Patella Luxation: Clinical findings, Imaging, Stabilization Techniques

Patellar luxation is a common stifle condition in dogs that can result in pain, lameness and osteoarthritis (Hulse 1981). The condition has traditionally been recognised in toy and miniature breeds (LaFond and others 2002); however, it is becoming an increasing problem in large breed dogs, especially Labrador Retrievers. Patellar luxation is most commonly a congenital disorder resulting from multiple anatomic abnormalities of the pelvic limb. Medial luxation is more frequently recognised than lateral luxation.

Anatomy and biomechanics
The patella is a sesamoid bone in the tendon of insertion of the quadriceps femoris muscle. It is ovate in shape and curved so as to articulate with the femoral trochlea of the femur. Parapatellar fibrocartilages on each side of the patella articulate with ridges of the trochlea. Lateral and medial femoropatellar ligaments exist as delicate bands of loose connective tissue connecting the patella to the fabella laterally and the periosteum of the femoral epicondyle medially.

The femoropatellar articulation greatly increases the mechanical efficiency of the quadriceps muscle group and facilitates stifle extension. The extensor mechanism is composed of the quadriceps femoris muscle, patella, trochlea, patellar tendon and tibial tuberosity. These structures should be in correct anatomical alignment to prevent patellar luxation or subluxation. The angle between the rectus femoris muscle, the patella and the patellar tendon is referred to as the quadriceps angle (Q-angle). It may be measured by magnetic resonance methods (Kaiser and others 2001a). There is a significant difference in the Q-angle in dogs with grade II and grade III congenital patellar luxation compared to dogs without patellar instability. With abnormal alignment of the extensor mechanism there is a reduced extensor moment of the stifle.

Aetiologypathogenesis
Traumatic luxation of the patella is uncommon. The majority of patellar luxations are a result of congenital or developmental malalignment of the quadriceps mechanism. Patellar luxation should be considered as one aspect of a generalised deformity of the entire limb. In severe cases there can be marked angular and rotational deformity of the femoral and tibial bones. Over-representation of certain breeds supports the theory that patellar luxation is a genetic condition.

The pathogenesis of developmental patellar luxation remains speculative and controversial. Abnormal femoral head and neck angles of inclination and anteversion have been hypothesised as being key primary features affecting quadriceps alignment, however, they have not been proven (Kaiser and others 2001b). A variable degree of asymmetrical growth of the distal femoral and proximal tibial physes is recognised in many cases. When this occurs in very young dogs it may become a self-perpetuating problem with further retardation in growth on the compression aspect of the physes and acceleration of growth on the tension aspect of the physes. With medial patellar luxation this may result in marked lateral bowing of the distal femur and medial bowing of the proximal tibia. The limb has a resultant S-shaped conformation with tilting of the joint.
Failure of the luxated patella to articulate with the femoral trochlea results in loss of this physiological pressure and accelerated growth in this area. The femoral condyle on the side of the patella luxation may be hypoplastic. Repetitive luxation of the patella damages the articular surfaces of the patella and femoral condyle. This may result in further flattening of the condyle, so facilitating further luxation. Proximal location of the patella (patella alta) has been hypothesised as a possible predisposing factor for patella luxation in humans and may play a role in dogs since many luxations tend to occur when the stifle is extended (Johnson and others 2006).

Although the majority of cases present with complete femoropatellar luxation, subluxation is also possible. Dogs with patellar subluxation tend to be presented when adults due chronic abnormal tracking of the patella causing ulceration of patellar and trochlear ridge articular cartilage. Chronic patella luxation may be associated with concomitant cranial cruciate ligament rupture. It has been hypothesised but not proven that abnormal stifle joint biomechanics with excessive internal rotation is the cause of the cranial cruciate ligament degeneration and rupture.

**Grading of severity of patella luxation**
Grading patellar luxations is useful for monitoring progression of the condition and response to surgery. The following clinical grades have been proposed (Singleton 1969):

**Grade I** – The patella can be manually luxated when the stifle is extended, however, when released it returns to the trochlea. Internal rotation of the tibia and displacement of the tibial tuberosity are minimal.

**Grade II** – The patella is frequently located medially with flexion of the stifle joint, however, it is easily reduced when the stifle is extended and the tibia externally rotated. The tibial tuberosity is displaced medially. Mild angular deformity of the femur and tibia may be present.
Grade III – The patella is permanently luxated. It may be reduced, however, luxation recurs immediately. Angular and rotational deformities of the femur and tibia are common. The trochlea is usually shallow or flat.

Grade IV – The patella is permanently luxated and it is not possible to manually reposition it in the trochlea. Muscle contracture reduces the range of stifle extension. Angular and rotational deformity of the femur and tibia are generally marked and the tibial tuberosity is displaced 60 to 90 degrees medially. Concurrent external rotation of the distal tibia may result in reasonable alignment of the hock and hind paw. The trochlea is flat or convex.

Patella luxation is a problem in all breeds and sizes of dogs, but the condition is most common in small breed dogs. Commonly affected breeds include the Yorkshire terrier, maltese, toy poodle, miniature poodle, pomeranian, pekingese and chihuahua. Medial patellar luxation predominates in both small and large breeds, although past literature suggests lateral luxation is much more common in large breeds. Patellar luxation occurs less frequently in cats and medial luxation is most common. Patellar luxation is generally graded from 1-4 based on increasing severity. Grade 1 patellar luxations are generally not repaired, but surgical repair is recommended for grades 2-4, depending on the age and clinical presentation of the patient. Treatment of medial patella luxation may be conservative (small breeds only) or surgical. The decision as to which method is applicable for a patient is dependent upon the clinical history, physical findings and the age of the patient. An older patient in which patella luxation is noted as an incidental finding on physical examination and in which the client reports nonclinical lameness does not warrant surgical intervention. Rather, the client should be informed as to the clinical signs associated with patella luxation. Surgery is advised in the young adult patient even though no clinical problem is apparent since intermittent luxation may prematurely wear the articular cartilage of the patella. Surgery is indicated in any aged patient exhibiting lameness and is strongly advised in a patient with active growth plates since skeletal deformity may worsen rapidly. However surgical techniques used in actively growing animals should be those that will not adversely affect skeletal growth. Surgical options include trochleoplasty, trochlear wedge recession, trochlear block recession, tibial tuberosity transposition, tibial tuberosity transposition, rectus femoris transposition, retinacular imbrication, derotational suture, retinacular releasing incision and corrective osteotomy in cases of femoral or tibial deformity. In severe cases that do not respond to the above treatments, patellectomy and stifle arthrodesis are a possibility; these techniques are fortunately rarely needed (these techniques will not be presented).

Clinical Findings
Pet owners typically report a skipping lameness in affected pets. Typically the pet uses the affected leg normally between skipping episodes. Some owners do not recognize any lameness or gait abnormality in affected patients. Patellar luxation frequently occurs bilaterally, but may one stifle may be more severely affected than the other. Owners often report a slow progression in severity of clinical lameness. The lameness may appear to resolve in some patients over time, but this may be due to the progression of patellar luxation from grade 2 to grade 3. The skipping gait may disappear because the patella is no longer displacing into and out of the trochlear groove. It the patella remains in a luxated position, the patient may not exhibit obvious lameness, but may have a
This grade 4 MPL patient has varus deformity of the distal femur and valgus deformity of the proximal tibia. Slight internal rotation of the bones is also present.
Radiographic changes are most severe in puppies where the onset of patellar luxation occurs at an early age when the physis is undergoing rapid growth. Medial luxation of the patella in these dogs causes compression on one side of the distal femoral and proximal tibial physes and compression on the opposite side. As a consequence, the medial aspect of the femoral physis has retarded growth and the lateral aspect has accelerated growth resulting in distal femoral varus. The lateral aspect of the tibial physis has retarded growth and the medial aspect has accelerated growth resulting in proximal tibial valgus. Torsional deformity of the femur and tibia can also occur simultaneously. Correction of the deformity is usually based on comparison of the degree of angulation and torsion found on radiographic examination of the affected patient in comparison to normal reference values. The surgeon should be cautious when interpreting the measured angle of axial deformity as torsional deformity can artificially raise or lower the actual amount of axial malalignment. A CT scan is likely to give the most accurate measurement of axial and torsional deformity.

Patients with medial patellar luxation should also be evaluated for the potential for concomitant cranial cruciate injury. Typical radiographic changes include joint distension and cranial tibial displacement. Osteoarthritic changes are more likely with cranial cruciate ligament injury. If cranial cruciate ligament injury is suspected, measurement of the slope of the tibial plateau may be helpful.

**Reconstructive techniques**

Various techniques have been devised to correct the anatomic abnormalities associated with patellar luxation. Soft tissue techniques such as fascial release, fascial imbrication, and anti-rotational sutures can be used to augment anatomic reconstructive techniques, but should not be relied upon as the sole method of correction.

- **Trochlear chondroplasty** In the immature animal (<9 months of age), a flap of hyaline cartilage is raised from the trochlear sulcus, the subchondral bone is removed, and the flap is reseated.

- **Trochlear sulcoplasty** The sulcus is deepened by débridement of the articular cartilage and subchondral bone with a bone rasp or high-speed bur. The defect is replaced by hyaline cartilage over time.

- **Trochlear wedge recession (TWR)** Using an X-acto hobby saw, or similar fine-toothed saw, an osteochondral wedge is developed from the trochlear sulcus. Additional cut(s) are made to remove slice(s) of cartilage and bone so that the original wedge can be seated deeper in the trochlear sulcus.

- **Trochlear block recession** A rectangular osteochondral block is developed from the trochlear sulcus using a saw and osteotome. Additional subchondral bone is removed allowing the block to be seated deeper in the trochlear sulcus. This technique is reported to preserve a greater surface area of the hyaline cartilage within the trochlear sulcus than the trochlear wedge recession.
**Tibial tuberosity transposition (TTT)** The tibial tuberosity and associated patellar tendon insertion is osteotomized, leaving the distal periosteal attachment intact. The tuberosity is moved to align the quadriceps mechanism, and reattached with 2 K-wires.

**Femoral osteotomy** In cases with significant femoral varus, valgus, or torsional deformities, the femur must be straightened by angular and torsional correction. Multiple techniques have been described including the laterally based closing wedge ostectomy, the medial opening wedge osteotomy, and the radial osteotomy; plate fixation is usually employed.

*Deepening of the Trochlear Groove.*

If the medial and lateral trochlear ridges do not constrain the patella, the trochlear groove must be deepened. This technique is generally necessary in dogs/cats with a grade III or IV luxation. Deepening the groove may be achieved with a trochlear wedge recession, trochlear block recession, or trochlear resection.

**Trochlear wedge recession** deepens the trochlear groove to restrain the patella and maintains the integrity of the patellofemoral articulation. Make a diamond shaped outline cut into the articular cartilage of the trochlea with a scalpel (use smooth arcs rather than corners on the lateral and medial sides of the diamond). The width of the cut must be sufficient at its' midpoint to accommodate the width of the patella. An osteochondral wedge of bone and cartilage is removed by following the outline previously made. Make the osteotomy so that the two oblique planes that form the free wedge intersect distally at the intercondylar notch and proximally at the dorsal edge of the trochlear articular cartilage. Use caution to avoid making the wedge too long (may affect cruciate ligament insertions) or too deep (may go through the caudal aspect of the femur).

In larger patients, use an oscillating saw but in smaller breeds and toy breeds of dogs use a fine-tooth hand held saw (hobby saw; Fig 5) or the cutting edge of a number 20 scalpel blade and mallet. Remove the osteochondral...
wedge and deepen the recession in the trochlea by removing additional bone from one or both sides of the newly created femoral groove. With medial luxations, it is often best to take more bone from the lateral side of the groove, thus preserving as much of the medial ridge as possible. Remodeling the free osteochondral wedge with rongeurs may also be necessary to allow the wedge to seat deeply into the new femoral groove. The wedge can also be rotated 180 degrees when it is returned to the femoral groove if doing so will aid in heightening the medial ridge. Replace the free osteochondral wedge when the depth is sufficient to house 50% the height of the patella (Fig 7). The osteochondral wedge remains in place due to the net compressive force of the patella and the friction between the cancellous surfaces of the two cut edges. Some surgeons, once satisfied with the shape of the wedge, will cover the cartilage surface with a damp surgical sponge and gently impact the wedge into the femoral bed with an instrument.

A **trochlear block recession** is performed similarly to the wedge recession. Some surgeons find the block recession most appropriate for dogs that seem to luxate primarily with the stifle joint in extension, and for larger breed dogs. The advantage of the block recession is deeper placement of the patella and more advantageous proximal tracking of the patella into the trochlear groove. Measure the width of the articular surface of the patella and use this measurement to determine the proper width of the block recession. Begin with two vertical cuts separated by the measured width at the respective medial and lateral trochlear ridges. The vertical cuts should penetrate 3-4 mm below the surface of the trochlear groove. Having the stifle fully flexed and exposed will help in judging the angle of the first cut, avoiding having it too shallow (leading to cutting through the articular surface) and too deep (burying the osteotome in the femoral shaft).

Using a thin osteotome equivalent to the determined width of the block recession, remove a block section of the trochlea. Begin just proximal to the intercondylar notch and direct the osteotome proximally by gently tapping with a mallet. The exit point proximally is at the proximal extent of the trochlear groove.
Remove the block of cartilage and bone. Make a second pass with the osteotome through the exposed cancellous surface of the trochlear groove. Begin the second pass 2-3mm below the surface of the previous cut just above the intercondylar notch. Direct the osteotome proximally to exit at the proximal extent of the trochlea as was done previously. Remove the 2-3mm section of cancellous bone and replace the cartilage block into the now deepened trochlea.

**Tibial tuberosity transposition:** Tibial tuberosity or crest transposition is an effective method of treatment for grades II, III, and IV patellar luxations. Make a craniolateral skin incision 4cm proximal to the patella and extend the incision 2cm below the tibial tuberosity. Incise the subcutaneous tissue along the same line. Make a lateral parapatellar incision through the fascia lata and carry the incision distally onto the tibial tuberosity below the joint line. Reflect the cranial tibial muscle from the lateral tibial tuberosity and tibial plateau to the level of the long digital extensor tendon. Use sharp dissection to gain access to the deep surface of the patellar tendon for placement of the osteotome. Beginning at the level of the patella, make a medial parapatellar incision through the fascia and distally through the periosteum of the tibial tuberosity.

Position an osteotome beneath the patellar tendon 3-5mm caudal to the cranial point of the tibial tuberosity. Use a mallet to complete the osteotomy in a proximal to distal direction. Bone cutting forceps may also be used, or in large dogs, Gigli wire. *The distal periosteal attachment should not be transected, and take care not to accidentally transect the patellar tendon.* The degree of lateral movement of the tibial tuberosity is subjective but is based on the longitudinal
realignment of the tuberosity relative to the trochlear groove. Once the site of relocation is chosen, remove a thin layer of cortical bone with a rasp or the osteotome. Lever the tibial tuberosity into position and stabilize it with one or two small Kirschner wires directed caudally and slightly proximally. It is important to gage the depth and direction of pin placement.

The pins should not exit the tibia caudally but should only engage the caudal cortex. If the pin protrudes too far from the caudal cortex of the tibia, persistent lameness will result. Palpate the caudal aspect of the joint carefully and put the joint through a complete range of motion prior to cutting the pins. Bend the tips of the pins over as close to the surface of the bone as possible. Although these pins do not routinely need to be removed, they should always be removed if the dog or cat has persistent lameness after the osteotomy has healed. In addition, the owner should be warned that they may occasionally migrate and may need to be removed in a few weeks to months.

Medial release: The medial joint capsule is thicker than normal and contracted in patients with grade III or Grade IV patella luxations. In this group of animals, the medial joint capsule and retinaculum must be released to allow lateral placement of the patella. The pull of the sartorius muscles and vastus medialis muscle directs the patella medially, the insertions of these muscles at
the proximal patella are released. Redirect the insertions and suture them to the vastus intermedius. Make a medial parapatellar incision through the medial fascia and joint capsule with a scalpel. Begin the incision is begun at the level of the proximal pole of the patella and extend it distally to the tibial crest. Allow the incision to separate and do not suture the cut edges when surgery is completed. Rather, suture medial subcutaneous tissue to the cranial cut edge of the incision, which will help prevent scar tissue formation, leading to relaxation.

**Lateral reinforcement:** Reinforcement of the lateral retinaculum is accomplished with suture placement and imbrication of the fibrous joint capsule, by placement of a fascia lata graft from the fabella to the parapatellar fibrocartilage, or excision of redundant retinaculum. For suture reinforcement, place a suture (we often use large gauge polyester or monofilament nylon) through the femoral-fabellar ligament and lateral parapatellar fibrocartilage. Next, place a series of imbrication sutures through the fibrous joint capsule and lateral edge of the patella tendon. With the leg in slight flexion, tie the fabellar-patellar suture and imbrication sutures. Alternatively, the lateral retinaculum may also be reinforced through transposition of fascia lata. A section of fascial lata equal in width to the patella and in length twice the distance from the patella to the fabella is isolated. Free the graft proximally and leave it attached to the proximal pole of the patella distally. Pass the free end of the graft deep to the femoral-fabellar ligament and back to the lateral parapatellar fibrocartilage. Suture the graft to itself and the femoral-fabellar ligament with the leg in slight flexion.

If the patella is out of position most of the time, the retinaculum opposite the side of the luxation will be stretched; with medial luxations, there is redundant lateral retinaculum. Once the patella is reduced, excise the excess retinaculum.
and joint capsule allowing tight closure of the arthrotomy. None of the
reinforcement techniques alone are adequate to permanently prevent reluxation. If
the mechanical forces pulling the patella out of the trochlear groove have not been neutralized (using the techniques listed above such as tibial crest transposition), the reinforced retinaculum will stretch again with time.

**Femoral Osteotomy**

Femoral varus/valgus correction is required in cases where the angulation of the distal femur precludes correct alignment of the extensor mechanism. This abnormal / excessive varus/valgus is present with cases of Grade 4 patella luxation. With the latter, abnormal forces are placed along the active physis resulting in growth retardation with increased load and growth acceleration with decreased load. The result is excessive femoral varus with medial patella luxation and excessive femoral valgus with lateral patella luxation. The method of planning correction is based upon the CORA methodology. CT imaging and reconstruction are the most accurate method of determining correction. In severe cases, prototype development is ideal. Many centers do not have the ability to perform CT/reconstruction and prototype development; accurate radiographic positioning and planning will suffice except in the more severe cases. These cases can be very complex and therefore recommended only for the experienced surgeon.