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Patellar Luxation in Dogs and Cats: Pathogenesis and Diagnosis

KEY FACTS

- Medial patellar luxation occurs more frequently than lateral patellar luxation in dogs, regardless of the size of the animal.
- Optimal contact between the patella and femoral trochlea is essential for adequate supply of articular cartilage with nutrients from joint fluid.
- Radiographs are not necessary for the diagnosis of patellar luxation but are useful to document the degree of skeletal deformity and osteoarthritis.

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ABSTRACT: Patellar luxation can be either medial or lateral and is one of the most common orthopedic diseases of the hindlimb in dogs. The condition is most often congenital and associated with varying degrees of skeletal deformity of the femur and tibia. It is suggested that an abnormal conformation of the hip joint or pelvis is the origin of the disease. The condition is less common in cats. Patellar luxations can be classified into four grades of severity. Diagnosis is based mainly on palpation of the affected stifle and patella.

Patellar luxation is one of the most common orthopedic conditions in dogs. More than 75% of the luxations in dogs are medial luxations, whereas less than a quarter of affected dogs have lateral luxations.[1] Cats can also be affected, although the incidence is clearly lower than in dogs.[2] Medial patellar luxation is a frequent congenital abnormality in toy- and miniature-breed dogs.[2–4] Females appear to be more at risk for patellar luxations than males.[5–7] Breeds showing a predisposition for medial patellar luxation include miniature and toy poodles, Yorkshire terriers, Pomeranians, Pekingese, Chihuahuas, and Boston terriers.[5,6] Medial patellar luxations, however, also occur in large-breed dogs[8] and are more common than lateral patellar luxations, regardless of the dog's size.[9] Lateral patellar luxation is seen more often in larger dogs but can occur in dogs of all sizes.[1] Occasionally, both medial and lateral patellar luxation can occur in the same stifle. This article reviews the anatomy and biomechanics of the patella as well as the pathogenesis and diagnosis of patellar luxation.

ANATOMY AND BIOMECHANICS

Situated within the tendon of insertion of the quadriceps muscle group,[10] the patella is the largest sesamoid bone in the body. The portion of the tendon that

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lies between the distal aspect of the patella and the tibial tuberosity is known as the patellar ligament. The caudal surface of the patella articulates with the distal end of the femur, and on each side of the patella the parapatellar fibrocartilages articulate with the ridges of the femoral condyles. The patella is held in place in the trochlea mainly by the lateral fascia lata and the medial femoral fascia. It is also held in place by a thin band of loose fibers on each side, which are known as the medial and lateral femoropatellar ligaments or medial and lateral retinaculum.[11]

The quadriceps muscle, which is composed of the rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis, provides for extension of the stifle in conjunction with the cranial portion of the sartorius muscle. The patella modifies the direction of pull of the extensor muscles and acts as a lever arm by reducing the contractile force necessary to extend the stifle. During the extension process, the patella protects the ligament by providing a large surface of contact between the ligament and the trochlea of the femur and provides cranial and rotational stability to the stifle joint.[10] Good contact between the articular surfaces of the patella and femoral trochlea is essential for adequate supply of articular cartilage with nutrients from joint fluid. Lack of normal articulation results in trochlear articular cartilage degeneration.[1]

PATHOGENESIS

Proper anatomic alignment of all structures participating in the extension mechanism of the stifle (i.e., quadriceps, patella, trochlea, patellar ligament, tibial tuberosity) is necessary for the stability of the patella. Malalignment of one or more of these structures may lead to patellar luxation. Although the patella may become dislocated after trauma, most cases of patellar luxation are considered congenital because they occur at an early age and are not related to trauma. In fact, mild patellar instability may predispose an animal to traumatic patellar luxation[12]; therefore, it is not certain that these are two completely separate entities. Although the specific etiology of patellar luxation is unknown, it is generally agreed that a defect in pelvic limb conformation is the underlying cause.

Medial Patellar Luxation

Patellar luxation is often associated with deformities of the femur and tibia in varying degrees (Figure 1). Deformities seen in dogs with medial patellar luxation include lateral torsion of the distal femur, medial displacement of the quadriceps, lateral bowing of the distal femur, dysplasia of the distal femoral epiphysis, and tibial deformities.[13,14] The etiology of congenital medial patellar luxation is not fully understood, and there are little objective data to suggest which of the associated deformities contribute to the cause of patellar luxation and which develop as a consequence of displacement of the patella.

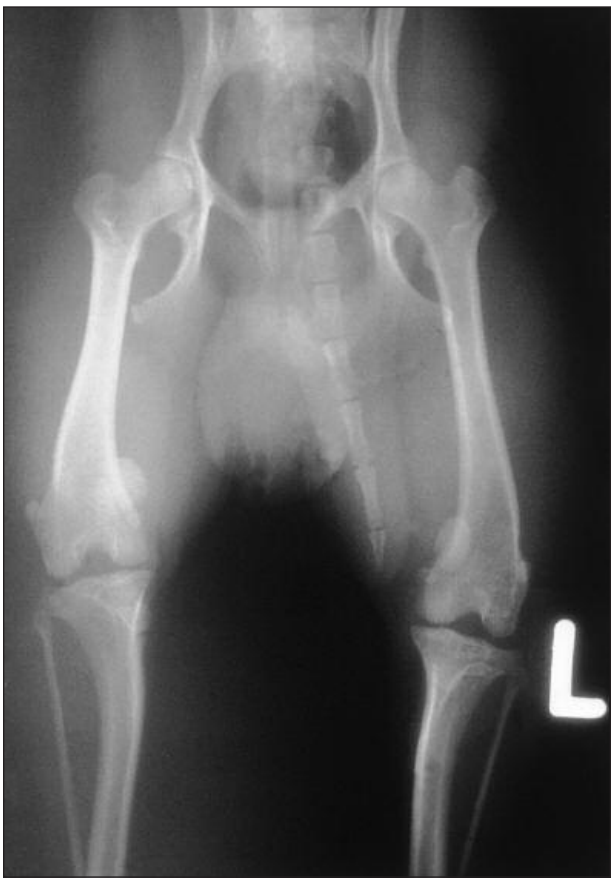

Figure 1—Anteroposterior radiograph of the hindlimbs of a dog with bilateral grade 4 medial patellar luxation.

In an experimental study of poodles with luxations, Putnam[15] concluded that the appearance of coxa vara due to a reduced angle of anteversion of the femoral neck was at the origin of the sequence of changes leading to patellar luxation.[15] Coxa vara could be caused by enhanced adduction of the limbs and by the resulting abnormal forces in the epiphysis of the femoral head.[14] In a theory extrapolated from human literature, it was hypothesized that reduced anteversion causes external rotation of the hip joint, which requires compensatory internal rotation of the distal limb to place the foot properly. As a result, the lateral soft tissues supporting the stifle joint are stretched and a lateral torsion force is exerted on the distal femoral growth plate, causing lateral torsion of the distal femur.[14] This lateral rotation of the distal femur displaces the femoral trochlea lateral to the line of contraction of the quadriceps. The compen-

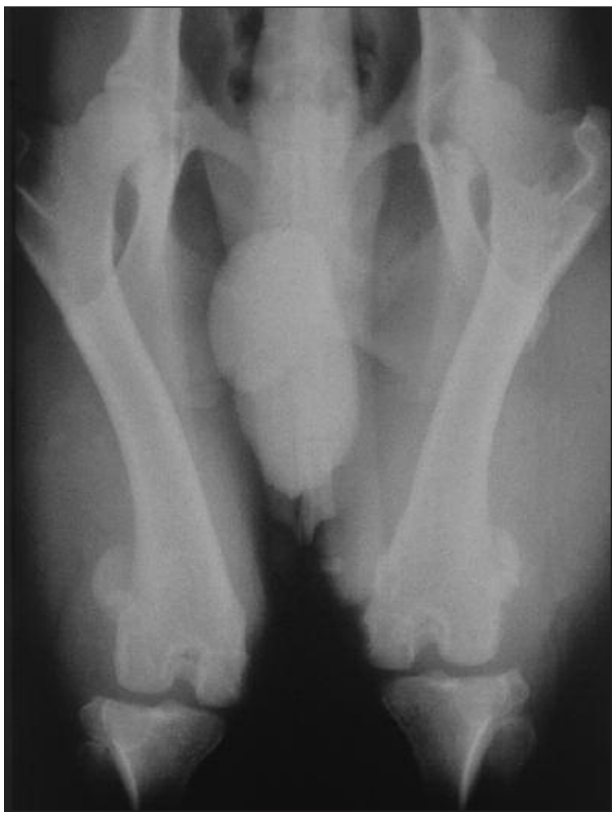

Figure 2—Anteroposterior radiograph of the hindlimbs of a dog with bilateral grade 4 lateral patellar luxation.

satory internal rotation of the limb simultaneously causes displacement of the quadriceps muscle group medially. The result is a displacement of the patella medially.[14] The postural abnormality due to the anomalies in the hip joint and the compensatory mechanisms more distally lead to differences in pressure between the medial and lateral cortex of the femur (increased pressure on the medial cortex). This difference in pressure influences the growth plate, causing the distal femur to bow laterally. Similarly, this increased pressure on the medial part of the distal femur retards the growth of the medial femoral condyle, causing dysplasia of the femoral epiphysis.

The only objective clinical data were obtained in a study[16] in which puppies 1 to 3 months of age were treated surgically for severe medial patellar luxation. All puppies showed varus deformity of the distal femur and internal rotation of the tibia. Postoperative follow-up of these puppies showed that if surgical correction occurred before the age of 60 days, these changes could be completely reversed with lateralization of the tibial tuberosity. The authors observed severe atrophy of the quadriceps muscle, particularly the rectus femoris, leading to the conclusion that the tension of this muscle had a bowstring effect that caused internal rotation of the tibia. Therefore, these results indicate that the changes in the distal femur are a consequence of the dislocation of the patella rather than a cause. If the normal pressure exerted by the patella onto the femoral trochlea is absent, the trochlear articular cartilage is not slowed down in its growth and the trochlear groove fails to develop normal depth.[14] The result is a shallow or absent trochlear groove. The tibial deformities are also thought to result from abnormal forces on the proximal and distal growth plates of the tibia.[14]

Other authors suggest that the origin of the sequence of changes that cause the described limb deformities may lie not in the hip joint but in the conformation of the pelvis.[17,18] In a radiographic study of 100 papillon dogs, approximately half of which had grade 1 or 2 patellar luxation, no significant difference was seen in the angles of anteversion and inclination of the femoral neck between those with patellar luxation and normal dogs.[17] There was a significant difference in weight and size between the two groups of dogs (those with medial patellar luxation were smaller and lighter). This indicates that selection by breeders to obtain smaller, lighter dogs could lead to an increased incidence of patellar luxation in this breed. Morphometric analyses of the pelvis showed that the origin of the cranial head of the sartorius muscle lies significantly more medially in dogs with patellar luxation than in normal dogs. Such a conformation of the pelvis could lead to increased medial traction on the patella and medial displacement of the patella.[17] The proposed transplantation of the cranial head of the sartorius muscle for the treatment of patellar luxation supports this theory.[18]

Lateral Patellar Luxation

In lateral patellar luxation, the associated abnormal anatomic features are reversed compared with medial luxation (Figure 2), including an increased angle of anteversion, coxa valga, medial torsion of the distal femur, lateral condylar dysplasia, and lateral rotation of the tibia.[1,19] As with medial luxation, the causes of lateral patellar luxation are not entirely clear. It is suggested that coxa valga and increased anteversion lead to medial displacement of the distal femur, causing alterations in the femur and tibia consistent with genu valgum. Likewise, these changes affect the distal femoral growth plate, causing dysplasia of the lateral condyle and a shallow trochlear groove. In addition to abnormal angles of inclination and anteversion, it has been suggested that hypoplasia of the vastus medialis muscle following injury or immobilization could in some cases be the initiating factor that causes other deformities that in turn lead to lateral patellar luxation.[1,20]

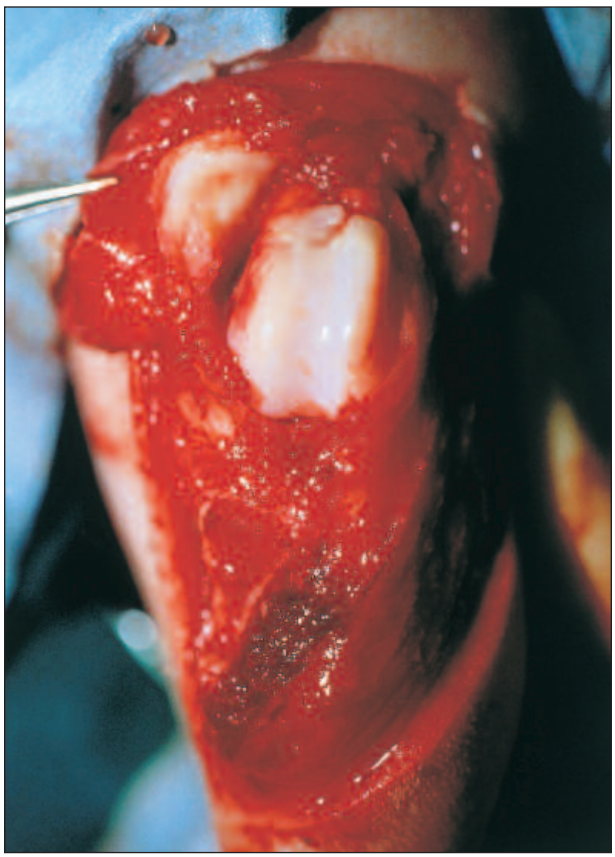

Figure 3—Intraoperative view of a stifle joint. The patella is luxated laterally and reflected with thumb forceps. Note the pathologic changes of color on the articular surface of the patella, indicating retropatellar chondromalacia.

Figure 4—Intraoperative view of the stifle joint of a dog with lateral patellar luxation. Note the synovial reaction at the origin of the long digital extensor muscle.

In both medial and lateral patellar luxation, displacement of the patella results in destruction of cartilage on the articular surface of the patella (retropatellar chondromalacia; Figure 3) and subsequent osteoarthritic changes.[1,21] The degree of osteoarthritis is usually mild to moderate and is not correlated to either the grade of luxation or lameness.[22] Lateral luxation of the patella may cause a marked synovial reaction at the origin of the long digital extensor muscle, leading to rupture of the tendon in extreme cases (Figure 4).

Patellar Luxation in Cats

Patellar luxation is less common in cats than in dogs. Predisposed breeds include the Devon Rex and the Abyssinian. Congenital medial patellar luxation is associated with a shallow trochlear groove and an underdeveloped medial femoral condyle. Coxa vara and lateral bowing of the distal femur have not been observed in cats[6,23,24]; however, a statistically weak association between medial patellar luxation and hip dysplasia has been found in cats.[25]

CLINICAL SIGNS AND DIAGNOSIS

Variable clinical and pathologic changes in patellar luxation have led to the development of a classification system that differentiates four grades of luxation based on palpation of the affected stifle.[15,26] Grade 1 is the slightest and grade 4 the worst degree of luxation (see the box on p. 238). In his classification system, Singleton[27] also accounted for the degrees of rotation of the tibial tuberosity in relation to the length of the axis of the limb. In grade 1 there is only a slight deviation of the tibial tuberosity. Higher grades of patellar luxation are characterized by rotation of the tibial tuberosity by up to 30° in grade 2 luxation, 30° to 60° in grade 3, and 60° to 90° in grade 4. The degree of lameness is not always consistent with the degree of patellar luxation and is possibly related to the presence of retropatellar chondromalacia. Dogs with intermittent luxation commonly have a history of occasionally skipping but using the limb normally most of the time. Sometimes owners complain that their pet is reluctant to jump or to walk down a slope. In severe cases of

Classification of Patellar Luxation[26]

Grade 0: The patella cannot be completely luxated, regardless of the limb's position.

Grade 1: The patella can be completely luxated, but when pressure is released without manipulation of the limb the patella regains its original position.

Grade 2: The patella can be completely luxated, but manipulation of the hindlimb causes the patella to regain its original position.

Grade 3: The patella is found (at least once) spontaneously luxated with the animal in a standing position, or it is permanently luxated but can be repositioned manually or by manipulating the limb.

Grade 4: The patella is permanently luxated and cannot be repositioned.

bilateral grade 4 luxation, some animals may scarcely be able to walk or may move in a crouched position with both limbs partially flexed, while others will walk normally. Clinical signs also vary with the age of the animal and may worsen as the animal gains weight, as articular cartilage becomes eroded, or if the cranial cruciate ligament ruptures.[12]

The animal should be examined both standing and while in lateral recumbency. The patella is best located by first palpating the tibial tuberosity, then continuing in a proximal direction over the patellar ligament. The limb should be flexed and extended during examination, and the stability of the patella should be tested in all positions of the limb to determine the degree of luxation. Both medial and lateral stability of the patella should be tested. In certain large-breed, straight-legged dogs (e.g., Akita Inu), the patella is sometimes found to ride very high or completely above the trochlear groove. This position is known as patella alta.[12] Other findings, such as pain caused by pressure on the patella, crepitation, or drawer movement, should be carefully registered.

Diagnosis is based on palpation of the affected stifle. Radiography is usually not necessary to diagnose patellar luxation but may be useful to document the degree of limb deformity as well as the degree of osteoarthritis present in the stifle. Precise positioning of the limbs for lateral and posteroanterior views has been described in the literature to enable optimal preplanning of realignment procedures.[19] The depth of the femoral trochlea can be determined preoperatively with a skyline view.[6]

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ARTICLE #4 CE TEST

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1. The ratio of medial:lateral patellar luxation is
   a. 9:1.
   b. 3:2.
   c. 3:1.
   d. 1:1.
   e. 1:3.

2. Which of the following statements regarding medial patellar luxation is true?
   a. Medial patellar luxation occurs more frequently in females than males.
   b. Toy poodles show a predisposition for medial patellar luxation.
   c. Medial and lateral patellar luxation can occur in the same stifle.
   d. Medial patellar luxation occurs more frequently than lateral patellar luxation in dogs of all sizes.
   e. all of the above

3. The patella
   a. is situated in the tendon of insertion of the biceps muscle group.
   b. acts as a lever arm, reducing the forces necessary to extend the stifle.
   c. is held in place mainly by the femoropatellar ligaments.
   d. has cartilage extensions on each side called supra-patellar cartilages.
   e. all of the above

4. The extensor muscles of the stifle are the
   a. vastus medialis, vastus lateralis, vastus intermedius, rectus femoris, and the cranial portion of the sartorius.
   b. quadriceps femoris, rectus femoris, sartorius, vastus lateralis, and vastus medialis.

c. quadriceps femoris and the caudal portion of the sartorius.
d. vastus medialis, vastus lateralis, vastus intermedius, rectus femoris, and the caudal portion of the sartorius.
e. vastus medialis, vastus lateralis, rectus femoris, and the cranial portion of the sartorius.

5. Deformities associated with medial patellar luxation include
   a. medial torsion and bowing of the distal femur, medial displacement of the quadriceps muscle, and dysplasia of the distal femoral epiphysis.
   b. valgus deformity of the distal femur and internal rotation of the tibia.
   c. varus deformity of the distal tibia and external rotation of the tibia.
   d. lateral torsion and bowing of the distal femur, dysplasia of the distal femoral epiphysis, and tibial deformities.
   e. coxa valga, lateral torsion and bowing of the distal femur, and tibial deformities.

6. In puppies, deformities in the distal femur associated with medial patellar luxation were shown to be fully reversible with surgical treatment of the luxation if treated before the age of ____ days.
   a. 30
   b. 45
   c. 60
   d. 75
   e. 90

7. In a study of papillon dogs, it was reported that
   a. there was no significant difference in the angle of inclination between dogs with medial patellar luxation and normal dogs.
   b. there was no significant difference in the angle of retroversion between dogs with medial patellar luxation and normal dogs.
   c. the incidence of medial patellar luxation was correlated to the size of the dogs (smaller dogs were more at risk of having medial patellar luxation).
   d. the origin of the cranial head of the sartorius muscle was significantly more medial in dogs with medial patellar luxation compared with normal dogs.
   e. all of the above

8. Lateral patellar luxation
   a. occurs more frequently than medial patellar luxation in large-breed dogs.
   b. is associated with lateral torsion and bowing of the distal femur.
   c. is usually traumatic.
   d. can cause rupture of the tendon of origin of the long digital extensor muscle.
   e. is frequently seen in Devon Rex and Abyssinian cats.

9. Destruction of articular cartilage on the articular surface of the patella
   a. is seen only as a consequence of medial patellar luxation.
   b. is called patellar chondrodysplasia.
   c. can lead to osteoarthritis but does not cause any pain.
   d. is called retropatellar chondromalacia.
   e. is only visible histologically.

10. During clinical examination of the stifle joint of a dog, it is found that the patella can be luxated medially with digital pressure and remains luxated until manipulation (extension) of the limb causes the patella to jump back into place. This indicates
    a. medial patellar luxation grade 1.
    b. medial patellar luxation grade 2.
    c. medial patellar luxation grade 3.
    d. medial patellar luxation grade 4.
    e. that radiographs of the stifle are needed for diagnosis.