Tibial tuberosity fracture		1				
		(1.0%)				
Soft tissue irritation	1	3	1		1	1
	(1.0%)	(3.0%)	(1.0%)		(1.2%)	(1.2%)
Minor Bone lysis by implant					2	3
					(2.5%)	(3.7%)
Lameness without reluxation		3	3		3	4
		(3.0%)	(3.0%)		(3.7%)	(4.9%)
<b>Total complications</b>	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.

## 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, relaxation 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 relaxation 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 relaxation 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 relaxation, 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 relaxation 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 relaxation. 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 relaxation (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 relaxation 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 relaxation after corrective surgery for MPL.

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# 슬개골 내측탈구 교정수술을 받은 133마리 소형견에서 경골 조면 이식술과 경골 회전 방지술의 비교

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## 초 록

본 연구에서는 내측 슬개골탈구 교정수술을 받은 개에서, 경골조면이식술과 경골회전방지술의 효과를 비교하였다. 2013년 1월부터 2017년 5월까지 내측 슬개골탈구 교정수술을 실시한 개 133두를 대상으로 하였다. 내측 슬개골탈구 교정술은 182례의 슬관절에 실시하였고, 그 중 경골조면이식술은 101례, 경골회전 방지술은 81례였다. 수술을 받은 개의 품종 분포에서는 말티즈가 가장 많았고 그 다음으로 포메라이언, 치와와 및 푸들이었다. 수술 당시의 평균 연령은 32.6개월이었고, 평균 체중은 4.26kg이었으며, 성비는 수컷52.6%, 암컷47.4%이었다. 수술 당시의 개의 슬개골탈구 등급은 2기, 3기 및 4기는 각각 18.7, 72.0 및 9.3%였다. 경골조면이식술 후 합병증은 16.8%가 발생하였고, 그 중 중증은 5.9%, 경증은 10.9%였다. 경골회전방지술 후 합병증은 29.6%가 발생하였고, 그 중 중증은 12.3%, 경증은 17.3%였다. 경골회전방지술 보다 경골조면이식술에서 합병증 발생률 및 재탈구율이 유의적으로 낮았다( $p < 0.05$ ). 그러나 슬개골탈구 등급 2기에 적용한 경골회전방지술의 재탈구율은 1.2%로써 3기의 8.6%보

다 유의적으로 낮았다( $p < 0.05$ ). 수술 후 파행이 없어지는 기간은 경골회전방지술이 경골조면이식술 보다 유의적으로 길었다( $p < 0.001$ ). 결론적으로, 경골조면이식술이 경골회전방지술 보다 수술 후 합병증이 적고 회복이 빨랐다. 그러나 소형견 슬개골탈구 등급 2기에서는 경골회전방지술을 적용하는 경우에는 재탈구율이 낮았다.