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CLINICAL RESEARCH

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Increased radiographic stifle soft tissue opacity in dogs with patella luxation

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Abstract

Objective: To determine the prevalence of increased radiographic soft tissue opacity in canine stifles with patella luxation in the absence of overt cranial cruciate ligament (CCL) pathology.

Study design: Retrospective case series.

Animal population: A total of 49 client-owned dogs (57 limbs).

Methods: Dogs with patella luxation that underwent arthrotomy with CCL evaluation were included. Dogs were excluded if overt pathology of the CCL was noted during orthopedic examination and/or surgical evaluation. Correlation of increased radiographic soft tissue opacity with age, breed, weight, duration of clinical signs, presence of stifle osteoarthritis, muscle atrophy, and luxation grade were evaluated.

Results: Increased radiographic soft tissue opacity of the stifle was appreciated in 37/57 (65%) stifles. Weight ($p = .029$) and presence of osteoarthritis ($p = .0143$) were associated with the presence of increased radiographic soft tissue opacity. For every 1 kg increase in weight there is a 10% increased risk in having this radiographic change. Four of 21 dogs (19%) with long term follow-up were diagnosed with a CCL injury 2, 2.5, 4, and 4.5 years postoperatively. Two of the four dogs (50%) with later CCL injury had increased radiographic soft tissue opacity in the stifle joint when initially presenting for patella luxation.

Conclusion: Increased soft tissue opacity of the stifle joint may be found on radiographs of dogs with patella luxation without overt CCL pathology.

Clinical significance/impact: Increased radiographic soft tissue opacity within the stifle joint is not uncommon in dogs with patellar luxation that do not have overt CCL pathology. Increased radiographic soft tissue opacity alone should not infer pathology of the CCL in dogs with patella luxation.

Abbreviations: CCL, cranial cruciate ligament; CCLR, cranial cruciate ligament ruptures; MPL, medial patella luxation; OA, osteoarthritis; ORs, odds ratios.

1 | INTRODUCTION

Patella luxation is a common orthopedic condition found in small breed dogs and with increasing prevalence in large breed dogs.[1–7] Medial patella luxation (MPL) is most common, while lateral or bidirectional luxations also occur.[2,3,8] This is a multifactorial disease that varies greatly in age of onset, direction, grade, and severity of lameness. Numerous associated developmental skeletal and biomechanical factors include coxofemoral joint conformation, femoral torsion and angulation, stifle rotation, deviation of the tibial crest, quadriceps muscle atrophy, patella malpositioning and hypoplastic trochlear groove.[7,9–11] Any combination of these may be present in a dog with patella luxation.[12] Patella luxation is commonly graded on a scale of I–IV.[13]

Cranial cruciate ligament (CCL) disease has been associated with patella luxation, with 13%–25% of dogs presenting with patella luxation having concurrent cranial cruciate ligament rupture (CCLR); however, the mechanism of their correlation has not been thoroughly established.[4,14] Increased radiographic soft tissue opacity presumed to be stifle effusion is considered to be the first indication of deterioration of the CCL, and numerous studies demonstrate the association between increased soft tissue opacity and CCL disease.[15–19] Consequently, the presence of stifle effusion with patella luxation is accepted to be a potential indicator of concurrent CCL disease.[7,18,20,21] While increased soft tissue opacity may be an early indicator of many pathological changes in the stifle, there are no known reports investigating the prevalence of radiographic changes consistent with stifle effusion in dogs with patella luxation in the absence of overt CCL disease. Increase in radiographic soft tissue opacity of a joint may be associated with effusion, thickening of the joint capsule and/or synovial membrane, or soft tissue masses; joint fluid and the surrounding soft tissues cannot be differentiated.[22]

The aim of this study was to retrospectively evaluate the radiographic prevalence of increased soft tissue opacity in the stifle joint of dogs with patella luxation and intact CCLs. The secondary aim was to determine what patient variables were associated with an increased prevalence of stifle soft tissue opacity in this population. It was hypothesized that increased soft tissue opacity of the stifle joint would be most common in dogs with grade II and III patella luxations.

2 | MATERIALS AND METHODS

The medical records at Ryan Veterinary Hospital at the University of Pennsylvania were reviewed for dogs with patella luxation presenting between January 2013 and July 2023. Dogs were included if they had a diagnosis of a luxating patella (medial, lateral, or bidirectional) based on orthopedic examination, two-view (craniocaudal and mediolateral) stifle radiographs with radiologist interpretation, and surgical reports noting an intact CCL devoid of any overt pathology upon visual inspection via arthrotomy and manual probing. Cases were excluded if there was history of CCL disease of the affected limb, trauma or other pathology of the affected joint, lack of orthogonal stifle radiographs, lack of a complete surgical report, or if evidence of CCL pathology was present, defined as cranial instability of the tibia on orthopedic examination and/or notation of any cruciate pathology within the surgery report. Only dogs with an intact and overtly normal CCL explicitly noted in the surgery report were included. Dogs with evidence of CCL disease in the contralateral limb (cranial drawer or cranial tibial thrust, pain on extension) were excluded from the study.

Signalment, affected hindlimb(s), direction of patella luxation (medial, lateral, bidirectional), grade of luxation (I–IV/IV[13]), severity of lameness, duration of clinical signs, presence of radiographic increased soft tissue opacity within the joint, presence of radiographic osteoarthritis (OA) (present or not-present), and presence of muscle atrophy upon physical examination (present or not-present) were recorded. Evaluation of muscle atrophy was subjective based on visual observation via standing examination and/or palpation of proximal thigh musculature. Age and weight were further subdivided into categories with ages grouped into less than 1 year old, between 1 and 3 years old, 3–6 years old, or greater than 6 years old and weights grouped into 0–10 kg, 11–20 kg, 21–30 kg, or greater than 31 kg. Lameness was recorded as non-weightbearing or weightbearing, the latter subjectively graded as mild, moderate, and severe. The radiographic presence of increased soft tissue opacity and OA within the stifle joint, OA, and muscle atrophy were retrospectively collected from the radiographic reports. Additionally, the radiographic report categorized the increased soft tissue opacity in the joint as mild, moderate, or severe for all cases, and this was recorded. The complete medical records and available records from the primary/referring veterinarians that were uploaded at time of statistical analysis were examined for any subsequent diagnosis of CCL disease on follow-up examinations. Records included medical notes (i.e., SOAPS, procedures, diagnostics, treatments) and communication logs between the referring veterinarian and client. Referring veterinarians were not contacted by the authors of this study for follow-up records of each patient for the specific purpose of this study. Long-term follow up was defined as greater than 12 months postoperatively.[23]

2.1 | Statistical analysis

All analyses were conducted with Stata 17MP, StataCorp, State College, Texas, with two-sided tests of hypotheses and a $p < .05$ as the criterion for statistical significance. Descriptive analyses included computation of medians and tabulation of categorical variables. A Shapiro-Wilks test was used to test the normality of the data. Frequency counts and percentages were used for categorical variables.

Inference statistical analysis was conducted in two steps. First, a univariate exploratory. A spearman rank correlation analysis was used to assess the association between the presence of increased radiographic stifle soft tissue opacity with age, breed, weight, grade of luxation, duration of clinical signs, presence of stifle OA, and muscle atrophy. Dogs with bilateral disease were further separated to right and left hindlimbs. Logistic regression was then performed between the outcome of interest and the independent variables identified in the previous step that were showing statistical trend ($p < .2$) for significance. Significant associations are reported as odds ratios (ORs) with their respective 95% confidence interval (95% CI).

3 | RESULTS

A total of 49 dogs and 57 stifles (right-26, left-31) met the inclusion criteria. Of the 49 dogs, 20 were male neutered, 2 were male intact, 23 were female neutered, and 4 were female intact. The median age was 2 years (range, 8 months–8 years). The median bodyweight was 11.8 kg (range, 0.7–37.4 kg). Breeds included 24 (49%) mixed breeds; four (8%) Pomeranian, four (8%) Cavalier King Charles Spaniel, three (6%) Yorkshire Terrier, two (4%) Boston Terrier, two (4%) Bulldog, two (4%) Great Pyrenees and one (2%) French Bulldog, Bichon Frise; Labrador Retriever, Chihuahua, Dachshund, Pug, Staffordshire Bull Terrier, and Akita.

Out of the 49 dogs (57 stifles) included, 41 (84%) dogs had unilateral luxation while eight (16%) had bilateral luxation. A total of 53 stifles (93%) had medial patellar luxation and four (7%) had lateral patellar luxation; no patella luxation was bidirectional. Grades of patella luxation included 19 (33%) grade 2, 36 (63%) grade 3, and two (4%) grade 4. A total of 94% (46/49, 54 stifles) of dogs had a weightbearing lameness and 3/49 (6%) had no visible lameness. Among those that had bilateral patella luxations, 8/8 dogs (100%) had a weightbearing lameness; 6/8 (75%) mild, 1/8 (12.5%) moderate, and 1/8 (12.5%) severe. A total of 50% (4/8 dogs) were bilaterally lame. Bilateral lameness was characterized in the records by a bunny hopping gait, weight shifting from one pelvic limb to another, bilateral hocks held in extension, equal abnormal swing phase, and/or both hindlimbs equally stiff and stilted or bow-legged. No dogs included in the study had evidence or history of CCL disease in the stifle with a patella luxation or contralateral stifle. The median duration of clinical signs prior to presentation was 4 months (range, 0.33–66 months). Muscle atrophy was present in 19/49 (39%) dogs. Data are summarized in Table 1. All dogs underwent surgery to correct the patella luxation, and the cruciate ligaments were examined directly via arthrotomy and confirmed to be intact in the surgical report. Out of the dogs with bilateral surgeries, 75% (6/8, dogs) had staged bilateral surgeries and 25% (2/8, dogs) had single-session bilateral surgeries.

Increased radiographic soft tissue opacity was appreciated in 37 (65%) stifles on orthogonal radiographs (Figure 1). Weight ($p = .0029$, OR = 1.10) and

TABLE 1 Total number and frequency (No [%]) of examined variables in stifles of dogs with patella luxation without overt CCL patholo.

Variable	Total stifles in group *n* (%)
Age	57 (100)
<1 years old	8 (14)
1–3 years old	30 (53)
3–6 years old	16 (28)
Greater than 6 years old	3 (5)
Weight	
0–10 kg	28 (49)
11–20 kg	10 (18)
21–30 kg	13 (23)
Greater than 31 kg	6 (10)
Patella luxation grade	
Grade 1	0 (0)
Grade 2	19 (33)
Grade 3	36 (63)
Grade 4	2 (4)
Muscle atrophy	
Present	20 (35)
Absent	37 (65)
Presence of stifle OA	
Present	20 (35)
Absent	37 (65)
Limbs with luxation	
Unilateral	49 (86)
Bilateral	8 (14)

Abbreviations: CCL, cranial cruciate ligament; OA, osteoarthritis.

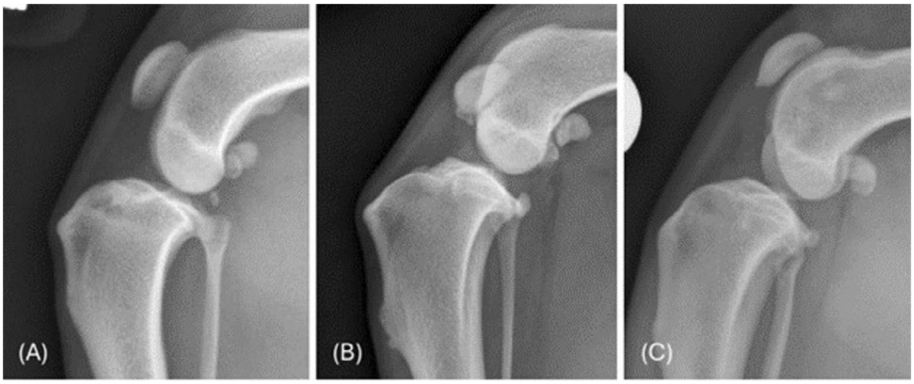

FIGURE 1 Radiographs of stifles without (A) and with (B, C) increased soft tissue opacity within the joint; all have osteoarthritis present. All radiographs were evaluated by a radiologist for the presence or absence of stifle effusion and stifle joint osteophytosis. All dogs had medial patella luxation with no overt pathology of the cranial cruciate ligament upon arthrotomy.

presence of OA ($p = .0143$) were associated with the presence of increased soft tissue opacity of the stifle joint. For every 1 kg increase in bodyweight there was a corresponding 10% increase in risk of having increased soft tissue opacity in the stifle ($p = .006$, OR = 1.10, 95% CI: 1.03–1.18). Other variables including age, duration of clinical signs, presence of muscle atrophy, and grade of patella luxation, were not associated with an increased soft tissue opacity within the joint (Table 2).

A total of 21 dogs (21/49; 43%) had long-term follow-up with a mean follow-up of 37 months (range, 12–102 months). A total of 20 dogs (95%) had follow-up via the authors' institution and one dog (5%) through referring veterinarian records. Four of these dogs (19%) had a CCLR in the same stifle after correction of their patella luxation. At the time of original presentation prior to patella correction, 2/4 dogs (50%) had increased radiographic soft tissue opacity. For the two dogs that did not have increased opacity prior to their patella correction, one dog was presented for lameness 26 months after a unilateral right patella luxation correction and had in situ patellas upon re-examination but did have bilateral CCLRs diagnosed via cranial drawer and cranial tibial thrust on orthopedic examination. The second dog was presented 55 months after a left patella luxation correction also with in situ patellas and a CCLR in the same limb as the previous surgery diagnosed via cranial tibial thrust on orthopedic examination. For the two dogs that did have increased opacity prior to patella correction, one presented for lameness 32 months after a unilateral right patella luxation correction and had in situ patellas but positive tibial thrust and cranial drawer with a complete CCLR confirmed on arthroscopy at the time of the recommended TPLO procedure. The second dog was presented 49 months after a left patella luxation correction with an in situ patella, negative tibial thrust, but positive cranial drawer. Surgery was not pursued.

TABLE 2 The association (p-values) of evaluated variables and the presence of increased radiographic soft tissue opacity of the stifle joint.

Variable	*N* (stifles)	Association with increased radiographic stifle soft tissue opacity (*p*-values)
Age	57	.9804
Weight	57	**.0029**
Duration of clinical signs	57	.2578
Patella luxation grade	57	.7643
Muscle atrophy	20	.2784
Presence of stifle OA	20	**.0143**

Note: A univariate Spearman rank-correlation analysis was used to calculate statistical significance. The statistically associated variables ($p < .05$) are demarcated in bold.
Abbreviation: OA, osteoarthritis.

4 | DISCUSSION

This study supported the hypothesis that an increase in radiographic stifle soft tissue opacity is present in a population of dogs with patella luxation in the absence of overt CCL pathology; 65% of stifles in this population had evidence of increased soft tissue opacity. No conclusions can be made about the second hypothesis that an increase in soft tissue stifle opacity would be associated with grade 2–3/4 patella luxation due to small sample size. Weight and the presence of OA were positively associated with increased radiographic soft tissue opacity within the stifle joint.

Stifle effusion is considered an indicator of joint inflammation or synovitis and associated with the development of OA.[15–17,19] However, few studies have evaluated the prevalence of stifle effusion, or radiographic evidence of increased soft tissue opacity in the joint in dogs with patella luxation alone. A previous study determined that the development of OA was associated with

CCLR, patella luxation, weight (>10 kg), and female sex.[24] This study aimed to evaluate a population of dogs with radiographic and arthroscopic OA secondary to stifle joint instability, identified by a positive cranial drawer sign or a patellar luxation. The study found that 11% of the cases were attributed to patellar luxation.[24] The prevalence of radiographic OA in dogs with patella luxation alone was not investigated nor was the presence of increased radiographic soft tissue opacity prior to the development of radiographic OA.[17] The results of the current study demonstrate a prevalence of radiographic OA specifically in 35% of dogs with patella luxation. All but three dogs that had stifle OA also had increased radiographic soft tissue opacity with 65% of dogs having radiographic evidence of increased soft tissue opacity within the stifle joint with patella luxation as the only identified pathology.

Radiographs were evaluated in the current study for increased soft tissue opacity of the stifle joint causing cranial displacement of the infrapatellar fat pad. This finding may be consistent with effusion or synovial hyperplasia, while other differentials including neoplasia or other soft-tissue structural changes/pathologies were considered less likely following joint exploration.[22] Differentials including septic arthritis, immune-mediated polyarthropathy and other polyarthropathies cannot be excluded as joint fluid analysis was not performed. However, these are considered less likely given the absence of joint pathology noted during arthrotomy, along with the initial history and presenting clinical signs.

Both synovitis and effusion are anticipated when joint pathology is present. While stifle effusion is often linked to cruciate disease, there is evidence to support that patellar luxation also contributes to joint inflammation and secondary OA.[19,25] Patellar instability causes altered biomechanics across the joint surface causing abnormal cartilage wear leading to erosive lesions.[25] Similar to the correction of femorotibial joint instability associated with a CCLR, it is possible providing stabilization of the patellofemoral joint via surgical repair may slow the progression of OA over time.[17] Further studies are justified to explore this potential.

Synovial hyperplasia is secondary to synovitis and may be appreciated as increased soft tissue opacity of the stifle joint as previously mentioned. It has been proposed that synovitis may precede and contribute to the development of CCL disease.[18] A similar association between synovitis and patella luxation has yet to be evaluated in veterinary medicine. Synovial changes and pathology were not routinely reported in the evaluated surgery reports, and histopathology was not performed, therefore differentiating effusion and synovial hyperplasia was not possible in the current study.

This study found that for every 1 kg increase in bodyweight there was a 10% increased risk in having increased radiographic soft tissue opacity in the stifle. A similar result was observed by Ramirez-Flores et al. in dogs presenting with acute or chronic onset of unilateral limping as a result of stifle joint instability confirmed via positive cranial drawer sign or patella luxation.[24] That study reported dogs weighing more than 10 kg were associated with twice the risk of having evidence of OA in the stifle joint based upon results of orthopedic, radiographic, ultrasonographic and arthroscopic examinations.[24] Other literature suggests that heavier dogs with congenital medial patellar luxation or dogs with grade IV luxation have larger cartilage lesions on the patella articular surface.[25] While damage to the patellofemoral cartilage is most likely present in most cases of patella luxation,[25] cartilage wear was not routinely documented in the surgical reports evaluated in this cohort of dogs, therefore making it impossible to assess in this study. Abnormal wear of articular cartilage causes an increased recruitment of inflammatory mediators and likely leads to the observed increase in intra-articular radiographic soft tissue opacity in this population of dogs.[26]

This study found no significant relationship between increased soft tissue opacity within the stifle joint, the grade of patellar luxation, or the duration of clinical signs. It was the authors' expectation that more dynamic patella luxations, such as grades II or III, would increase cartilage damage and soft tissue trauma, leading to effusion and/or synovial hyperplasia in this population. In the current study, most cases had grade II or III patella luxations, consistent with the clinical decision to pursue surgical correction, which therefore prevented the ability for this study to adequately evaluate this hypothesis. Greater case numbers would be required to more thoroughly evaluate any association between increased soft tissue opacity within the joint and grade of luxation.

Out of the eight dogs that had bilateral patella luxations, 6/8 (75%) underwent staged instead of single-session bilateral surgeries. Unilateral versus bilateral patella luxations were not statistically analyzed as it was not the aim of the study and did not impact radiographic interpretation. Age subdivisions selected for this study were based on skeletal maturity and weight was subjectively categorized into the following groups, toy/small, medium, large, and giant breeds.

Four dogs in the study developed CCLRs after surgery. It is possible that degenerative cruciate disease was present and missed at the time of surgery. However, this is considered less likely given 2/4 (50%) of dogs had no increase in soft tissue opacity within the stifle joint before surgery, and there was prolonged time (2–5 years) between surgery and the reported CCLR. Although all dogs involved in this study underwent direct examination of the CCL via arthrotomy, there is a possibility that damage to the ligament was not appreciated at time of surgery. Arthrotomy was performed in these patients per surgeon preference and because arthrotomy was performed for the trochleoplasty procedure. Arthroscopy remains the diagnostic tool of choice for assessment of stifle intraarticular soft tissue structures in humans and veterinary medicine, allowing for magnification to appreciate more subtle pathology.[27,28] A thorough assessment of the CCL at time of patella luxation correction is recommended regardless of the presence or absence of stifle effusion.[7]

This study was limited by its retrospective nature and limitations of the data present in the medical records. Lameness evaluation and muscle atrophy were consistently stated in the physical examination record but rarely graded or measured on an objective scale. These findings should therefore be interpreted with caution, particularly given the small sample size and multiple evaluators. In this study, body condition score was not regularly noted in the medical record and therefore could not be evaluated. Further studies would be required to investigate this potential association for dogs with patella luxation.

The follow-up provided was limited, and subsequent cruciate pathology may have been diagnosed elsewhere. Follow-up was not sought after for clients that did not voluntarily return to the hospital and referring veterinarians were not contacted for long-term follow up from the time of presentation. The criteria with which stifle effusion and the presence of OA were determined were standardized via the American College of Veterinary Radiology and were based on multiple radiologists' reports.[22] All radiologists were from the same institution; however, interobserver agreement among radiologists was not evaluated. Additionally, differences in sample population, small sample size (type II error), sensitivity of examination of the CCL via arthrotomy versus arthroscopy, and lack of long-term follow-up for evaluation of CCL pathology could affect results.

In this study, increased soft tissue opacity was present in 65% of dogs with 46% of those dogs having also been diagnosed with radiographic OA. Risk of a dog with a patella luxation and intact CCL having increased soft tissue opacity upon evaluation of stifle radiographs was associated with increased bodyweight and the presence of OA. The findings support the need for a thorough orthopedic examination and surgical evaluation of the CCL at the time of patella luxation correction rather than making a presumption of CCL pathology based on the presence of increased radiographic stifle soft tissue opacity.

AUTHOR CONTRIBUTIONS

Hoenecke KE, BVetMed: Primary author who performed medical record search, reviewed medical records, performed data collection, drafted and revised the manuscript. Agnello KA, DVM, MS, DACVS (Small Animal), ACVSMR: Contributed to the design of the study, provided constructive reviews of the manuscript and contributed to its scientific content. Stefanovski D, BS, MS, PhD: Analyzed data for statistical significance and contributed to the statistical methods and results sections of the manuscript. Massie AM, DVM, DACVS (Small Animal): Contributed to the design of the study, data collection, provided constructive reviews of the manuscript and contributed to its scientific content. All authors provided a critical review and endorsed the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no financial support, financial or other conflict of interest of any author related to a company or product used in the report.

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