PAPER

The natural history of canine occult Grade II medial patellar luxation: an observational study

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Objectives: To determine the risk of lameness and the rate of subsequent medial patellar luxation surgery in dogs that present with occult Grade II medial patellar luxation.

Materials and methods: Retrospective owner survey and review of clinical records of adult dogs diagnosed with Grade II medial patellar luxation that were initially asymptomatic and managed non-surgically that had a minimum of 4-year follow-up. Clinical notes and owner questionnaires identified dogs that subsequently developed lameness and required surgery on the previously asymptomatic stifle.

Results: Thirty-eight dogs were included with an average follow-up of 51 months. Seventeen dogs represented for unscheduled contralateral medial patellar luxation surgery at an average of 15 months after initial presentation. A further two dogs had chronic contralateral limb lameness after an average of 33 months after initial surgery and may have been potential surgical candidates.

Clinical Significance: Fifty percent of adult dogs presenting with occult Grade II medial patellar luxation subsequently developed chronic lameness or required surgery.

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INTRODUCTION

Some canine orthopaedic conditions, including hip and elbow dysplasia, humeral intracondylar fissure (HIF) and patellar luxation (PL) can occur without causing clinical signs (Ness *et al.* 1996, Moores *et al.* 2012). These so-called occult conditions present clinicians with a dilemma because if there is no current clinical problem, is treatment warranted? This decision is influenced by the risks and costs of the proposed treatment weighed against the potential risks and costs of no treatment. For dogs affected by occult PL, possible negative clinical endpoints include progression of limb deformity in immature dogs, lameness caused by worsening PL grade, progressive stifle osteoarthritis and a potentially higher incidence of cranial cruciate ligament (CCL) disease (Hayes *et al.* 1994, Piermattei & Flo 2006, Schulz 2007, Campbell *et al.* 2010, Kowaleski *et al.* 2017). In puppies affected by either occult or clinical PL, there is a compelling argument for surgical intervention: as puppies continue to grow, mild PL can develop into severe PL as a consequence of progressive limb deformity (Schulz 2007). In adult dogs, studies assessing the impact of PL surgery on radiographic progression of stifle osteoarthritis have not demonstrated a significant difference compared with non-surgically managed cases (Willauer and Vasseur 1987, Roy *et al.* 1992). In a study assessing the risk of untreated medial patellar luxation (MPL) on subsequent CCL insufficiency, the risk was only higher in dogs with Grade IV MPL (Campbell *et al.* 2010). A relationship between PL grade and clinical importance is well accepted, with most authors citing Putnam's grading system (Putnam 1968):

Grade I: The patella can be manually luxated but returns to a normal position when released.

Grade II: The patella may luxate during stifle flexion or manual manipulation and remains luxated until stifle extension or manual replacement occurs.

Grade III: The patella is permanently luxated but can be manually replaced. It reluxates spontaneously when manual pressure is removed.

Grade IV: The patella is permanently luxated and cannot be replaced.

The patella should not luxate spontaneously in dogs with Grade I PL so there is no surgical indication. In contrast, Grades III and IV consistently result in lameness and surgical treatment is recommended by most authors (Piermattei & Flo 2006, Kowaleski *et al.* 2017). Controversy surrounds the best management of Grade II MPL (Roy *et al.* 1992, Roush 1993, Tomlinson & Constantinescu 1994, Piermattei & Flo 2006, Kowaleski *et al.* 2017). This grade covers a broad spectrum of abnormality; some cases may demonstrate signs of luxation frequently while others may have infrequent lameness or may not demonstrate lameness. Thus, for Grade II MPL in adult dogs, the decision to operate is usually made based on the frequency of lameness episodes; for example, lameness episodes occurring once every year would be managed non-surgically while daily lameness would be managed surgically.

Some orthopaedic conditions, such as HIF, are initially asymptomatic but may become clinically important over time (Moores & Moores 2017). Anecdotally, a similar situation may occur with MPL. If sufficient outcome data are available, a useful epidemiological metric is the number-needed-to-treat (NNT). A human study by Sever *et al.* is commonly cited in literature as an example of NNT (Sever *et al.* 2003). In this study, the NNT to prevent one cardiovascular event by treating with the cholesterol-lowering drug atorvastatin was 98 over a 3.3 year period. While NNT has been used in veterinary medicine in the past, its use is uncommon (Imhoff *et al.* 2011). Importantly, NNT values are time-specific. In order to calculate the NNT for occult canine PL, a sample population of affected dogs would need to be followed for a predetermined duration and the proportion of dogs suffering an adverse outcome would need to be established during that time. As canine MPL is significantly more prevalent than lateral PL (O'Neill *et al.* 2016), we elected to perform such a study using a sample population of dogs affected by clinically occult Grade II MPL.

MATERIALS AND METHODS

The study was a retrospective cohort survey. Predefined inclusion criteria were:

- All dogs were skeletally mature (*i.e.* >12 months old at the time of diagnosis).
- Presentation at one of three referral centres for unilateral MPL surgery.
- An incidental finding of contralateral Grade II MPL by a specialist or resident-in-training using Putnam's grading system. Incidental (clinically occult) MPL required an absence of any previous or current history of lameness affecting that limb and an absence of stifle pain during the orthopaedic examination.
- A minimum of 4-year follow-up unless unscheduled contralateral surgery had been performed (in which case follow-up duration was defined as the time between presentation and contralateral surgery).

Cases with concurrent CCL disease at the time of diagnosis, previous pelvic limb surgery, or cases in which subsequent MPL surgery was recommended on initial presentation were excluded. Cases that had incomplete records, equivocal grading or grading using an alternative system were also excluded.

Information retrieved from the clinical records included age at initial presentation, affected limb (surgical and occult), breed, bodyweight and sex. Any record of subsequent contralateral MPL surgery or subsequent contralateral lameness was noted. Owners of animals that had no record of an adverse outcome were contacted by telephone and asked to complete a questionnaire designed to establish whether lameness occurred on the previously asymptomatic limb. Lameness was also categorised according to frequency; *i.e.* constant lameness, lameness at least once *per* week, once *per* month or once *per* year. This is defined in the owner questionnaire (Appendix 1, Supporting information). Owners were also asked if they treated lameness with medication.

Medical records of surgically managed cases were reviewed to confirm that the surgery performed was MPL repair. For calculation of the NNT, we defined an adverse outcome as lameness that occurred at least once every month or lameness that prompted surgical intervention.

Results were grouped based on outcome (Figs. 1 and 2). Statistical analysis was performed using statistical software (IBM SPSS v19, August 2010, SPSS, Armonk, NY). Results were expressed as mean ± standard deviation (sd) for normally distributed variables and as median and range for non-normally distributed variables. The Kolmogorov-Smirnov test was used for evaluation of normality of continuous variables (*i.e.* age, weight, time to last follow-up and surgery). All variables but weight followed a normal distribution (P-values>0.05). The NNT is the number of patients needed to treat to prevent one adverse outcome.

RESULTS

The results are summarised in Figs. 1 and 2. Fifty-three cases were identified from clinical records to have asymptomatic Grade II MPL on the contralateral limb.

Hospital records indicated that 17 dogs returned to the same institution for unscheduled contralateral MPL surgery and 36 did not have any record of contralateral surgery being performed or scheduled. An attempt was made to questionnaire these 36 owners and 22 responded. One case had died 43 months postoperatively and was excluded due to failing to meet the 4-year follow-up. Cases were subsequently grouped into the following four groups based on level of lameness described on questionnaire and if surgery had been performed - Group 1: Cases that received unscheduled contralateral MPL surgery. Duration of follow-up was defined as the time between initial presentation and the date of contralateral limb surgery. Surgical treatment was considered an adverse event. Seventeen cases represented for unscheduled contralateral medial patellar luxation correction. The mean time between the first and the contralateral limb requiring surgery was one year and three months (SD one year and eleven months). Group 2: Questionnaire respondents with dogs that had a history of significant contralateral limb lameness attributed to MPL (daily or monthly lameness) and that would have considered surgery but surgery was not performed because of financial limitations. Duration of follow-up

Group 1: Required contralateral surgery (n=17)			
Case	*Age*	*Breed*	*Time to contralateral surgery*
1	1 year and 4 months	Shetland Sheepdog	1 month
2	4 years	Akita	32 months
3	1 year and 4 months	Cavalier King Charles spaniel	85 months
4	3 years and 11 months	Chihuahua	3 months
5	1 year and 5 months	Staffordshire bull terrier	4 months
6	8 years and 8 months	Jack Russell terrier	59 months
7	6 years and 2 months	Labrador retriever	8 months
8	1 year	Pug	5 months
9	1 year	Akita	6 months
10	2 years and 1 month	Brittany spaniel	1 month
11	1 year and 4 months	Staffordshire bull terrier	6 months
12	1 year and 1 month	Crossbreed	6 months
13	1 year	King Charles cocker spaniel	2 months
14	1 year and 2 months	West Highland white terrier	18 months
15	2 years and 2 months	Staffordshire bull terrier	2 months
16	2 years and 5 months	Yorkshire terrier	8 months
17	1 year and 1 month	Crossbreed	12 months
			Average: 15 months

Group 2: Frequent long-term lameness (≥ once per month; n=2)			
Case	*Age*	*Breed*	*Time to follow-up (lameness onset)*
18	1 year and 1 month	Cavalier King Charles spaniel	4 months
19	3 years	Lhasa apso	62 months
			Average: 33 months

Group 3: No long term lameness (n=17)			
Case	*Age*	*Breed*	*Time to follow-up (questionnaire or death)*
20	8 years	Brussels griffon	81 months
21	1 year	Yorkshire terrier	115 months
22	1 year and 2 months	Springer spaniel	130 months
23	2 years	Cavalier King Charles spaniel	90 months
24	2 years and 6 months	Cavalier King Charles spaniel	143 months
25	1 year and 6 months	Yorkshire terrier	76 months
26	3 years	Bull terrier	93 months
27	1 year	Crossbreed	92 months
28	2 years	Staffordshire bull terrier	91 months
29	2 years and 2 months	Staffordshire bull terrier	79 months
30	2 years	Yorkshire terrier	62 months
31	1 year and 7 months	Staffordshire bull terrier	61 month
32	8 years	Chihuahua	55 months
33	1 year and 6 months	Shih tzu	54 months
34	1 year and 5 months	Yorkshire terrier	50 months
35	4 years and 5 months	Cavalier King Charles spaniel	50 months
36	1 year and 10 months	Cavalier King Charles spaniel	117 months
			Average: 86 months

Group 4: Infrequent lameness (≤ once per year; n=2)			
Case	*Age*	*Breed*	*Time to follow-up (questionnaire or death)*
37	1 year and 2 months	Bichon frise	72 months
38	2 years and 5 months	Staffordshire bull terrier	114 months
			Average: 93 months

FIG 1. Group 1: unscheduled contralateral limb MPL correction. Group 2: significant contralateral limb lameness (daily or monthly lameness) that would have been considered for surgery. Group 3: no reported long-term contralateral limb lameness. Group 4: infrequent (non-significant) contralateral limb lameness.

was defined as the time between initial presentation and lameness onset. Frequent lameness was considered an adverse event. Two cases were reported by questionnaire to have significant lameness on a monthly basis. For both of these cases, the owners considered surgery but financial constraints prohibited this option. One of these cases required intermittent non-steroidal anti-inflammatory medication. The mean time between the surgery for the first limb and contralateral limb lameness onset was two years and nine months (SD three years and five months). Group 3: Questionnaire respondents with dogs that had no reported long-term contralateral limb lameness. Duration of follow-up was defined as the time between presentation and the questionnaire (live dogs) or until the date of death. Seventeen cases were reported by questionnaire to have no contralateral limb lameness at a mean follow-up of seven years and two months (SD two years and five months). Group 4: Questionnaire respondents with dogs that had infrequent (non-significant) contralateral limb lameness (intermittent skipping lameness with a frequency of less than once per year and spontaneous resolution). Surgery was not considered for these cases and lameness was not considered an adverse event. Duration of follow-up was defined as the time between presentation and the questionnaire (live dogs) or until the date of death. Two cases were reported to have lameness annually and were not considered by the owner to require surgery or medication with a mean follow-up of seven years and nine months (SD two years and six months).

The following analysis only includes the 38 cases that either had questionnaire follow-up or had surgery performed on the contralateral limb.

Mean age at initial presentation was 30 months (sd 24 months). There were 18 males (12 neutered) and 20 females (14 neutered).

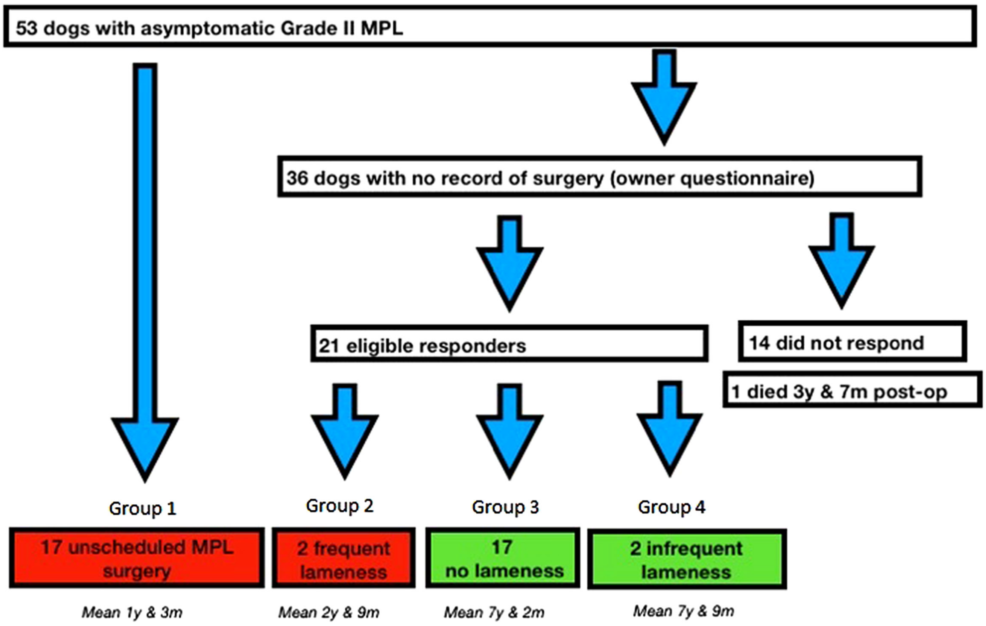

FIG 2. Group 1: unscheduled contralateral limb MPL correction. Group 2: significant contralateral limb lameness (daily or monthly lameness) that would have been considered for surgery. Group 3: no reported long-term contralateral limb lameness. Group 4: infrequent (non-significant) contralateral limb lameness.

Median bodyweight was 8.6 kg (range 1.8-56 kg). The most common breeds were Staffordshire bull terriers (n = 7), cavalier King Charles spaniels (n = 6) and Yorkshire terriers (n = 5). Nineteen cases had MPL surgery on the right stifle and 19 were operated on the left on initial presentation.

According to our predetermined criteria, an adverse event occurred in 19 of 38 cases (*i.e.* 50%), with a mean follow-up time of 51 months (sd 43 months). Thus, if surgery had been performed to treat clinically occult Grade II MPL at the time of initial presentation, two dogs would have required surgery to prevent an adverse outcome in one dog (*i.e.* the NNT was two).

DISCUSSION

In this retrospective study of adult dogs with occult Grade II MPL, the NNT was two. This means that after a minimum of 4-year follow-up, for every dog in which surgery would have prevented an adverse outcome, another dog would have received an unnecessary surgical procedure. Although this data has potential value in counselling owners of dogs with occult MPL, we suggest that the NNT data is presented as an *estimate* rather than an absolute value due to several potential study biases. The selection of a sample population of dogs that had already received MPL surgery was an important potential source of bias. It is possible that owners may have been more inclined to choose contralateral surgery if the result of the first surgery was good, especially if they believed that not performing surgery would pose a high risk of future problems. It is also possible that the original surgeon may have warned owners of a high chance that the contralateral stifle would require future surgery but this advice was not recorded in the medical record. This potential source of bias would have caused a reduction in the estimated NNT.

It is possible that contralateral lameness was masked at initial presentation, although this appears unlikely. Dogs affected by Grade II MPL typically have a characteristic intermittent limp. In all cases, owners presented their dog for an intermittent or constant limp on the operated limb. It is fair to assume that these owners should have been equally capable of recognising an obvious limp on the contralateral limb. Also, if contralateral lameness was obscured by severe ipsilateral lameness, we would have expected lameness to manifest shortly after surgical correction of the more severely affected limb. It is acknowledged that this potential bias is possible in the five dogs that re-presented less than 3 months after initial surgery, but unlikely in the remaining dogs given the average length of time to contralateral surgery was 15 months.

Another possible source of bias is the intentional exclusion of immature dogs and dogs with Grades I, III and IV MPL. Immature animals were excluded due to the potential for progression of anatomical deformity associated with continued growth, which in turn can increase the severity of MPL (Schulz 2007). For this reason, it is likely that if these cases were included, more dogs would have required subsequent MPL surgery and the estimated NNT would have been lower. We did not include occult Grade I MPL in our analysis as this grade does not carry a surgical indication. We would not expect practitioners to warn owners of adult dogs with occult Grade I MPL that future surgery is likely. Nevertheless, it is accepted that some dogs with Grade I MPL may subsequently develop a higher grade of MPL that causes clinical signs. Equally, there may be cases of bilateral Grade III or Grade IV MPL in which lameness is initially difficult to detect but becomes obvious later in life. Although it was not our intention to assess these groups, this may be an interesting area of future research.

Fundamentally, NNT is used as a tool to estimate the relative risks of performing an intervention compared with not performing the intervention. Consequently, the ideal study of occult Grade II MPL would prospectively compare a population of dogs having "prophylactic" MPL surgery to a control group managed non-surgically. Possible confounding variables including exercise, diet and body condition would be controlled and the adverse outcomes of surgery (on-going lameness, requirement for revision surgery and cost) would be compared to the adverse outcomes of the control group. Although this assessment was beyond the scope of our study, others have assessed the relative complication rates of simultaneous bilateral MPL repair, unilateral MPL repair and staged bilateral MPL repair (Clerfond *et al*. 2014, Fullagar *et al*. 2017). In these studies, the overall complication rates were higher in dogs having simultaneous bilateral MPL surgery although differences were not statistically significant. Nevertheless, MPL surgery complications are common, with quoted ranges from 18 to 43%, and a 7 to 18% incidence of major complications that required surgical revision (Arthurs & Langley-Hobbs 2006, Gibbons *et al*. 2006, Alam *et al*. 2007, Linney *et al*. 2011, Cashmore *et al*. 2014, Stanke *et al*. 2014, Clerfond et al. 2014, Fullagar *et al*. 2017). Previous studies have not specifically addressed the more subjective problem of early postoperative pain and poor function. Intuitively, increased discomfort and poorer function would be expected after any bilateral orthopaedic procedure.

It has been suggested that stifles affected by MPL are predisposed to CCL lesions because of the inflammatory environment and abnormal stifle biomechanics which increase strain on the CCL (DeAngelis 1971, Hulse & Shires 1985, Roy *et al*. 1992) although a statistically significant relationship has only been demonstrated in dogs with Grade IV MPL (Campbell *et al*. 2010). Alternatively, the cause and effect may be reversed and stifle effusion coupled with internal tibial rotation caused by CCL insufficiency may predispose to MPL. In our study, none of the dogs that were managed surgically had reported evidence of CCL lesions. Although it is routine practice to preoperatively test cranial drawer and intraoperatively inspect the CCL during MPL repair, it is accepted that there may have been microscopic disease of the CCL in some cases. It is also possible that some of the lame dogs that were not treated surgically had CCL lesions that were not severe enough to cause cranial drawer. A potential limitation of future studies in this area would be proving that lameness associated with CCL disease was caused by the original occult MPL or if CCL lesions would have occurred regardless of pre-existing MPL.

In conclusion, the estimated NNT data presented in this study can be used to help predict the likelihood of future lameness in cases of occult Grade II MPL that might require surgical management. This data should be presented alongside potential morbidity data for surgical treatment of MPL in dogs with no current clinical signs. There are several possible areas of future study including prospective evaluation of dogs which were not managed surgically on the contralateral limb and evaluation of dogs with other grades of MPL. Finally, NNT data may prove useful in epidemiological studies of surgical interventions recommended for other clinically occult veterinary orthopaedic problems including juvenile pubic symphysiodesis and double/triple pelvic osteotomy for hip dysplasia and distal ulnar osteotomy for elbow dysplasia.

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Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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Supporting Information

The following supporting information is available for this article:

Appendix 1: Client questionnaire