Severity of patellar luxation and frequency of concomitant cranial cruciate ligament rupture in dogs: 162 cases (2004–2007)

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Objective—To evaluate severity of medial patellar luxation (MPL) and frequency of concomitant cranial cruciate ligament rupture (CCLR) in dogs.

Design—Retrospective case series.

Animals—162 dogs (266 stifle joints).

Procedures—Medical records of 162 small-breed dogs with MPL were reviewed. Signalment, body weight, luxation grade, bilateral or unilateral MPL, CCLR, and difference in luxation grades between stifle joints were evaluated. Association between severity of MPL and CCLR was investigated.

Results—58 dogs had unilateral MPL, and 104 dogs had bilateral MPL. Dogs ranged from 8.4 months to 16.7 years of age (mean, 5.7 years), and mean body weight was 5.45 kg (12 lb). Forty-one percent of all dogs had concomitant CCLR. Mean age for dogs with MPL alone was 3.0 years, which differed significantly from mean age of dogs with MPL and concomitant CCLR (7.8 years). Dogs with grade IV MPL were significantly more likely to have concomitant CCLR than were dogs with any other grade of MPL. In dogs with bilateral MPL and unilateral CCLR, there was a significantly higher grade of luxation in the stifle joint with CCLR.

Conclusions and Clinical Relevance—Small-breed dogs with MPL and concomitant CCLR were older than were dogs with only MPL. Dogs with grade IV MPL were more likely to have CCLR than were dogs with other grades of MPL. Most dogs with concomitant CCLR had a higher MPL grade in the affected stifle joint than in the intact joint. These findings should be beneficial in client education and clinical diagnosis. (*J Am Vet Med Assoc* 2010;236:887–891)

Medial patellar luxation is one of the most common conditions affecting the stifle joint in dogs.[1–4] Small-breed dogs are 12 times as likely to be affected by MPL as are large-breed dogs.[5,6] Breed predilections have been reported for the Boston Terrier, Chihuahua, Pomeranian, Miniature Poodle, and Yorkshire Terrier.[1,4,6] In these breeds as well as in others, luxation of the patella is primarily a developmental condition, with traumatic luxation being less common.[3,7] A low-grade MPL may not result in clinical signs and frequently is an incidental finding during physical examination.[3,7]

Similarly, CCLR is a common disease affecting the stifle joint in dogs.[3,7–9] Cruciate ligament disease has been recognized in both large- and small-breed dogs, with dogs of the Miniature Poodle, Lhasa Apso, Maltese, and Pomeranian breeds being the most frequently affected small-breed dogs.[3,7,9]

Definitive causes for MPL and CCLR have not been elucidated; however, it has been suggested that they have different causes.[1–3,5] Classically, skeletal abnormalities associated with MPL are a shallow trochlear sulcus and medial displacement of the tibial tuberosity.[2,3,5] Other skeletal abnormalities suggested to contribute to this condition are genu varum, hypoplasia of the medial femoral condyle, medial bowing of the proximal portion of the tibia, coxa vara, and internal rotation of the pes.[3,7,8,10] Many causes of CCLR have been investigated, and common etiopathogeneses include trauma, age-associated degeneration of the ligament, immune-mediated disease, conformational abnormalities, and processes associated with breed, sex, and tibial plateau angle.[3,7,8]

Abbreviations

CCLR	Cranial cruciate ligament rupture
MPL	Medial patellar luxation

Patients with bilateral MPL may have clinical signs in a chronic or intermittent manner or may be completely devoid of clinical signs of the condition.[3,7,11] When a dog with chronic MPL develops an acute hind limb lameness, concomitant CCLR should be considered.[3,7] The suggested pathogenesis for dogs with MPL that develop concomitant CCLR is an increase in strain on the ligament as a result of anatomic abnormalities associated with MPL.[3,7,12] Conversely, investigators have hypothesized that dogs with CCLR with no previous history of an MPL may acquire an MPL as a result of the

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increased internal rotation of the tibia once the cranial cruciate ligament has ruptured.[3,12]

To our knowledge, there are no published studies confirming an association between the grade of MPL and frequency of CCLR in small-breed dogs. The objective of the study reported here was to determine whether there was a relationship between the grade of MPL and frequency of CCLR in a population of dogs. We hypothesized that dogs with an increase in the grade of MPL would be more likely to have a concomitant CCLR and that the grade of MPL would be greater in the stifle joint with the concomitant CCLR.

Materials and Methods

Case selection—Medical records of all dogs with patellar luxation at the Las Vegas Veterinary Referral Center from January 2004 through December 2007 were reviewed. Dogs with MPL (unilateral and bilateral) were included in the study when body weight was ≤ 15.5 kg (34.1 lb) and they were classified as small-breed dogs according to American Kennel Club standards.[13] Bilateral CCLR, concomitant or previous orthopedic diseases of the hind limbs, traumatic patellar luxation, and lateral patellar luxation were reasons for exclusion from the study population.

Medical records review—Recorded data included age, breed, sex, body weight, bilateral or unilateral MPL, direction of the luxation, bilateral or unilateral CCLR, and grade of MPL. For dogs with bilateral MPL, the difference in grade of luxation between the stifle joints was determined. All diagnoses and grading of MPL were assigned by board-certified veterinary surgeons (CLH and DRM) in accordance with the Putnam classification (**Appendix**).[3] A CCLR was diagnosed on the basis of a cranial drawer sign or tibial thrust (or both) at the initial physical examination. Surgical confirmation was made of the conditions in all dogs with MPL and concomitant CCLR. In dogs with only MPL, surgical confirmation and correction were performed by use of several surgical techniques in 165 stifle joints of 134 dogs with grade II, III, and IV patellar luxation. Dogs with grade I MPL were managed conservatively, which varied among patients but included cage confinement, administration of anti-inflammatory medications, and rehabilitation.

Statistical analysis—Fisher exact and χ^2 tests were used to determine significant univariable associations between categorical variables, including breed, sex, age, body weight, duration of lameness, unilateral or bilateral luxation, grade of luxation, concomitant CCLR, time between diagnosis of MPL and concomitant CCLR, and difference in grades between stifle joints of dogs with unilateral concomitant CCLR. Significance was set at values of $P \leq 0.05$.

Results

In all 162 dogs included in the study, MPL was considered to be a developmental condition. Of the 162 dogs, 93 were females (75 spayed) and 69 were males (56 neutered). Age ranged from 8.4 months to 16.7 years (mean, 5.7 years), and body weight ranged from 1.13 to 12.35 kg (2.49 to 27.17 lb), with a mean of 5.45 kg (12 lb). Fifty-eight dogs had unilateral MPL, and 104 dogs had bilateral MPL. The most common breeds with MPL in the study were the Chihuahua (n = 35 dogs), Yorkshire Terrier (26), and Pomeranian (15). Age of dogs with MPL alone ranged from 8.4 months to 9 years (mean, 3.0 years), and body weight of dogs with MPL alone ranged from 1.13 to 12.35 kg, with a mean of 5.45 kg. Of the 266 stifle joints included in the study, 19 were grade I, 120 were grade II, 90 were grade III, and 37 were grade IV (**Table 1**).

Of the 162 dogs with MPL, 67 had concomitant CCLR. The interval from the diagnosis of MPL to the diagnosis of CCLR ranged from 0 to 1,095 days. All of the 67 dogs, except for 2, had both conditions diagnosed at the same time. Seven of the 67 dogs with CCLR were described as having a partially torn cranial cruciate ligament or a ligament with increased laxity. There was no relationship detected between grade of luxation and full or partial tears of the cranial cruciate ligament. Breeds with MPL and concomitant CCLR were the Yorkshire Terrier (n = 22 dogs), Chihuahua (20), Bichon Frise (5), Lhasa Apso (4), Toy or Miniature Poodle (4), Pekingese (2), Pomeranian (2), Silky Terrier (2), Maltese (1), Miniature Pinscher (1), Jack Russell Terrier (1), Papillion (1), West Highland White Terrier (1), and a Terrier-type dog (1). Age of dogs with MPL and concomitant CCLR ranged from 2.1 to 16.7 years (mean, 7.8 years). Mean age of dogs with MPL and concomitant CCLR at the time of diagnosis (7.8 years) was significantly (P = 0.01) higher, compared with the mean age of dogs with only MPL at the time of diagnosis (3.0 years). Four of the 19 (21.1%) dogs with grade I MPL had a concomitant CCLR, compared with 24 of 120 (20.0%), 21 of 90 (23.3%), and 18 of 37 (48.6%) dogs with grades II, III, and IV MPL, respectively (Table 1). Stifle joints with grade IV MPL were significantly (P = 0.02) more likely to have concomitant

Table 1—Grade of MPL in 266 stifle joints of 162 small-breed dogs at time of initial examination and frequency of concomitant CCLR.

Grade of luxation	No. of stifle joints with MPL only	Surgical exploration or correction completed	No. of stifle joints with MPL and concomitant CCLR	Surgical exploration or correction completed	MPL with concomitant CCLR (%)
I	15	0	4	4	21.0
II	96	85	24	24	20.0
III	69	65	21	21	23.3
IV	19	15	18	18	48.6*

*Value differs significantly (P = 0.02) from the values for the other grades of luxation.

CCLR, compared with the likelihood for concomitant CCLR for all other grades. Dogs with grade IV MPL and concomitant CCLR were not significantly (P = 0.09) older than dogs with other grades of luxation and concomitant CCLR.

In 104 dogs with bilateral patellar luxation, 79 (76.0%) had a higher grade of luxation in the stifle joint with CCLR, 21 (20.2%) had the same grade of luxation in both stifle joints, and 4 (3.8%) had a lower grade of luxation in the stifle joint with CCLR. Dogs with MPL and concomitant CCLR were significantly (P = 0.01) more likely to have a higher grade of luxation in the stifle joint with CCLR, compared with the grade of luxation in the stifle joint without CCLR.

Discussion

The most common breeds affected with MPL in the study reported here were the Chihuahua and Yorkshire Terrier, which corroborates results of a report[14] in which there was overrepresentation of Chihuahuas. In another study,[4] the Miniature Poodle was the breed most commonly affected. This finding may be explained by the hospital population evaluated in our study.

The sex distribution for patellar luxation in the present study was a male-to-female ratio of 1:1.3, which is consistent with the ratio of 1:1.5 in small-breed dogs reported in other studies[4,7,14] but is in contrast to the sex distribution (male-to-female ratio, 1.8:1) reported in large-breed dogs.[4,15] In the present study, spayed or neutered dogs were more likely to have MPL. These findings are in agreement with those of another report[16] in which investigators detected a higher incidence of patellar luxation in spayed females.[16] The findings of the present study may be attributable to our study population, an increase in spaying and neutering, or a true increase in the prevalence of MPL in dogs that have been spayed or neutered. We believe that our study population is representative of that at most referral institutions because there is a great number of similarities between our study population and the study populations in other investigations.

In the study reported here, we hypothesized that higher grades of MPL would be associated with an increase in the frequency of concomitant CCLR. We found that dogs with grade IV MPL were significantly (P = 0.02) more likely to have concomitant CCLR than were dogs with all other grades of luxation. It has been theorized[3,4] that increased internal rotation attributable to MPL may contribute to increased strain on the cranial cruciate ligament and eventual rupture. Others[3,5] have theorized that dogs with MPL are at increased risk of developing CCLR because of malalignment of the extensor mechanism and internal rotation of the stifle joint. In the present study, no significant association was detected between MPL grades ≤ III and the frequency of CCLR. The lack of an association between grades I to III and frequency of CCLR may have been attributable to a number of reasons. First, there may not have been a sufficient number of dogs in this investigation to enable us to detect significant differences (type II error). Second, the subjectivity of grading patellar luxation may have obscured the results. Third, complete loss of the extensor mechanism and stability within the stifle joint as a result of grade IV MPL may be needed to create sufficient strain within the joint to lead to CCLR. Finally, there may not have been an association between MPL and concomitant CCLR. The cause for the associations detected in this study cannot be elucidated from the data alone; therefore, the authors can only speculate on how CCLR may be associated with severe patellar luxation.

Because of similarities in structural and functional aspects between the patellofemoral joint in humans and dogs,[17–20] conclusions can be made as to the basic functions of the patellofemoral articulation. The patellofemoral joint serves to greatly increase the mechanical efficiency of the quadriceps muscle group,[7] facilitate extensor function,[7] centralize the forces of the different quadriceps muscle bellies, and provide a smooth gliding mechanism for the quadriceps muscle with little friction because of its cartilage cover[21]; it also contributes to the global stability of the stifle joint.[20] Forces on the patellofemoral joint increase during flexion as a result of lengthening of the moment arm between the line of body weight and the stifle joint and because the patellar ligament swings caudally relative to the tibia.[22] The geometric force created on the patellofemoral joint (between the quadriceps mechanism and patella ligament) must be perpendicular to the joint surfaces and caudally directed to maintain the patella in equilibrium.[22] We speculate that in grade IV MPL, there is a complete lack of the caudally directed vector force of the patellofemoral joint. The cranially directed shear force of cranial tibial translation places increased strain on the cranial cruciate ligament and may predispose the ligament to excessive forces and eventual rupture.

The cranial cruciate ligament may also be subjected to increased strain as a result of loss of the supporting structures of the stifle joint. Dogs with severe MPL may have atrophy of the supporting structures of the stifle joint as a result of severe lameness.[7] Abnormalities, such as atrophy of the vastus lateralis muscle, lateral retinaculum, and patella-femoral ligament, are reported[23] to be factors in the pathogenesis of patellar luxation in humans. Similarly, atrophy of those structures in dogs as a result of prolonged lameness attributable to severe (grade IV) patellar luxation, in combination with a lack of patellar ligament stability, may contribute to global joint instability and further strain the cranial cruciate ligament.[23]

To our knowledge, there have been no reports of the small-breed dogs most commonly affected or the sex of dogs with MPL and concomitant CCLR. In the study reported here, the Yorkshire Terrier and spayed female dogs were slightly overrepresented. The study revealed a significant association between age and concomitant CCLR. Mean age at which dogs with concomitant CCLR were identified (7.8 years) was significantly higher than the mean age of dogs in which MPL alone was identified (3.0 years). This is consistent with results of studies[3,4] in which middle-aged to older dogs with patellar luxation appeared to be at an increased risk of developing CCLR. The overall incidence of MPL with concomitant CCLR of 25% in the study reported here was higher than that in other reports[4,15,24,25]; however, those studies did not have strict exclusionary criteria with regard to breed.

It has been suggested[11] that in dogs with chronic patellar luxation, there is a progression of skeletal deformities with age, which then increases overall pathological changes in a stifle joint and grade of luxation.[11] For example, a retrospective evaluation[26] of dogs with bilateral MPL that underwent surgery revealed a similar progression of degenerative joint disease in operated and nonoperated stifle joints. It has been suggested[4] that middle-aged to older dogs with patellar luxation are at increased risk of developing CCLR. The skeletal deformities associated with chronic MPL are thought to place abnormal stress on supportive soft tissue structures of the stifle joint and cranial cruciate ligatment.[5,23] These stresses, combined with the normal progression of osteoarthrosis, joint effusion, and degenerative joint disease,[5,12,26] could account for the finding of CCLR in the older dogs with MPL in the study reported here. Because degenerative disease of the stifle joint may increase despite surgical correction of MPL,[10,26] dogs with MPL (corrected or uncorrected) may be at an increased risk for developing CCLR.[26] These theories were not explored in our study because of the extremely low number of dogs (n = 2 dogs) that developed CCLR subsequent to surgical correction of MPL.

The aforementioned bony anatomic deformities, such as genu varum, a shallow trochlear sulcus, and medial displacement of the tibial tuberosity, believed to contribute to patellar luxation may also contribute to concomitant CCLR.[3,10,16] Radiographic assessment of these abnormalities was not within the scope of the study reported here.

In the present study, 79 of 104 (76.0%) dogs with bilateral MPL had a higher grade of luxation in the stifle joint with concomitant CCLR. Although the grades of MPL have been described in detail, clinical subjectivity with regard to scoring of grades of luxation persists. The significantly higher grade of luxation in the cranial cruciate ligament–deficient stifle detected in the present study may be ascribed to the cranial translation of the tibia. Increased cranial translation of the tibia reduces the contact force of the patellofemoral joint by increasing the angle between the patellar ligament and quadriceps tendon and consequently increasing patellar laxity.[22] The increase in patellar laxity may result in a higher score for grade of luxation assigned by the examiner. Furthermore, the cranial cruciate ligament functions to counteract internal tibial rotation,[3,12] and a cranial cruciate ligament–deficient stifle joint may further displace the patella as a result of increased internal rotation.[3,12] Concomitant CCLR may also influence radiographically quantifiable factors of patellar luxation, including patella tendon angle, Q angle (defined as the angle between the vector force of the quadriceps muscle, the patella, and the patella ligament),[27] and ratio of the length of the patella tendon to the length of the patella. Further studies are warranted to investigate the effect concomitant CCLR has on these radiographic measurements.

Limitations of this study are related to its retrospective nature. Recorded data are dependent on the accuracy and completeness of the medical record entries. There was not a standardized or defined protocol for clinical examinations, and there may have been variation among the surgeons who graded the MPLs. Our criteria for inclusion were designed to minimize selection bias for breed, age, sex, or other variation and to focus the study on breeds predisposed to developmental abnormalities that lead to patellar luxation. Although we restricted our sample population to small-breed dogs, variability among dogs may have influenced the results. Grade I MPL may have been too subtle to be detected or may not have been recorded. Furthermore, surgical intervention was based on clinical judgment at the time of examination and diagnosis, rather than in accordance with a standardized protocol. For example, dogs may have had MPL at the time of initial examination but they did not undergo surgery because of a lack of clinical signs of lameness. There was no standardized protocol for follow-up examinations to determine whether dogs had future luxation episodes or CCLRs after surgical correction of the MPL. The lack of a control group prevented direct comparisons for frequency of dogs with CCLR without MPL in a similar sample population.

In conclusion, middle-aged to older dogs and dogs with grade IV MPL were at an increased risk for developing CCLR. Dogs with bilateral patellar luxation and concomitant unilateral CCLR were more likely to have a higher score for grade of luxation in the cranial cruciate ligament–deficient stifle joint. Studies are warranted to evaluate the reproducibility of the results reported here, in addition to results for follow-up monitoring, radiography, physical examination findings, and other factors that influence MPL and concomitant CCLR.

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Appendix

Grade of patellar luxation, as determined on the basis of the Putnam classification.[3]

Grade	Description
I	Patella is easily luxated with minimal pressure when the stifle joint is in full extension, but the patella returns to the femoral trochlear sulcus when released. Clinical signs are infrequent.
II	Luxation occurs when walking. Patellar luxation occurs with rotation of the paw and flexion of the stifle joint, but the patella returns to the femoral trochlear sulcus with extension of the stifle joint. Clinical signs of intermittent skipping-type lameness.
III	Patella is permanently luxated; luxation can be reduced with manual pressure.
IV	Patella is permanently luxated; luxation cannot be reduced with manual pressure.