Prevalence, treatment and outcome of patellar luxation in dogs in Italy. A retrospective multicentric study (2009-2014)

Title

Prevalence, treatment and outcome of patellar luxation in dogs in Italy A retrospective multicentric study (2009–2014)

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Keywords
Dogs, patellar luxation, prevalence

Summary

Objective: To determine the prevalence of patellar luxation in dogs in Italy and its re- lation to signalment, the frequency and the type of postoperative complications and the outcome of treatment, and to compare the findings with those of other studies.
Materials and methods: The medical records from four referral clinics were searched for dogs with orthopaedic disorders referred from 2009 to 2014. From these data, the records of dogs with patellar luxation were identified, and the signalment, age and body weight, grade, side and direction of patellar luxation, treatment, postoperative complications, and outcome were retrieved. Univariate and multivariate statistical analyses were used to evaluate the data.
Results: Of 8,694 canine orthopaedic cases, fractures not included, patellar luxation was diagnosed in 559 dogs (801 stifles). Mixed breed dogs were most commonly affected (18%), 85% of the luxations were medial, and 52% of the dogs were female. Of the 559 dogs examined, 400 (574 stifles) met the inclusion criteria for treatment evaluation. Minor complications occurred in five percent of the dogs, and major complications in 16%, including re- currence of patellar luxation in seven percent of the dogs. The outcome was good in 88% of stifles, fair in two percent, and poor in 10%.
Clinical significance: Although patellar lu- xation was more common in small breed dogs, it also was diagnosed in a significant number of large breed dogs, which included medial patellar luxation in 73% and lateral patellar luxation in 27% of stifles. Body weight and grade of luxation were the only variables stat- istically correlated with surgical complications.

Introduction

Patellar luxation is one of the most com- mon orthopaedic diseases of the canine stifle. It was ranked the seventh most com- mon orthopaedic condition in small animal practice in Great Britain, and was shown to have a prevalence of 5.4% in dogs in the United States of America (1, 2).
Medial patellar luxation is much more common than lateral luxation (92% com- pared to 8%) in both small and large breed
dogs (3–4). Lateral patellar luxation has been previously associated with large breed dogs, but a recent study by Gibbons and colleagues showed that although the preva- lence of patellar luxation in large breed dogs is increasing, lateral patellar luxation is not (5). The frequency of bilateral lu- xation varies from 50% to 93% of stifles (6). These results support the notion that con- genital factors are involved in the occur- rence of patellar luxation (7).
Patellar luxation can be classified as congenital, developmental, or traumatic depending on its time of onset. The major- ity of cases are considered developmental because they occur early in life during skel- etal growth and there is no history of trau- ma. Luxation may not be present at birth, but the anatomical deformities causing lu- xation often can be detected in puppies (8). Patellar luxation can be treated conser- vatively or repaired using a variety of surgi- cal techniques, which depend on the age and size of the dog, the grade and degree of chronicity of the luxation, and the presence of underlying limb deformities (9). Surgical techniques include capsulorrhaphy, reti- naculum release, rectus femoris transposi- tion, tibial tuberosity transposition, troch- leoplasty, patellar groove replacement, and corrective osteotomies of the tibia or femur (10-19).
To the authors' knowledge, the preva- lence and treatment of canine patellar lu- xation have not been determined in Italy. The present retrospective study collected data on patellar luxation from four veterin- ary referral clinics, which were located in different parts of Italy, to determine the prevalence of canine patellar luxation relative to the orthopaedic case load, the prevalence of patellar luxation in different breeds of dogs, the age at diagnosis, and the relationship with sex and weight of dogs. Additional aims were to determine the di- rection and degree of luxation, the frequen- cy and severity of complications after con- servative or surgical treatment in relation to the degree of luxation, and the risk fac- tors and outcomes associated with different surgical approaches.

Materials and methods

Case selection

Medical records of dogs with patellar lu- xation referred to two orthopaedic referral centres (Clinic 1: Clinica Veterinaria Vez- zoni, and Clinic 3: Clinica Veterinaria Mil- ano Sud) and to two university hospitals (Clinic 2: University of Perugia, and Clinic 4: University of Tourin) between January 2009 and December 2014 were examined retrospectively. The total number of stifles was recorded for that same time period. An affected stifle joint was defined as a case and dogs with bilateral patellar luxation were considered to be two surgical cases for the purpose of statistical analysis. All dogs that had a follow-up examination a mini- mum of two months after treatment of patellar luxation, independent of type of treatment, were included in the study. Dogs that had no record of a follow-up examination were included in the epidemiological prevalence study only. The medical records of dogs with patellar luxation were searched for breed, sex, age at diagnosis, body weight, limb affected, direction and grade of luxation, uni- or bilateral

involvement, conservative or surgical treatment(s) and complications. Dogs were divided into three categories based on their weight as defined by Priester: small = less than 9 kg, medium = 9.1 to 18 kg, and large = 18.1 kg and over (20).

Complications

Complications were considered major when a second surgical procedure was required and minor when they could be re- solved conservatively. Recurrence after sur- gical correction was considered a major complication. The population was divided into two groups (dogs with and without postoperative complications) to determine whether age and body weight had a signifi- cant effect on surgical complications.

Outcome

The outcome was considered good when primary surgical treatment resulted in pa- tellar stabilization and complete functional recovery, fair when patellar luxation recurred but was less severe than the original grade of luxation, and poor when patellar luxation recurred and was the same grade or worse.

Statistical analysis

Statistical softwarea was used for all analyses. The 10 most commonly affected breeds were included in a histogram for the epidemiological study. Dogs of other breeds were allocated to three categories according to size. Because the number of stifles for each veterinary centre was different, the percentage of dogs of each breed was used instead of real numbers. A second histogram was created to show the distribution of stifles in relation to the grade of luxation as well as the distribution of medial patellar luxation versus lateral patellar luxation among the four veterinary centres.

To determine the prevalence of medial and lateral patellar luxation in relation to sex, age and body weight, descriptive stat- istics were used. Chi-squared test, Student's t-test or Fisher's exact test was used to examine the association between categorical variables (sex, age, body weight, grade and direction of luxation, unilateral or bi- lateral luxation). Logistic regression analy- sis was used to investigate variables associated with complications, outcome, and recurrence. Kruskal-Wallis test and Mann-Whitney U test were used to analyse differ- ences in surgical techniques and in out- come. Differences were considered significant at $p < 0.05$.

Results

Prevalence

Of 8,694 canine orthopaedic cases seen during the six-year period, there were 801 cases of patellar luxation in 559 dogs re- sulting in an overall prevalence of patellar luxation of 9.2% (Clinic 1: 10%, Clinic 2: 12%, Clinic 3: 8%, Clinic 4: 5%).

Signalment

Dogs with patellar luxation ranged in age from three months to 15 years (mean age: 31.1 months); 43% were less than one year of age, 30% were one to three years, and 27% were more than three-years-old. Small breeds comprised 47% of the population, medium-sized breeds 22%, and large breeds 31%. The female-to-male ratio was 1:1.1; 48% were male and 52% were female dogs (**Table 1)**. Bilateral patellar luxation was diagnosed in 43% of the dogs and uni- lateral patellar luxation in 57%. Medial pa- tellar luxation was seen in 85% of the stifles and lateral patellar luxation in 15%. The se- verity of patellar luxation was classified as grade 1 in 110 stifles (14%), grade 2 in 371 stifles

(46%), grade 3 in 214 stifles (27%), and grade 4 in 106 stifles (13%). Grades 2 and 3 patellar luxation predominated in all groups of dogs.
Patellar luxation was diagnosed in 73 breeds of dogs. The most common breeds in descending order were mixed-breed dog (19.6%), Cavalier King Charles Spaniel (7.5%), Miniature Pinscher (6.6%), Chi- huahua (6.2%), Miniature or Toy Poodle (5.4%), Labrador Retriever (4.7%), German Shepherd Dog (3.7%), English Bulldog and Yorkshire Terrier (3.1%), and Boxer (3%). Each of the remaining 63 breeds had a fre- quency of less than three percent and were included in one of the three groups accord- ing to body size **(Figure 1)**.

Treatment

Of the 559 dogs (801 stifles) examined, 400 dogs (574 stifles) met the inclusion criteria. Forty dogs (64 stifles) underwent medical management and restricted exercise, and 360 dogs (510 stifles) underwent single session surgical repair of patellar luxation, which was unilateral in 58% and bilateral in 42% of the cases.
Conservative treatment was the most common therapeutic choice for grade 1 pa- tellar luxation (60%). Transposition of the tibial tuberosity, trochleoplasty, or overlap- ping capsulorrhaphy were the most em- ployed treatment options, alone or in com- bination, for grade 2 patellar luxation (re- spectively 52%, 50% and 50%) and for grade 3 patellar luxation (respectively 28%, 32% and 31%).
Corrective osteotomy of the tibia or femur, in combination with either troch- leoplasty or patellar groove replacement were used in 38% of grade 3 patellar luxation and in 33% of grade 4 patellar lu-xation.

Complications

The overall frequency of major compli- cations after surgical correction was 16%. Recurrence of luxation was the most com- mon major complication (7%; 35% of all complications) and had the highest fre- quency of 11% in grade 3 patellar luxation. There was a significant correlation ($p = 0.01$) between the frequency of major com- plications and grade of patellar luxation, but not between complication and sex and side of luxation. The highest prevalence of major complications was 24% in grade 3 patellar luxation and 15% in grade 4 patel- lar luxation. Other major complications were implant failure (2.1%), cranial cru- ciate ligament rupture (1.2%), improper correction of limb deformities (0.9%), tibial tuberosity avulsion (0.7%), wound dehis- cence (0.7%), fracture of the tibia or femur (0.7%), patellar ligament laceration (0.5%), infection (0.5%), non-union of the femur (0.4%), improper soft tissues release (0.4%), lysis of the fracture site (0.4%), and peroneal neurapraxia (0.3%).
There was a five percent frequency of minor complications, which were most common in grade 1 (9%) and grade 4 patel- lar luxation (8%). Minor complications in- cluded infection ($n = 7$), delayed union of corrective distal femoral osteotomy ($n = 4$), delayed functional recovery ($n = 4$), pin migration ($n = 2$), muscle contracture ($n = 2$), and arthrosynovitis ($n = 2$).
The population was divided into two groups. Dogs with complications (147 of 400 dogs, 37%) and without complications (253 dogs, 63%) to determine whether age and body weight significantly affected sur- gical complications. Body weight was the only variable significantly associated with complications; the body weight of dogs without complications was significantly less than that of dogs with complications ($p = 0.003$). Logistic regression was used to deter- mine the effect of different variables on the outcome of the various surgical procedur- es. There was no correlation between re-currence and independent predictors (sex, age, body weight and side of luxation) but there was a significant correlation between body weight and the occurrence of compli- cations ($p = 0.0035$). Eighteen different surgical approaches were identified, and each

combination of surgical corrections was evaluated in relation to the grade of lu-xation. There were no complications in 79% of stifles re-evaluated at a minimum of two months postoperatively. Of the 109 stifles with complications, 83 were major requiring an additional surgical intervention, and 26 were minor and did not require a further operation **(Table 2).**

The most common repair techniques for each grade of patellar luxation and their complications are shown in **Table 3.**

In grade 1, 3 and 4 patellar luxation, there were no differences in the rate of re- currence among the most common types of surgical treatments. In grade 2 patellar luxation, chi-square analysis showed a sig- nificant association between recurrence rate and surgical treatment, particularly transposition of the tibial tuberosity only and transposition of the tibial tuberosity with capsulorraphy and trochleoplasty ($p = 0.002$).

Outcome

The best surgical results were achieved in grade 1 (92%) and grade 2 (92%) patellar luxation. The frequency of poor outcome was 17% in grade 3 and 12% in grade 4 patellar luxation. The prevalence of fair out- come was inversely proportional to the grade of patellar luxation **(Table 4).**

There were no significant associations between independent predictors (sex, age, body weight and side of luxation) and the outcome scores. To better understand the frequency of good, fair and poor outcome in relation to the surgical technique, the two most com- monly used surgical techniques were con- sidered for each grade of patellar luxation **(Table 5)**.

In grade 1 patellar luxation, transposition of the tibial tuberosity with capsulorrhaphy resulted in a good outcome in 100% of stifles. In grade 2 patellar luxation, both transposition of the tibial tuberosity com- bined with trochleoplasty, and transposition of the tibial tuberosity combined with cap-sulorrhaphy and trochleoplasty, had good outcomes (94% and 97% of stifles). The highest prevalence of poor outcomes oc- curred in grade 3 patellar luxation that did not undergo a corrective osteotomy; this re- sulted in a failure of 18% of stifles. In grade 4 patellar luxation treated with corrective os- teotomy together with trochleoplasty, recurrence of luxation (9%) was similar to those treated with traditional techniques (trans- position of the tibial tuberosity, capsulorrhaphy, and trochleoplasty; 10%).

Discussion

The prevalence of patellar luxation in dogs with orthopaedic disorders in four veterin- ary practices in Italy was 9.2% during a six year period, which was considerably higher than the prevalence of 5.4% observed in a study from the USA during a 10 year peri- od conducted in 10 veterinary teaching hospitals (2). It is possible that the preva- lence of patellar luxation calculated in the present study was inflated due to a different breed distribution between the American and Italian dog owners.

Studies on the relationship between the age of the dog and prevalence of patellar lu-xation are conflicting. In agreement with the findings from Hayes and colleagues, we reported diagnosis of patellar luxation at an earlier age in large breed dogs compared to medium and small breeds **(Figure 2)** (21). Among our dogs, those less than one year of age formed the largest group, whereas the groups of one to three years and older than three years were of similar size. It is not surprising that patellar lu- xation manifests relatively early in life in dogs predisposed to this condition. How- ever, another study reported a positive cor- relation between age and the occurrence of patellar luxation, and that the prevalence of patellar luxation increased 1.1-fold with every additional year (22).

Large-breed dogs weighing a minimum of 18 kg made up 31% of patellar luxation stifles in the present study. Our results dif- fered from those reported in a study by Bound and colleagues in which large-breed dogs (43% of that study population) had a higher prevalence of patellar luxation than dogs of small breeds (3). Even though lat- eral patellar luxation has always been con- sidered more common in medium and large breeds, a number of studies have found that the prevalence of medial patellar luxation is greater in these breeds (11, 21, 23, 24). In the present study, 75% of dogs with medial patellar luxation belonged to small and medium-sized breeds. This was in agreement with reports of an inverse rela- tionship between body weight and the probability of developing patellar luxation (20, 22). The distribution of lateral patellar luxation was 20% in small breeds, 24% in medium-sized breeds, and 56% in large breeds. Again, our results contrast those of Bound and colleagues, in which only 10% of dogs with lateral patellar luxation were small breeds and 70% were large and giant breeds (3). Our investigation found that in large-breed dogs with patellar luxation, 73% had medial luxation, and 27% had lateral luxation. The prevalence of medial patellar lu- xation in our study was high at 85% and the prevalence of lateral patellar luxation was low at 15%; however, the latter was higher than the rates reported by Hayes and colleagues (2%) and Bound and col- leauges (8%) (3, 21). The majority of cases of lateral patellar luxation in our study oc- curred in large-breed dogs (67 of 124 stifles), which is in agreement with the findings of others (5, 10, 33). Older studies found that unilateral pa- tellar luxation was more common in dogs, but recent research has shown that the prevalence of bilateral patellar luxation is higher (21, 23-26). By contrast, the fre- quency of unilateral patellar luxation (57%) was slightly higher than that of bi- lateral patellar luxation (43%) in the pres- ent study.

Mixed-breed dogs and Cavalier King Charles Spaniels (7.5%) had a relatively high prevalence of patellar luxation. Other studies determined that Toy Poodles, Boston Terriers, Chihuahuas, Yorkshire Ter- riers, and Pomeranians were breeds with the highest predisposition for patellar lu-xation (21, 27). Hayes and colleagues re- ported a low prevalence of patellar luxation for mixed-breed dogs (4.8%), whereas our study found that mixed-breed dogs repre- sented 19.6% of the population of ortho- paedic patients (21). LaFond and col- leagues reported a high prevalence of patel- lar luxation in Toy Poodles (19.7%), which is in contrast to the results of our study in which this breed comprised only 5.4% of the affected dogs (2). Labrador Retrievers had the highest prevalence of patellar luxation in the study conducted by Bound and colleagues, but were ranked sixth in our study (3). The divergence of these results probably reflects differences in the popularity of dog breeds among countries. Studies investigating the association be- tween sex and patellar luxation in dogs have generated conflicting results; some have reported a higher prevalence in males, while others have shown a higher preva- lence in females (5, 20, 21, 24, 28, 30). We found no significant difference in the prevalence of patellar luxation in females and males (1.1:1), which was in agreement with other recent studies (3, 26). We calculated a higher prevalence for grade 2 (46%) and grade 3 (26%) patellar luxation than for grades 1 and 4, which is in agreement with the findings of Hayes and colleagues (23). The low prevalence of grade 1 patellar luxation (13%) may have been a reflection of the caseload of referral centres, where usually the most severe cases are diagnosed. The frequency of complications re- ported after treatment using traditional re- pair techniques varies from 18% to 48% (29). The most frequent complications in- clude recurrence of luxation, implant fail- ure, wound dehiscence, arthrosynovitis, pin migration, avulsion fractures, and defi- ciency of the stifle extensor mechanism (31, 32).

There are no guidelines for selecting the type of surgical procedure that will best reduce the prevalence of recurrence in a given case of patellar luxation. Surgical guidelines are subjective and influenced by the conditions associated with patellar lu- xation, such as the age and body weight of the dog, direction and chronicity of luxation, and underlying skeletal alterations (9).

Grade 1 patellar luxation is usually treated conservatively when it is not ac- companied by clinical signs (5). Of the 40 dogs (68 stifles) treated conservatively in our study, worsening of the grade of patel- lar luxation was seen in three (4 stifles) at the following check-up. Because they were all younger than one year of age, corrective surgery may have been more beneficial than conservative therapy. Traditional surgical repair techniques usually are chosen in grade 2 and 3 patellar luxation, whereas corrective osteotomies of the distal femur, proximal tibia, or a combination of both may be required in grade 4, but occasion- ally also in grade 3 patellar luxation (8, 27). Trochleoplasty, overlapping capsulorrhaphy, and transposition of the tibial tube- rosity were the most common surgical pro- cedures carried out in dogs with grade 2 and 3 patellar luxation, which is in agree- ment with the results of another study done in 2014 (6). In contrast to the study of Shaver and colleagues, we used corrective osteotomies not only in dogs with grade 4 patellar luxation but also in those with grade 3 patellar luxation (68 stifles) (34). The highest prevalence of poor outcome was reported in dogs with grade 3 patellar luxation that did not undergo corrective osteotomy. The outcome of grade 3 and 4 patellar luxation could have been in- fluenced by the underlying skeletal abnormalities over surgical technique employed. Unfortunately, the underlying skeletal abnormalities were not included in the available data. Complications occurred in 21% of stifles (109); 16% (83 stifles) were major complications, including recurrence of pa- tellar luxation (7%, 38 stifles) required sur- gical revision, and five percent (26 stifles) were minor complications. These findings were in general agreement with the results of Clerfond and colleagues (6).

Shaver and colleagues reported that the rate of complications after surgical correc- tion of patellar luxation is greater in hea- vier dogs than in lighter dogs (34). This is in agreement with the results of the present study, which showed a significant differ- ence between the rate of complications in small and large breeds. We found that age was not a risk factor for the development of complications after surgical correction of patellar luxation, which supports the find- ings of recent studies (4).

There was no significant difference in recurrence or outcome among the most commonly used combinations of surgical techniques for repair of the different grades of patellar luxation except for patellar luxation grade 2, in which treatment was significantly associated with the frequency of complications.

Consistent with other studies, a satisfac- tory outcome was achieved in 88% of all stifles (n = 449) in the present study and in 92% of stifles with grade 1 (41 out of 45) and 2 patellar luxation (223 out of 242) (29, 30). A good outcome was reported in 100% of stifles with grade 1 patellar luxation treated with transposition of the tibial tuberosity and overlapping capsulorrhaphy, even though minor complications oc- curred in eight percent of those stifles. In the majority of the 38 cases that had recurrence of patellar luxation after surgical correction, the owners declined a sec- ond surgical procedure for financial rea- sons or because they felt that the clinical signs did not warrant further treatment. Nevertheless, nine owners agreed to a sec- ond corrective surgery, and the outcome was good in eight of these cases that were re-evaluated two months postoperatively. The outcome in the other case was fair.

While the data collected from four veterinary referral centres in different areas of the Country with large orthopaedic case-loads may reflect the general prevalence of patellar luxation in Italy, collection of data from numerous veterinary clinics around the country would have given a more pre- cise picture of the epidemiology and prevalence of patellar luxation. It was not possi- ble to determine the underlying skeletal ab- normalities in each dog and correlate them with the surgical treatment and outcome. Those data would have provided a better understanding of the prevalence of recurrence of patellar luxation after surgical treatment. Risk factors such as age, sex, body weight and breed would have been deter- mined more precisely by including a con- trol population. In turn, this would have allowed comparison with other case- control studies.

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Author Contributions

AV was responsible for conception and de- sign of the study. FB, AB, BP, and MP were responsible for data acquisition while FB and AV were responsible for data analysis and interpretation. All authors were in- volved in the drafting and revising of the manuscript and all approved the submitted version.

References

1.Ness MG, Abercrombie RH, May C, et al. A survey of orthopaedic conditions in small animal veterinary practice in Britain. Vet Comp Orthop Trauma- tol 1996; 9: 43–52.

2. LaFond E, Breur GJ, Austin CC. Breed susceptibil- ity for developmental orthopaedic diseases in dogs. J Am Anim Hosp Assoc 2002; 38: 467–477.

3. Bound N, Zakai D, Butterworth SJ, et al. The prevalence of canine patellar luxation in three centres. Vet Comp Orthop Traumatol 2008; 22: 32–37.

4. Wangdee C, Theyse LF, Techakumphu M, et al. Evaluation of surgical treatment of medial patellar luxation in Pomeranian dogs. Vet Comp Orthop Traumatol 2013; 26: 435–439.

5. Gibbons SE, Macias C, Tonzing MA, et al. Patellar luxation in 70 large breed dogs. J Small Anim Pract 2006; 47: 3–9.

6. Clerfond P, Huneault L, Dupuis J, et al. Unilateral or single-session bilateral surgery for correction of medial patellar luxation in small dogs: short and long-term outcomes. Vet Comp Orthop Traumatol 2014; 27: 484-490.

7. Cashmore RG, Havlicek M, Perkins NR, et al. Major complications and risk factors associated with surgical correction of congenital medial pa- tellar luxation in 124 dogs. Vet Comp Orthop Traumatol 2014; 27: 263-270.

8. L'Eplattenier H, Montavon P. Patellar luxation in dogs and cats: Management and prevention. Com- pendium on Continuing Education for the Practis- ing Veterinarian 2002; 24: 292–298.

9. Vezzoni A. Decision making in patellar luxation. In: Proceedings of the First Latin American Con- gress of Veterinary Traumatology, Orthopaedics and Veterinary Imaging. 2014 September 11–14; Santiago, Chile.

10. Campbell JR, Pond MJ. Capsular overlap for lu- xated patella. Modern Vet Pract 1972; 53: 44.

11. Harasen, G. Patellar luxation: pathogenesis and surgical correction. Canadian Vet J 2006; 47: 1037–1039.

12. Read R. Rational treatment options for medial pa- tellar luxation. Waltham Focus 1999; 9: 25–31.

13. Singleton WB. Surgical correction of stifle deform-ities in the dog. J Small Anim Pract

1969; 10: 59–69.

14. Yap FW, Calvo I, Smith KD, et al. Perioperative risk factors for surgical site infection in tibial tube- rosity advancement: 224 stifles. Vet Comp Orthop Traumatol 2015; 3: 199–206.

15. Boone EG, Hohn RB, Weisbrode SE. Trochlear re- cession wedge technique for patellar luxation: An experimental study. J Am Anim Hosp Assoc 1983; 19: 735–742.

16. Johnson AL, Probst CW, Decamp CE, et al. Com- parison of trochlear block recession and trochlear wedge recession foLr canine patellar luxation using a cadaver model. Vet Surg 2001; 30: 140–150.

17. Vezzoni A. Patellar groove prosthesis. In: Proceed- ings of the 15th Annual ESVOT Congress: Seminar on Patellar Luxation. 2011 October 22; Lyon, France. pg. 64–67.

18. Roch SP, Gemmill TJ. Treatment of medial patellar luxation by femoral closing wedge ostectomy using a distal femoral plate in four dogs. J Small Anim Pract 2008; 3: 152–158.

19. Petazzoni M. Corrective osteotomies in treating patellar luxation in large breed dogs. Proceedings of the European College of Veterinary Surgeons Annual Scientific Meeting. 2014 July 3-5; Copenhagen, Denmark. pg. 175-176.

20. Priester WA. Sex, size and breed as risk factors in canine patellar dislocation. J Am Vet Medical Assoc 1972; 160: 740–742.

21. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing; 2013; Vienna, Austria. ISBN 3–900051–07–0, URL http://www.R-project.org/

22. Vidoni B, Sommerfeld-Stur I, Eisenmenger E. Diagnostic and genetic aspects of patellar luxation in small and miniature breed dogs in Austria. Wien Tierärztl Monatsschr 2006; 92: 170–181.

23. Hayes AG, Boudrieau RJ, Hungerford IL. Frequen- cy and distribution of of medial and lateral patellar luxation in dogs: 124 cases. J Am Vet Med Assoc 1994; 205: 716–720.

24. Piermattei DL, Flo GL. The stifle joint. In: Hand- book of Small Animal Orthopaedics and Fracture Repair. 3rd ed. Philadelphia, PA: Saunders; 1977. pg. 516–534.

25. Remedios AM, Basher AWP, Runyon CL, et al. Medial patellar luxation in 16 large dogs. A retro- spective study. Vet Surg 1994; 21: 5–9.

26. Nunamaker DM. Patellar luxation. In: Newton CD, Nunamaker DM, editors. Textbook of Small Animal Orthopaedics. Philadelphia: JB Lippincott Co; 1985. pg. 941-947.

27. Robins GM. The canine stifle joint. In: Canine Or- thopaedics. Whittick WG, editor. 2nd ed. Philad- elphia: Lea & Febiger; 1990. pg. 693–760.

28. Hulse DA. Pathophysiology and management of medial patellar luxation in the dog. Vet Med Small Anim Clinic 1981; 76: 43–51.

29. Arthurs GI, Langley-Hobbs SJ. Patellar luxation as a complication of surgical intervention for the management of cranial cruciate ligament rupture in dogs. A retrospective study of 32 cases. Vet Comp Orthop Traumatol 2007; 20: 204–210.

30. Arthurs GI, Langley-Hobbs SJ. Complications as- sociated with corrective surgery for patellar lu- xation in 109 dogs. Vet Surg 2005; 35: 559–566.

31. DeAngelis M, Hohn RB. Evaluation of surgical correction of canine patellar luxation in 142 cases. J Am Vet Medical Assoc 1970; 156: 587–594.

32. Willauer CC, Vasseur PB. Clinical results of surgi- cal correction of medial luxation of the patella in dogs. Vet Surg 1987; 16: 31–36.

33. Alam MR, Lee JI, Kang HS, et al. Frequency and distribution of patellar luxation in dogs: 134 cases (2000–2005). Vet Comp Orthop Traumatol 2007; 20: 59–64.

34. Shaver SL, Mayhew KN, Sutton JS, et al. Compli- cations after corrective surgery for lateral patellar luxation in dogs:36 cases (2000–2011). J Am Vet Med Assoc 2014; 4: 444–448.

Legends of figures and tables

Figure 1
Breed distribution of dogs with patellar luxation seen at four referral centres because of orthopaedic problems (CKCS = Cavalier King Charles Spaniel).

Figure 2
Median age at diagnosis of patellar luxation in large breed dogs compared to medium and small breeds.

Table 1
Distribution of dogs with medial patellar luxation and with lateral patellar luxation according to sex, age and body size.

Table 2
Frequency of postsurgical complications (n = 109 stifles) in dogs in relation to different grades of patellar luxation (n = 510 stifles).

Table 3
Most employed repair techniques used in dogs with different grades of patellar luxation and their frequency of complications. The percentage of treatment performed for each combination of techniques is correlated to the total number of surgeries for each grade

Table 4
Surgical outcome in dogs with different grades of patellar luxation, regardless of the treatment performed in the 510 stifles surgically treated

Table 5
Surgical outcome of the two most employed repair technique(s) amongst all of the different techniques used, performed in different grades of patellar luxation, for 199 dogs

Tables and figures

Figure 1

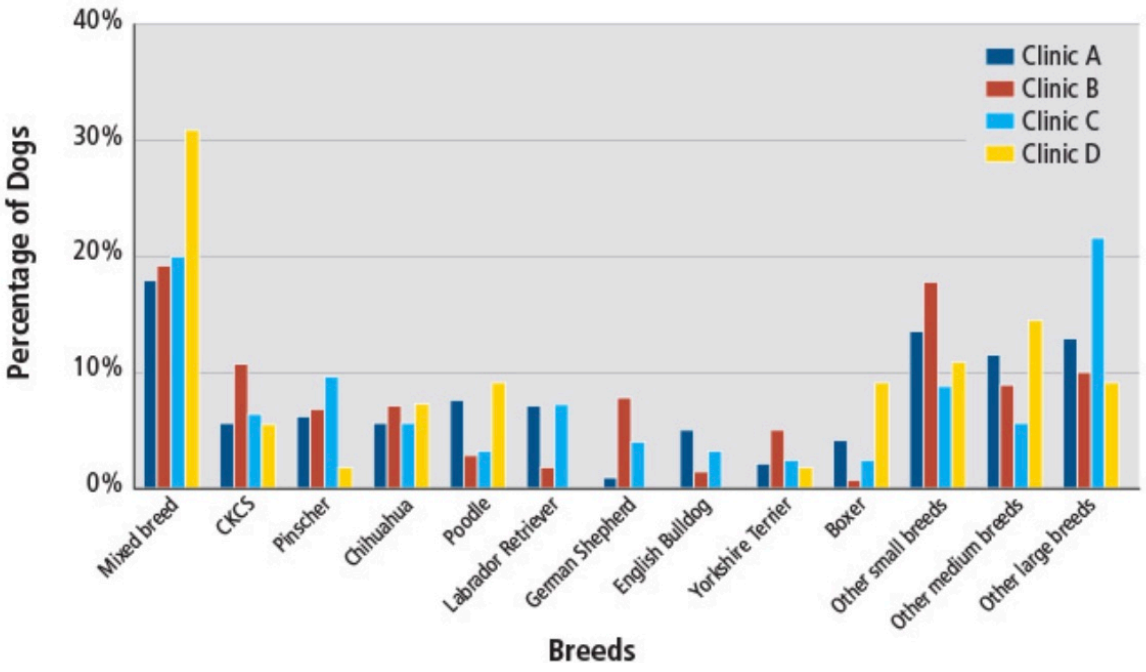

Figure 2

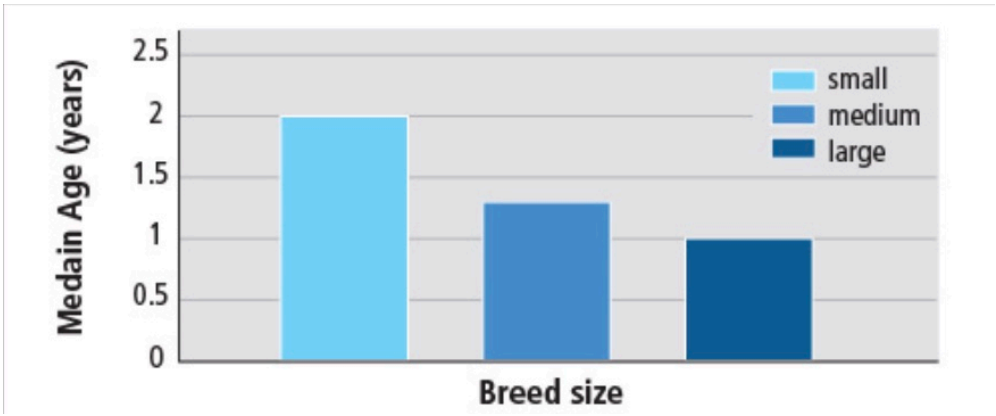

Table 1

	Medial patellar luxation (474 dogs or 85%)			Lateral patellar luxation (85 dogs or 15%)			Total (559 dogs)
	Unilateral	Bilateral	Total	Unilateral	Bilateral	Total	
Female	138 (29%)	118 (25%)	256 (54%)	19 (22%)	18 (21%)	37 (43%)	293 (52%)
Male	133 (28%)	85 (18%)	218 (46%)	27 (32%)	21 (25%)	48 (57%)	266 (48%)
<1 year	94 (20%)	95 (20%)	189 (40%)	27 (32%)	24 (28%)	51 (60%)	240 (43%)
1–3 years	91 (19%)	61 (13%)	152 (32%)	7 (8%)	7 (8%)	14 (16%)	166 (30%)
>3 years	86 (18%)	47 (10%)	133 (28%)	12 (14%)	8 (9%)	20 (23%)	153 (27%)
Small (≤9 Kg)	123 (26%)	123 (26%)	246 (52%)	7 (8%)	10 (12%)	17 (20%)	263 (47%)
Medium (9.1 – 18 Kg)	55 (11%)	46 (10%)	101 (21%)	10 (12%)	10 (12%)	20 (24%)	121 (22%)
Large (≥18.1 Kg)	93 (20%)	34 (7%)	127 (27%)	29 (34%)	19 (22%)	48 (56%)	175 (31%)

Table 2

Complications		Grade 1	Grade 2	Grade 3	Grade 4	Total
Major	Total number	6 (13%)	30 (12%)	36 (24%)	11 (15%)	83 (16%)
	Number with recurrence of patellar luxation	0	16 (7%)	17 (11%)	5 (7%)	38 (7%)
Minor		4 (9%)	10 (4%)	6 (4%)	6 (8%)	26 (5%)
None		35 (78%)	202 (84%)	107 (72%)	57 (77%)	401 (79%)
Total		45	242	149	74	510

Table 3

Grade	Treatment options	% treatments performed	Minor complications	Major complications	
				Total % of major complications	Recurrence of luxation
1	TTT + CAPS	30%	8.3%	0%	0%
	TTT	27.5%	0%	18%	0%
2	TTT + CAPS + TROCH	29.8%	0%	5.8%	4.1%
	TTT + TROCH	17.5%	2.5%	2.5%	2.5%
	TTT + CAPS	12.7%	0%	24%	10%
	CAPS + TROCH	10.1%	8.6%	4.3%	4.3%
	TTT	8.8%	5%	30%	15%
3	TTT + CAPS + TROCH	23.4%	5.8%	14.7%	11.7%
	TTT + CAPS	9%	0%	23%	23%
	TROCH + CO	9%	23%	15.3%	0%
	CAPS + TROCH	8.3%	0%	16%	8.3%
	TTT + TROCH	7.6%	0%	36%	0%
4	TROCH + CO	18.6%	9%	27%	9%
	TTT + CAPS + TROCH	16.9%	20%	10%	10%

TTT = transposition of the tibial tuberosity; CAPS = capsulorrhapy; TROCH = trochleoplasty; CO = corrective osteotomy.

Table 4

Outcome	Grade 1	Grade 2	Grade 3	Grade 4	Total
Good	41 (92%)	223 (92%)	121 (81%)	64 (87%)	449 (88%)
Fair	2 (4%)	5 (2%)	3 (2%)	1 (1%)	11 (2%)
Poor	2 (4%)	14 (6%)	25 (17%)	9 (12%)	50 (10%)
Total	45	242	149	74	510 stifles

Table 5

Outcome	Grade 1		Grade 2		Grade 3		Grade 4	
	TTT	TTT + CAPS	TTT + CAPS + TROCH	TTT + TROCH	TTT + CAPS + TROCH	TROCH + CO	TTT + CAPS + TROCH	TROCH + CO
Good	9 (82%)	12 (100%)	64 (94%)	39 (97%)	28 (82%)	13 (100%)	9 (90%)	8 (73%)
Fair	1 (9%)	0	0	0	0	0	0	2 (18%)
Poor	1 (9%)	0	4 (6%)	1 (3%)	6 (18%)	0	1 (10%)	1 (9%)
Total dogs	11	12	68	40	34	13	10	11

TTT = transposition of the tibial tuberosity; CAPS = capsulorrhapy; TROCH = trochleoplasty; CO = corrective osteotomy.

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