

# Retrospective Study of Medial Patellar Luxation Surgery Using Combination of Four Techniques without Bone Reconstruction in Non-flattened Femoral Sulcus: 133 Cases in 10 Years' Period (2006-2015)

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## Abstract

To assess signalment and outcome for dogs surgically treated for non-flattened femoral sulcus medial patellar luxation with combined soft tissue reconstruction techniques, cranial sartorius desmotomy, medial retinacular fascia release, patellar antirotational suture, and fascia lata overlapping, medical records from January 2006 to December 2015 were reviewed. Information obtained from medical records of cases in the study population included breed, age, sex, weight, type of patellar luxation (unilateral or bilateral), grade of patellar luxation, lameness score record, time of last follow-up, and time of luxation recurrent. The data were analyzed to determine factors influencing outcomes. Twenty-three dogs from 133 presented recurrent patellar luxation. A total of 12 from the 23 recurrent patellar luxation dogs were bilateral (52%) and 11 (48%) were unilateral. The time of recurrence after surgery varied from 1 month to 79 months. From the medical records as on the day of the study, it was found that the longest time that there was no recurrence in dogs was 10 years. It was found that, among the many factors, only grade 4 patellar luxation was a risk factor of considerable recurrence rate (OR=12.44, P=0.02). These results suggest that the combined four soft tissue reconstruction techniques demonstrated excellent outcome in the treatment of medial patellar luxation (with non-flattened femoral sulcus) in small breed dogs. At the same time, it can be stated that bone reconstruction technique is not always necessary.

**Keywords:** Patellar luxation, Dog, Surgery, Recurrence, Soft tissue

## Düzleşmemiş Femoral Sulkusda Kemik Rekonstruksiyonu Yapılmaksızın Uygulanan Dört Tekniğin Kombine Kullanıldığı Medial Patella Lukzasyon Operasyonu Hakkında Retrospektif Çalışma: 10 Yıllık Periyotta 133 Olgu (2006-2015)

## Özet

Düzleşmemiş femoral sulkus medial patella lukzasyonu kombine yumuşak doku rekonstrüksiyon teknikleri olan, kranial sartorius desmotomi, medial retinakular fasyanın serbestleştirilmesi, patella antirotasyonel dikiş ve fasia lata üstüste getirme ile tedavi edilen köpeklerin durumlarını ve elde edilen sonuçları değerlendirmek amacıyla, Ocak 2006 ile Aralık 2015 tarihleri arasındaki hasta raporları gözden geçirildi. Çalışmadaki olguların raporlarından elde edilen bilgiler ırk, yaş, cinsiyet, ağırlık, patella lukzasyon tipi (unilateral veya bilateral), patella lukzasyon derecesi, topallık skoru, son takip zamanı ve lukzasyon tekrarlamaya zamanı bilgilerini içerdi. Sonuçları etkileyen faktörleri belirlemek amacıyla veriler analiz edildi. Toplam 133 köpekten 23'ünde tekrarlayan patella lukzasyonu bulunmaktaydı. Bu olguların 12'si (%52) bilateral ve 11'i (%48) unilateral karakterdeydi. Operasyon sonrası tekrarlamaya zamanı 1 ay ile 79 ay arasında değişti. Çalışmanın yapıldığı zaman itibarıyla tekrarlamaya görülmeyen en uzun zaman 10 yıl olarak belirlendi. Birçok faktör arasından sadece 4. derece patella lukzasyonu tekrarlamaya oranı (OR=12.44, P=0.02) için risk faktörü oluşturmaktaydı. Bu sonuçlar kombine olarak dört yumuşak doku rekonstrüksiyon tekniğinin küçük cüsseli köpeklerde medial patella lukzasyon (düzleşmemiş femoral sulkuslu) tedavisinde mükemmel sonuç gösterdiğini belirtmektedir. Ayrıca, kemik rekonstrüksiyon tekniğinin her zaman gerekli olmadığı söylenebilir.

**Anahtar sözcükler:** Patella lukzasyonu, Köpek, Cerrahi, Nüks, Yumuşak doku



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## INTRODUCTION

As well documented, in small animal orthopedics, patellar luxation is one of the most common joint diseases in dogs, particularly small breed dogs [1-4]. Consequence of this disease being left untreated is that it can cause many complications and disorders such as cranial cruciate rupture [1,5], cartilage erosion [2,6], and osteoarthritis [7,8]. Veterinarians around the world have proposed many techniques for correcting patella luxation [9-14]. These techniques can be categorized into two main types: soft tissue reconstruction and bone reconstruction. So far, no studies have reported the standard procedure to be used for the correction of patellar luxation in different patient conditions. Bone reconstruction technique is effective in treating medial patellar luxation and lowest recurrent rate [5]. But this technique is highly invasive and traumatic to the animal, and the procedure needs well-trained surgeons and special instruments. Moreover, bone reconstruction technique has shown higher post-surgery complications such as articular cartilage damage, tibial tuberosity avulsion, and trochlear wedge displacement [15-17].

The objective of the study reported here was to evaluate the results of a series of cases in which treatment of medial patellar luxation (non-flattened femoral sulcus) is carried out without the bone reconstruction procedure. A combination of four soft tissue reconstruction techniques, including cranial sartorius desmotomy, medial retinacular fascia release, patellar antirotational suture, and fascia lata overlapping (imbrication), was applied in all the cases. We sought to assess the signalment and the outcomes, and evaluate whether osteoarthritis progressed during the 6 months' period following surgery. Our hypothesis was that the combination of the four procedures was enough to prevent the recurrence of the disease. We also hypothesized that there would be no progression of osteoarthritis detected in follow-up radiographs obtained 6 months after surgery. The advantage of this study over previous studies is that while the previous studies selected the difference surgical procedure to study the outcomes, this study included the same surgical procedure with variations of the grade of patellar luxation.

## MATERIAL and METHODS

### *Animal Inclusion/Exclusion Criteria*

Medical records for all patellar luxation surgery procedures performed at animal hospitals/clinics in Chiang Mai Province, Thailand, from January 2006 to December 2015 were reviewed. Information obtained from the medical records of cases included in the study population consisted of breed, age, sex, weight, type of patellar luxation (unilateral or bilateral), grade of patellar luxation, lameness score record, time of last follow-up, and time of luxation recurrent. One hundred and thirty-three dogs presented

with medial patellar luxation were treated and included in this study, and the selection was done according to the following inclusion and exclusion criteria.

Inclusion criteria for dogs included the following: dogs weighing below 10 kg diagnosed of medial patellar luxation. They were treated using a combination of four techniques including cranial sartorius desmotomy, medial retinacular fascia release, patellar antirotational suture, and fascia lata overlapping. All the dogs were operated upon by the same veterinarian. The dogs did not present any history of illness or injury that may have involved some abnormality of the musculoskeletal system such as fractures, severe hip osteoarthritis, severe hind limb deformity, cranial cruciate ligament rupture or meniscus tear. Moreover, in the case of bilateral patellar luxation, the dogs' nerves underwent surgery for the contralateral leg. Exclusion criteria included the following: the dog was operated by other veterinarians or other techniques such as tibia tuberosity transposition or trochlear groove deepening technique were performed on the dogs; such dogs were excluded from this study. Dogs weighing more than 10 kg; and dogs presenting osteoarthritis, dysplasia, or other joint diseases at the hip joint (by radiography) at the time of the surgery were also excluded. Moreover, bilateral patellar luxation dogs whose both legs had undergone surgery were also excluded from this study.

### *Patellar Grading*

The degrees of patellar luxation were classified into four grades, as determined by manipulation [1,18]. Grade I: The patella can be pushed out of the femoral groove when the stifle is fully extended, and the patella can return into the femoral groove immediately. Grade II: The patella moves out of the femoral groove for some time, but it can return to the normal position by itself. Grade III: The patella usually moves out of the femoral groove, and it can return to the normal position by manipulation only. Grade IV: The patella always moves out of the femoral groove and cannot return to the normal position.

### *Surgical Procedures*

To eliminate potential errors from surgical techniques, all dogs underwent the same procedure for the correction of patellar luxation performed by the same surgeon. The surgery was performed with the animal under anesthesia, by induction with 4 mg/kg propofol (Propofol-®Lipuro 1%; B. Braun Melsungen AG, Germany) and maintenance with isoflurane (Terrell™; Piramal Critical Care, Orchard Park NY, USA) and oxygen. A prophylactic antibiotic (20 mg/kg cefazolin; Nida Pharma, Bangkok, Thailand) was given intravenously in two doses in a 24 h period during and after surgery, and an anti-inflammatory drug (4.4 mg/kg carprofen; Rimadyl®; Pfizer, Thailand) was given subcutaneously in one dose 30 min before anesthesia. Those medicines (antibiotic and anti-inflammatory drugs) were given orally for 7 days after surgery.

Four techniques that were combined in this study include cranial sartorius desmotomy, medial retinacular fascia release, patellar antirotational suture, and fascia lata overlapping [19,20]. Briefly, the joint was thoroughly explored on the lateral side for observing intraarticular structures such as the patella, femoral sulcus, cranial cruciate ligament and meniscus tear; then the joint capsule was closed. Cranial sartorius desmotomy and medial retinacular fascia release started with cutting through the medial retinaculum with a scalpel blade without cutting the joint capsule. The incision extended from the tibial plateau to the insertion of the cranial sartorius muscle. At this point, we slightly modified the traditional technique by completely cutting the part of the insertion of the cranial sartorius muscle. After that, patellar antirotational suture was performed using non-absorbable suture material. The suture was passed around the lateral fabella. The suture was then passed through the patellar tendon just proximal to the patella in a lateral-to-medial direction. Then, the suture was passed along the medial side of the patella in a proximal manner toward the distal direction. Finally, fascia lata overlapping was performed as the last procedure. Extensive fascia lata was trimmed and then the fascia lata overlapping was performed in a Mayo mattress suture pattern.

#### **Assessment of Outcome of Surgery**

The data and the methods used for the assessment of the outcome of the surgery included radiographic image scoring, clinical lameness evaluation, and recurrence of luxation after surgery.

#### **Radiographic Scoring**

The standard craniocaudal and mediolateral radiography of stifle was performed to evaluate the progression of osteoarthritis before surgery and 6 months after surgery. The parameter used was adapted from previous studies [12,21,22] by using osteophytosis at the margins of the stifle joint and subchondral bone sclerosis. Our study did not use other parameters such as joint effusion or soft tissue thickening because the quality of the images was not good (classical film, not digital film). The grading scores of the lesions were given subjectively from 0 to 4 (0=normal, 1=slight, 2=mild, 3=moderate, and 4=severe). All the radiographic images were evaluated at the same time without being aware of the name or the number of animals. The same observer repeated the assessment with a minimum interval of 2 weeks to obtain the estimate for the intra-rater agreement, and there were two observers carrying out the evaluation. The intra-rater agreement and the inter-rater agreement for each radiographic feature were assessed using the unweighted kappa ( $\kappa$ ) test [22]. This radiography grade was report as the median (min-max) of the dogs.

#### **Clinical Lameness Evaluation**

Lameness scores from the medical records were categorized into four grades: 0=weight bearing, 1=partial

weight bearing (temporary), 2=partial weight bearing (permanent), and 3=non weight bearing. The evaluations were done at day 0 (pre-surgery), day 3, day 7, day 14, and day 30 after surgery. This grade was reported as median (min-max) of the dogs' recovery after surgery.

#### **Recurrence Rate**

The number of dogs that had recurrence and the number of dogs that did not have recurrence were recorded and presented as numbers of dogs and percentages. The periods between the surgery date and the recurrence date were recorded as months. In the non-recurrence group, the dates were record from the surgery date to the end of December, 2015. The recurrence rate was compared between the grade of patellar luxation (1-4), and between the unilateral and the bilateral patellar luxation.

#### **Statistical Analysis**

General information regarding the dogs was reported as the number of dogs and the percentage. Some data were compared between the unilateral and the bilateral patellar luxation. The risk factors for the unilateral disease and the bilateral disease, and the recurrence of patella luxation were determined by odds ratio with 95% confidence intervals (CI) through univariate logistic regression. The Wald test was used to analyze significance, and the factors were considered as significant at P-value <0.05.

Lameness scores were compared between unilateral and bilateral patellar luxation on the same day and the comparison between the observations on the day after the surgery and the day pre-surgery was carried out by the Mann-Whitney U test. In the comparison between the grades of luxation, the bilateral patellar luxation group was excluded because most of the bilateral luxation had different grades of luxation. The correlation between the patellar luxation grade and the lameness score was determined by Spearman's rank correlation. The difference in the lameness or radiography score between unilateral and bilateral disease, as well as between grades of unilateral and bilateral patellar luxation was examined by Mann-Whitney U test. The radiographic score was done by two experts, and the agreement of the obtained results was statistically tested by kappa statistics [23]. The recurrence probability of the time period (months) after the surgery between patellar luxation with grade 3 and that with grade 4 was analyzed by using the Bayesian logistic regression model using JAG in R with rjags package.

## **RESULT**

#### **Statistical Summary**

One hundred and thirty-three dogs met the inclusion criteria of this study (Table 1). The most common breeds were Pomeranian (39%), Chihuahua (17%), Poodle (16%),

Yorkshire (11%), Miniature (7%), Shih Tzu (6%), and mixed (4%). Of the 133 dogs, 79 (60%) had unilateral disease and 53 (40%) had bilateral disease. The female dogs (57%) were more affected than the male dogs (43%), and 71% of the dogs were not sterile yet. The median age of the dogs that underwent surgery was 25 months, and the ages of the dogs ranged between 6 months and 10 years. The median weight of the dogs was 3.3 kg, and the weights of the dogs ranged between 0.8 kg and 9.2 kg.

Table 2 shows the comparison between dogs with unilateral and bilateral patellar luxation; most cases in this study had unilateral patellar luxation. More than half of the dogs in both the groups were neutered dog, while the average age, weight, lameness score, and recurrent period were not different between the two groups ( $P>0.05$ ). Many factors were studied, along with the luxation type (unilateral or bilateral), and no risk factor of the luxation type was found (Table 3). Besides, we found that the correlation between patellar luxation and lameness score (pre-surgery) was mild, with Spearman's rank correlation = 0.2820 and  $P$ -value=0.0148, but there was no significant difference in the lameness scores between the unilateral disease and the bilateral disease (Table 2).

### Lameness Score

Pre-surgery data found that the lameness score between unilateral patellar luxation and bilateral patellar luxation did not have a significant difference. Almost all the dogs had the lameness score significantly high on day 3 after

surgery, and the score decreased at day 7 to day 30 (Table 4). Before the surgery, it was found that the lameness score of grade 4 of the unilateral group was significantly high. At day 30 after the surgery, the lameness scores in almost all of the dogs were lower than the pre-surgery scores, and were significantly lower in grade 2 and grade 3. The lameness scores were compared between the four grades of unilateral patellar luxation, and significant difference was found between the grades at day 0, day 7, day 14, and day 30, with the highest score in grade 4.

### Radiographic Progress of Stifle Osteoarthritis

The kappa test score of pre-surgery radiography was 0.90 and the score of radiography conducted 6 months after surgery was 0.97. Only 86 dogs had radiographic images that fit our criteria (preoperative and 6 months after operation) (Fig. 1).

The radiographic images of 59 dogs (68%) from 86 did not change in 6 months after the surgery. In this group, it was found that 80% (47/59), 7% (4/59), 12% (7/59), and 3% (1/59) of the dogs had scores of 0, 1, 2, and 3, respectively. The remaining 27 dogs (32%) from the 86 presented changes in the radiographic scores: 30% (8/27), 4% (1/27), 63% (17/27), and 4% (1/27) of the dogs had changed scores, from 0 to 1, 0 to 2, 1 to 2, and 2 to 3. The radiographic scores were compared between the scores pre-surgery and the scores 6 months after surgery (Table 5), and it was found that there was significant increase in the score in grade 4 of unilateral as well as bilateral patellar luxation.

**Table 1.** Information concerning total 133 dogs in this study

Breed	Total	Patellar Luxation		Age (month)	Sex		Weight (kg)	Neutered	
		Unilateral	Bilateral		Male	Female		Yes	No
Pomeranian	52	28	24	34±23	24	28	3.8±1.9	15	37
Chihuahua	22	13	8	25±19	7	15	2.7±1.5	6	16
Poodle	21	8	13	40±26	11	10	4.2±1.6	7	14
Yorkshire	15	12	3	32±22	6	9	2.8±1.1	3	12
Miniature	9	6	3	26±13	3	6	4.8±1.4	2	7
Shih Tzu	8	7	1	37±23	3	5	5.5±1.4	3	5
Mixed	6	5	1	29±20	3	3	5.6±2.8	2	4
Total	133	79	54	33±22	57	76	3.8±1.8	36	95

**Table 2.** Comparison between unilateral and bilateral patellar luxation in dogs

Patellar Luxation	N (m/f)	Nor./Ster.	Age* (month)	Weight* (kg)	Lameness Score*	Recurrent Rate	Recurrent Period* (month)
Unilateral	79 (33/46)	25/54	31.5±21.6	3.9±2.0	1 (0-3)	13.92% (11/79)	21.0±21.4 (1-79)
Bilateral	54 (23/31)	14/40	35.0±24.1	3.7±1.7	1 (0-3)	22.22% (12/54)	24.3±20.2 (2-79)
P-value	N.D.	N.D.	0.394	0.631	0.980	N.D.	0.699

N=number, N.D.=not determined; Statistical analysis between the unilateral and the bilateral groups used the pair t-test; Symbol "\*" indicates that the data are presented as mean±sd, symbol "\*" indicates that the data are presented as median (min-max)

**Table 3.** Odds ratio (OR) with 95% confidence interval (CI) and P-value of bilateral vs unilateral, along with recurrence of patellar luxation after surgery

Parameters	Bilateral vs Unilateral		Recurrence	
	OR (95% CI)	P-value	OR (95% CI)	P-value
<b>Breed</b>				
Mixed (reference)	-	-	-	-
Shih Tzu	7 (0.50, 97.76)	0.15	3 (0.23, 39.61)	0.40
Yorkshire	4 (0.52, 30.76)	0.18	1.82 (0.16, 20.71)	0.63
Poodle	0.62 (0.10, 3.82)	0.60	0.83 (0.07, 9.86)	0.88
Pomeranian	1.17 (0.22, 6.33)	0.86	1.19 (0.12, 11.35)	0.88
Chihuahua	1.75 (0.28, 10.81)	0.55	0.5 (0.04, 6.68)	0.60
Miniature	2 (0.24, 16.61)	0.52	0.62 (0.03, 12.41)	0.76
Gender (female vs male)	0.95 (0.48, 1.91)	0.90	1.91 (0.73, 5.01)	0.19
Age (>12 months vs <12 months)	0.72 (0.27, 1.92)	0.52	1.92 (0.41, 8.95)	0.41
Weight (<5 kg vs >5 kg)	0.83 (0.35, 2.01)	0.68	1.44 (0.55, 3.74)	0.45
Side (left vs right)	-	-	1.64 (0.78, 3.47)	0.19
Bilateral vs Unilateral	-	-	1.69 (0.68, 4.15)	0.26
<b>Grade</b>				
1 (reference)	-	-	-	-
2	0.65 (0.25, 1.70)	0.38	0.39 (0.02, 6.65)	0.51
3	1.03 (0.41, 2.60)	0.95	2.33 (0.26, 20.66)	0.45
4	1.21 (0.44, 3.34)	0.72	12.44 (1.47, 105.50)	0.02
Sterilized vs Fertile	0.88 (0.38, 2.04)	0.76	1.44 (0.55, 3.74)	0.45

**Table 4.** Median (min-max) of lameness scores in dogs that underwent surgery with four combined techniques

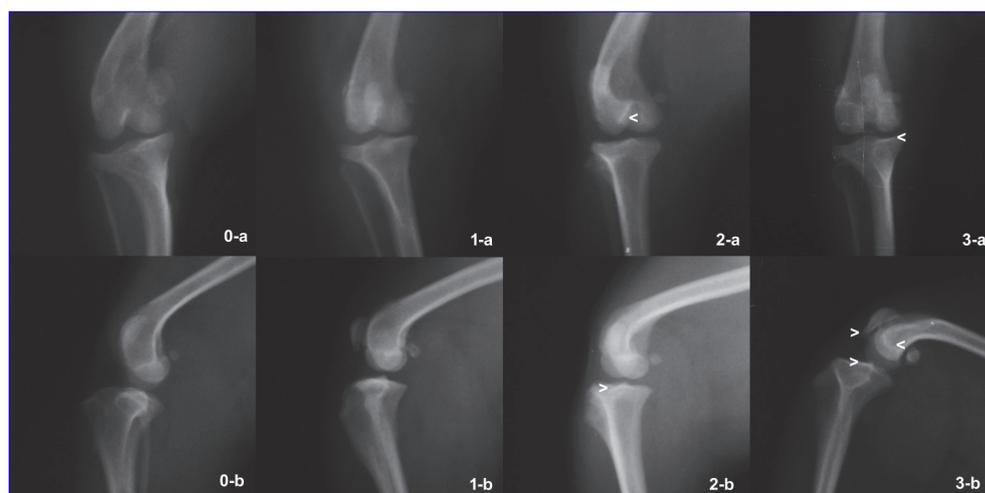
Type and Grade of Luxation	Day 0	Day 3	Day 7	Day 14	Day 30
Bilateral patellar luxation	1 (0-3)	3 (2-3)*	2 (0-3)*	1 (0-3)	1 (0-3)*
Unilateral patellar luxation	1 (0-3)	3 (1-3)*	2 (0-3)*	1 (0-3)	1 (0-3)*
P-value	0.980	0.990	0.574	0.887	0.896
<b>Categorized unilateral patellar luxation by grade</b>					
Grade 1	0.5 (1-0)	2 (1-3)*	1 (0-2)*	0 (0-2)	0 (0-2)
Grade 2	1 (1-2)	2 (2-3)*	1.5 (1-2)	1 (0-2)	0 (0-1)*
Grade 3	1 (0-3)	2.5 (2-3)*	2 (1-3)*	1 (0-2)	1 (0-3)*
Grade 4	1.5 (0-3)	3 (2-3)*	2 (1-3)*	2 (1-3)	1 (0-2)
P-value (among grades within same day)	0.006	0.080	0.004	0.004	0.001

Superscript "\*" indicates p-value <0.05 when compared with the lameness score at pre-surgery (day 0) within the same type of luxation (unilateral or bilateral) or the same grade (grades 1-4)

### Recurrence of Disease After Surgery

In this study, it was found that 23 dogs (17%) from 133 presented recurrent patellar luxation. The numbers of no recurrence and recurrence in the dogs after surgery were found to be the highest in grade 4 (18:16), followed by grade 3 (43:7), but in grade 1 (14:0) and grade 2 (35:0), no case of recurrence was found (Fig. 2). The percentages of recurrence and time in unilateral and bilateral patellar luxation are presented with a Kaplan-Meier curve (Fig. 3), which shows that bilateral patellar luxation has higher

change as regards recurrence of the disease. From 23 recurrent patellar luxation dogs, 12 were bilateral (52%), and the other 11 (48%) were unilateral. The recurrence time varied from 1 month to 79 months after surgery (Table 6). From the medical records at the day of study, it was found that the longest duration of non-recurrence in dogs is 10 years (n=2; Poodle and Pomeranian with unilateral patellar luxation). Bilateral patellar luxation presented higher percentage of recurrence (22%) in comparison with unilateral patellar luxation (14%).



**Fig 1.** Representative craniocaudal (a) and mediolateral (b) radiography image of stifle in grades 0, 1, 2 and 3. The arrow head (<) indicates subchondral bone sclerosis

**Table 5.** Median (min–max) of radiographic scores of dogs that underwent surgery with four combined techniques in comparison between pre-surgery and 6 months after surgery

Type and Grade of Luxation	Pre-surgery	6 Months After Surgery	P-value
Bilateral patellar luxation	0 (0-2)	0 (0-2)	0.426
Unilateral patellar luxation	0 (0-3)	0 (0-3)	0.194
P-value	0.833	0.703	-
<b>Categorized unilateral patellar luxation by grade</b>			
Grade 1	0 (0-0)	0 (0-0)	1.000
Grade 2	0 (0-2)	0 (0-2)	0.406
Grade 3	0 (0-2)	0 (0-2)	0.366
Grade 4	1 (0-3)	2 (1-3)	0.009
P-value (among grades within same day)	0.000	0.000	-
<b>Categorized bilateral patellar luxation by grade</b>			
Grade 1	0 (0-0)	0 (0-0)	1.000
Grade 2	0 (0-0)	0 (0-0)	0.368
Grade 3	0 (0-2)	0 (0-2)	0.721
Grade 4	1 (0-2)	2 (0-2)	0.037
P-value (among grades within same day)	0.003	0.000	-

The risk factor for recurrence of the disease was analyzed (Table 1). Among the many factors, only grade 4 patellar luxation (OR=23.68, P=0.00), along with grade 3 patellar luxation (OR=7.2, P=0.06), was found to be a risk factor for recurrence. The median time of recurrence was observed approximately 21 months after the surgery, while the time period after surgery of grade 3 and grade 4 patellar luxation without recurrence was about 42 months of median (Fig. 4). In addition, the time period after the surgery corresponding to recurrence among patellar luxation with grade 3 and grade 4 was considered. It was found that the risk of recurrence in patellar luxation with grade 3 and grade 4 decreased to 50% 18.7 months after the surgery (95%CI; 0.46 and 37.04 months) and that the

**Table 6.** Comparison of numbers of dogs as regards non-recurrence and recurrence in unilateral and bilateral patellar luxation in different age groups

Age at Surgery (month)	Unilateral Patellar Luxation		Bilateral Patellar Luxation	
	Non-recurrence	Recurrence	Non-recurrence	Recurrence
1-12	8 (89%)	1 (11%)	9 (90%)	1 (10%)
13-24	30 (86%)	4 (12%)	9 (90%)	1 (10%)
25-36	16 (89%)	2 (11%)	12 (12%)	1 (8%)
37-48	6 (86%)	1 (14%)	8 (64%)	4 (33%)
49-60	2 (100%)	0	1 (100%)	0
61-72	1 (100%)	0	0	5 (100%)
73-84	3 (100%)	0	0	0
85-96	1 (25%)	3 (75%)	0	0
97-108	0	0	0	0
109-120	0	0	2 (100%)	0
Total	67 (86%) <sup>*</sup>	11 (14%) <sup>#</sup>	41 (78%) <sup>*</sup>	12 (22%) <sup>#</sup>

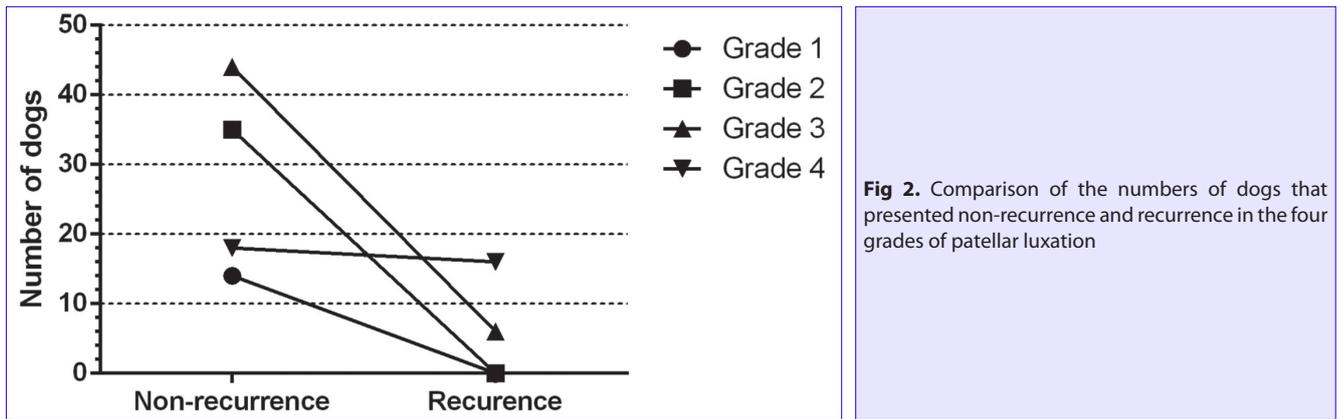
The superscript symbols (“\*” and “#”) represent high significance (P<0.05)

recurrence chance was less than 2.5% after more than 37 months after the surgery (Fig. 4).

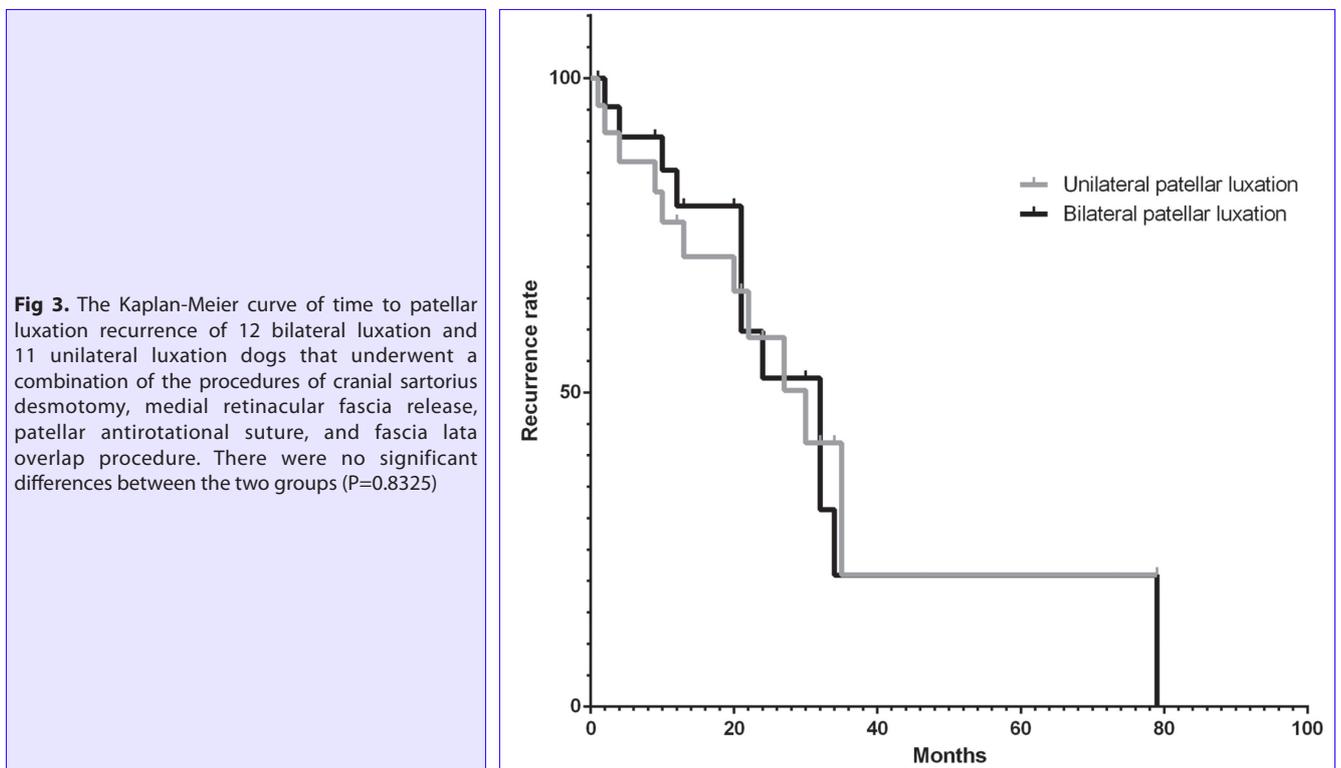
## DISCUSSION

In this study, it was demonstrated that combining four soft tissue techniques, namely cranial sartorius desmotomy, medial retinacular fascia release, patellar antirotational suture, and fascia lata overlapping for treating medial patellar luxation with not-fatted femoral sulcus in dogs of body weight lower than 10 kg yields excellence outcomes in grade 1 and grade 2.

As mentioned in most literature studies about patellar luxation treatment in dogs, in the cases of both medial and lateral patellar luxation, recurrence or relaxation is a major complication [5,12,13,15,16,24,25]. Our result found that



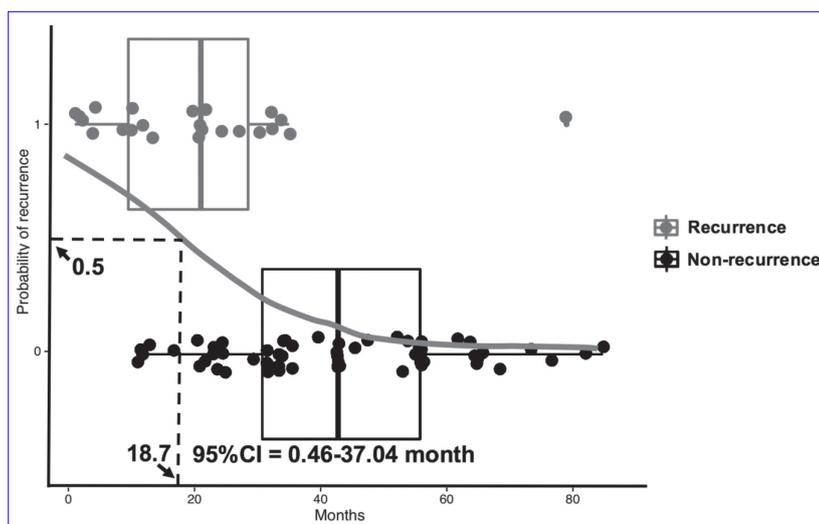
**Fig 2.** Comparison of the numbers of dogs that presented non-recurrence and recurrence in the four grades of patellar luxation



the highest recurrence rate occurred in grade 4 (48%) and grade 3 (16%); additionally, there was no recurrence found in grade 1 and grade 2. This means that combining these four techniques may not be enough to prevent recurrence in particular grade 3 and grade 4 patellar luxation. The recurrent rate from this study is due to many factors, but we believe a major problem comes from tibia rotation in patellar grades 3 and 4, which affected the patellar tendon and quadriceps femoris muscle. Only 4 combined techniques were not strong enough to hold the patella in the femoral sulcus, even in cases of a non-flattened femoral sulcus. As mentioned in most literature, there are recommendations to do tibial translocation as treatment for grades 3-4 patella luxation for tibial tuberosity rotating over 30 degrees [19]. The overall recurrence percentage of the disease after surgery in our study is 17%, which is not such high in comparison with what other publications

have reported as the recurrent rate found with variations in the rate from 7.6% up to 48%, depending on the grade of luxation and the surgical procedure [12,24,25]. Moreover, application of combinations of different procedures resulted in increased success rates [26]. One possibility that our overall recurrence rate was not high is because all the dogs included in this study had non-flattened femoral sulcus medial patellar luxation, while other publications did not exclude this condition.

In this study, by modifying a procedure from the literature on sartorius desmotomy, we performed completely cut insertion of the cranial sartorius muscle, as mentioned in the method. The cranial sartorius muscle is a lining between the crest of ilium and thoracolumbar fascia (origin) and the insertion was done at the patella. This muscle helps hip flexion and the extended stifle joint. From our



**Fig 4.** The recurrence and non-recurrence of patellar luxation of grade 3 and grade 4 in the time duration of months after the surgery are displayed in boxplot. The gray dots and the black dots represent the individual numbers of months after surgery with regard to recurrence and non-recurrence, respectively. The lines show the recurrence probability of the time period after the surgery among patellar luxation of grade 3 and grade 4. The red dashed line indicates that the time period after the surgery, 18.7 months (95% confidence interval (CI): 0.46 and 37.04 months), gives the chance of 0.5 for recurrence

observation, it was found that this muscle contracts more in medial patellar luxation dogs. However, so far, no study has reported this point, and we are studying the correlation between the cranial sartorius muscle and medial patellar luxation. From the lameness score evaluated following the surgery, in a month, it was not found that the dogs had any abnormality in walking. For this reason, we do believe that complete cranial sartorius desmotomy did not have any effect on gait. Our conclusion is supported by the findings of a previous study by Deban [27] on the activity of limb muscles in dogs at walk, trot, and gallop: It was reported that the cranial sartorius muscle shows significantly lower excitation in trotting. Previously, a study was carried out, in 2009, by Schilling [28] on the function of the extrinsic hind limb muscles in trotting dogs. It was demonstrated that the sartorius muscle had low activity during trotting at constant speed on flattened levels but increased activity during trotting uphill. The activity was not found to change when the dog trotted downhill.

Upon doing a comparison between the types of luxation (unilateral or bilateral), it can be observed that the recurrence rate in bilateral luxation (22%) is two times higher than the recurrence rate in unilateral patellar luxation (14%). A previous study reported that in unilateral patellar luxation, the dogs showed no effect in the opposite limb [29]. It is possible that the weight bearing ability of the hind limb after correction of one side of the affected limb in bilateral luxation is still abnormal and causes relaxation to occur easier than in unilateral luxation. On the other hand, unilateral luxation can balance the weight bearing, thus leading to lower recurrence rates. However, to confirm or prove our hypothesis, further experiments should be done by using faceplate analysis and gait analysis after correcting patellar luxation.

The radiography images of 32% of the dogs changed in 6 months after surgery, with significant changes in grade 4 patella luxation (both unilateral and bilateral). In patellar

luxation grade 1 to grade 3, the score of most radiographic images was 0, and the score did not change within 6 months after surgery. This shows good prognosis that the patellar luxation joint would not develop osteoarthritis, in particular in low grades.

This study is not the first study to look at the outcome of patellar luxation treated without the bone reconstruction technique. Linney [12] reported the outcome of surgical treatment of medial patellar luxation without femoral trochlear groove deepening in 91 dogs. Eighteen of the 91 (19.8%) dogs had recurrence. So, taken together with our study, this demonstrates that the trochlear groove deepening procedure is not always necessary.

However, this study had many limitations. First, the outcome of this study can only be evaluated from radiographs (6 months post-surgery) and rates of recurrence. We cannot perform a CT-scan in the cases after surgery to study the morphology of the bone after surgery. Moreover, we cannot perform the gait or motion analysis after surgery as well as we cannot evaluate the lameness score for periods longer than 1 month after surgery. The lameness scores from the medical records are limited to scores of 1 month after surgery. Other limitation was that the duration between the occurrence of the disease and the treatment is unknown as the records do not carry that information; hence, delay in treatment might be a cause for increase in recurrence rate.

In conclusion, our study demonstrated the outcome of combining four soft tissue techniques for treating medial patellar luxation with non-flattened femoral sulcus in dogs. These techniques demonstrated excellent results for grade 1 and grade 2 medial patellar luxation with non-flattened femoral sulcus by showing fast recovery after surgery, prevention of progression of osteoarthritis, and no rates of recurrence. These techniques may be a good choice for patients with conditions similar to those in this study (grades 1 and 2 with non-flattened femoral sulcus)

before the surgeon makes the decision to perform bone reconstruction.

### CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding the publication of this paper.

### AUTHORS' CONTRIBUTION

Nganvongpanit K. was a major contributor, who designed, conducted, and collected all the data used in this study. Buddhachat K. assisted in the statistical investigation and support of information for discussion. Boonsri B. and Sripratak T. assisted in data collection and Punyapornwithaya V. provided advice regarding statistical analysis. Nganvongpanit K. wrote the manuscript and Buddhachat K. assisted in the discussions and writing of the manuscript.

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