PATELLAR LUXATION - A STEP BY STEP GUIDE

Introduction

Patellar luxation is the condition where the patella luxates out of the femoral trochlear sulcus instead of tracking up and down within it. Most commonly the patella luxates medially but lateral luxation also occurs. It can occur in any size or breed of dog but is more common in small breed dogs.

Cats have a broad and flat patella and the femoral trochlear sulcus is shallow; therefore the normal cat patella is much more mobile mediolaterally and relatively unstable compared to dogs. Patellar subluxation is common in cats but, clinically significant patellar luxation is uncommon.

Patellar luxation is usually a diagnosis made from the patient history and signalment, and by stifle manipulation and palpation, rather than from radiographs. This is because the luxating patella is mobile and can change position which can be easily palpated but not necessarily appreciated on a radiograph.

Patellar luxation is graded depending on its severity and there are many ways of doing this. The most commonly used grading system is the Putnam / Singleton system which can be described as:

**Grade 1:** The patella tracks normally but luxates with digital pressure or manipulation of the tibia. Once manipulation is discontinued, the patella tracks normally in the trochlear groove. This causes minimal clinical problem with infrequent or no clinical signs. Surgical correction is usually not indicated nor of direct benefit to the patient.

**Grade 2:** The patella intermittently and spontaneously luxates and resolves. This may be mild and infrequent to severe and frequent, and anywhere in-between. Luxation normally happens as the stifle is flexed, and resolves when the stifle is extended. The typical history is of a dog with intermittent “skipping” hindlimb lameness. Surgical correction is usually of benefit to the patient.

**Grade 3:** The patella is always luxated but can be returned to the normal position in the trochlear sulcus by digital manipulation. Once such manipulation stops, patellar luxation recurs. This causes an abnormality of stifle function i.e. inability to extend the stifle and associated hindlimb lameness. Surgical correction is beneficial to the patient as it restores normal stifle function, particularly the quadriceps ability to extend the stifle.

**Grade 4:** The patella is permanently luxated and cannot be reduced to a normal position despite manipulation. This causes permanently abnormal stifle function with lameness and inability to extend the stifle, and can result in debilitating lameness with a crouched pelvic limb stance and gait. Surgical correction is of benefit. In puppies and young dogs with severe grade 4 developmental patellar luxation, surgery should be considered as soon as possible to prevent the progression of skeletal deformities that may otherwise develop. Surgical correction of grade 4 patellar luxation is challenging.

**Causes of patellar luxation, and surgical solutions**

Usually a combination of different factors cause patellar luxation. For successful correction, the surgeon must make an individual assessment of each patient and identify each factor present and correct appropriately. The common problems are illustrated below.

1. **Malalignment of the quadriceps mechanism and trochlear sulcus.** The quadriceps mechanism comprises the quadriceps muscle with the origin of the three vastus muscles on the proximal femur and rectus femoris on the pelvis just cranial to the acetabulum, the patella, patellar ligament and patellar ligament and tibial tuberosity malpositioning i.e. malalignment of the quadriceps mechanism relative to the femoral trochlear sulcus, and medial patellar luxation.

Red line indicates central axis of the limb.
Factors that affect quadriceps alignment are:
- Bowing of the distal femur. This changes the position and alignment of the femoral trochlear sulcus relative to the quadriceps mechanism.
- Tibial malformation – a rotational (torsional) deformity of the tibial tuberosity can cause malalignment of the quadriceps mechanism due to abnormal positioning of the tibial tuberosity relative to the femoral trochlear sulcus.
- Bowing of the proximal tibia; often the proximal tibia is bowed in the opposite direction to the distal femur.
- Hip conformation and pathology; for example cranio-dorsal hip luxation causes functional foreshortening of the femur with external rotation; this in turn causes quadriceps / femoral trochlear sulcus malalignment and patellar luxation can occur.
2. Shallow femoral trochlear sulcus; too shallow a sulcus or insufficiently high medial or lateral trochlear ridges can result in inadequate constraint of the patella and subsequent luxation. Assessment of sulcus depth and trochlear ridge height is subjective; there is no guide that helps to differentiate normal from abnormal.
3. Excessively tight medial soft tissues i.e. the retinaculum and joint capsule. If the soft tissues medial to the patella are too tight, they will constrain its movement by permanently “pulling” it medially. It is likely that these tissues become tight as a consequence of chronic patellar luxation, rather than causing it.
4. Loose lateral soft tissues i.e. retinaculum and joint capsule; if these tissues are loose, then the patella is not “pulled” or constrained laterally i.e. patellar luxation can occur. These tissues are loose in the opposite direction to the patellar luxation, and most likely develop as a result of patellar luxation rather than causing it.
5. Co-existing rupture of the Cranial Cruciate Ligament. Patellar luxation may also occur in association with cranial cruciate ligament rupture. When the cranial cruciate ligament ruptures, cranial and internal rotational stability of the tibia relative to the femur is lost; this causes malpositioning of the tibial tuberosity relative to the femoral sulcus, and quadriceps malalignment.

The four commonly performed surgical options available to correct patellar luxation include:
1. Femoral Trochlear sulcoplasty i.e. deepen the trochlear sulcus to constrain the patella and prevent luxation. This is done if the trochlear sulcus is assessed to be too shallow.
2. Tibial tuberosity transposition i.e. re-align the quadriceps mechanism by osteotomy and re-positioning the tibial tuberosity more laterally. This is done if malalignment of the quadriceps mechanism and the femoral trochlear sulcus are present.
3. Medial release i.e. transect the medial soft tissues (joint capsule and/or retinaculum) if they are excessively tight. This is done if medial soft tissue tension prevents the patella from tracking in the trochlear sulcus.
4. Lateral imbrication i.e. tighten the lateral soft tissues (joint capsule and retinaculum) to prevent patellar luxation. This is done if the soft tissues are too loose, but it should not be relied on to correct patellar luxation because future tissue loosening will likely develop if quadriceps alignment or inadequate sulcus depth persist.

Other surgical produces exist that may be used to correct patellar luxation, but these are more demanding procedures. Corrective osteotomies of the distal femur and/or proximal tibia may be performed if there is significant femoral / tibia malalignment, but the inclusion criteria are poorly defined. Partial parasagittal patellectomy may be performed in cats if patellar luxation cannot be constrained using traditional means. If significant hip pathology is present such as hip subluxation, this may need to be addressed to successfully correct patellar traceing. However, these are demanding surgeries, and best undertaken by experienced surgeons.

**Surgical technique for (medial) patellar luxation**

**Initial approach and assessment.**

1. Pre-operative assessment includes a full clinical examination of the patient including gait assessment and orthopaedic examination. Patellar stability and pelvic limb alignment should be assessed.

- Take orthogonal radiographs of the stifle (Fig 1 & 2). Consider including a full caudo-cranial view of the entire hindlimb from hip to tarsus to assess bowing deformities of the tibia and femur (Fig 1). The radiographs allow the diagnosis to be confirmed, other differential diagnoses to be excluded, and pre-operative measurements made to plan the correct position of the osteotomy for tibial tuberosity transposition (Figure 2).
3. Position the patient in dorsal recumbency (Fig 3) and prepare a full aseptic surgical preparation of the limb with the entire distal limb draped in (Fig 4) and the foot in a sterile impervious dressing. This allows full access and manipulation of the limb during surgery.

4. Before starting the surgery, check patella position and anatomic landmarks that will guide the surgery i.e. patella, patellar ligament and tibial tuberosity (Fig 5).

5. Make a lateral para-patellar skin incision over the stifle about 1cm lateral to the patella, extending from proximal to the patella to the tibial tuberosity (Fig 6).

6. Dissect the subcutaneous fascia until the patellar ligament and tibial tuberosity are clearly seen (Fig 7).

7. Assess the alignment of the quadriceps mechanism. Stand at the toe of the dog and visualise the course and position of the quadriceps mechanism. Review this whilst flexing the stifle and internally rotating the tibia. Note whether the quadriceps mechanism is aligned or malaligned i.e. does the patellar ligament deviate medially, laterally or is it neutral? (Fig 3 & 4).

8. Sharply incise the lateral retinaculum approx. 1cm lateral to the patella. Dissect free from the underlying joint capsule. This incision extends proximal to the patella. The joint capsule is exposed underneath (Fig 8).

9. Sharply incise the joint capsule. This incision extends proximal to the patella, extending slightly into distal vastus lateralis. Use suction to aspirate synovial fluid. Luxate the patella medially, flex the stifle and use Gelpi retractors to maintain position (Fig 9).

10. Inspect and confirm that the cranial aspect of the cruciate ligament is normal.
11. Assess the depth of the trochlear groove (this is subjective), and then for articular cartilage erosions of the femoral trochlear sulcus. Fig 10 shows full thickness cartilage erosion (circled green) of the proximal medial trochlear ridge where the patella has been luxating, a relatively shallow trochlea and a medial trochlear ridge with poor height.

12. Remove the Gelpi retractors, retroflex the patella and assess the articular cartilage damage on the caudal aspect of the patella. Fig 11 shows a large full thickness articular cartilage abrasions on the caudal aspect of this patella; this may adversely affect prognosis.

Medial Release

Medial release is not necessary for the majority of cases. It is necessary when the tension in the medial tissues is such that the patella cannot be returned to the trochlear sulcus without performing release, or if the tension is adversely influencing patellar tracking i.e. grade 4 or severe grade 3 patellar luxation. If medial release is to be performed, it is best performed as the first step i.e. before femoral trochlear sulcoplasty, and certainly before tibial tuberosity transposition.

To perform medial release, a medial approach is made to the stifle in a similar way as described above for the lateral approach. The incision extends far enough proximally until all excessive soft tissue tension has been abolished. In most dogs, this means releasing both the medial retinaculum and the joint capsule in the region of and just proximal to the stifle. If severe, the release may need to extend up to the proximal femur and pelvis.

Femoral Trochlear Sulcoplasty

Assess the depth of the femoral trochlear sulcus and the need for sulcoplasty; this is a subjective decision (Fig 10). If the trochlear sulcus is deep enough, sulcoplasty is not necessary. When assessing whether to perform sulcoplasty or not, consider that the detrimental effect of sulcoplasty is unavoidable cartilage damage; this needs to be carefully balanced against the benefits. Methods for sulcoplasty include:

1. Block Recession Sulcoplasty. In adult dogs, this is the best option as it preserves the largest amount of articular cartilage, it enables a larger amount of the sulcus to be deepened, and it creates a deeper femoral trochlea proximally compared to wedge recession sulcoplasty. However, it is also the most fiddly and technically demanding method and requires precise surgical technique and a modular osteotome (Fig 12) with thin, sharp blades of different widths. It is very challenging to do this well single-handed; a surgical assistant is necessary.

2. Wedge Recession Sulcoplasty. This is the next best option as it preserves some articular cartilage, but it does not deepen the trochlear sulcus as well as block recession sulcoplasty. It is simpler to perform and can be done with less specialised equipment or experience.

3. Abrasion Sulcoplasty (Rasping). A bone rasp (Fig 13) is used to rasp the trochlear sulcus until adequate depth is achieved. This is the least favourable option as all articular cartilage is destroyed. This technique is not recommended unless no articular cartilage present, which is uncommon except in revision surgery. Inexperienced surgeons may choose to start using this technique, particularly in very small stifles where the osteotomy techniques above may be challenging and carry a risk of fracture of the osteochondral graft, or even the femur if the cuts are made too deep.

4. Chondroplasty. This is rarely performed as it can only be done in very young patients, (less than 6 months); the cartilage isn’t flexible enough in older patients. The articular cartilage of the trochlear sulcus is sharply dissected away from the subchondral bone and remains attached distally. The underlying bone is deepened, then the articular cartilage is laid back in the trochlear groove.
1. Determine the width of the intended sulcoplasty by choosing the modular osteotome blade that best fits the maximum width of the trochlea. Using a #11 blade, gently score the medial and lateral trochlear ridges.

2. Using a fine X-ACTO saw or similar, create the lateral and medial cuts that will define the edges of the osteochondral block. (Fig 14) Make sure the base of the cuts are flat and do not become domed. Be careful to make the osteotomy as wide as possible, yet leave enough lateral and trochlear ridge width that neither is weakened.

3. Use the modular osteotome and mallet to cut the base of the block from distal to proximal. (Figure 15) Start just cranial to the intercondylar notch and aim for the osteochondral junction of the trochlear groove proximally. This must be done very carefully and with great care taken to avoid fracturing the block. A thick osteotome will increase the chance of fracture. If the block fractures, it can be salvaged.

4. Carefully remove the osteochondral block from the femoral trochlea (Fig 16).

5. Recess the block by taking further subchondral bone away: either from the exposed femoral subchondral bone or from the base of the osteochondral block.

6. Re-position the osteochondral block in the graft site and review for closeness of fit, stability, and depth of recession achieved (Fig 17). Adjust until satisfactory and stable.

7. Remove the Gelpi retractors, return the patella to the trochlear sulcus and assess the patella for normal tracking and medial lateral stability.

**Wedge Recession Sulcoplasty**

Saw shown making first cut

Subsequent cuts

Caudal cruciate ligament

Bone and cartilage wedge

Patella
1. Using a #11 blade, score the highest points of the medial and lateral trochlear ridges of the femur; this identifies the cutting points. Using an fine X-ACTO saw, create an osteochondral wedge from the trochlear sulcus.

The lateral and medial saw cuts should be oriented to meet just cranial to the intercondylar notch of the femur distally and proximally at the osteochondral junction (Fig 18).

2. Carefully remove the cut wedge from the femoral trochlea (Fig 19).

3. Recess the wedge by removing a further thin section of subchondral bone; either from the exposed femoral trochlear sulcus (Fig 20) which is best, or from the wedge itself but the latter is more difficult and will make the wedge narrower and lose more articular cartilage.

4. Replace the osteochondral wedge in the recessed femoral sulcus and review for closeness or fit, stability, and depth of trochlear recession achieved. Adjust until satisfactory (Fig 21).

Some surgeons prefer to remove some subchondral bone at the base (apex) of the wedge with rongeurs; this can give a better fit and stop the graft from rocking on the ridge of the base. Remove the Gelpi retractors, return the patella to the trochlear sulcus and assess the patella for stability through a full range of physiological stifle movement, specifically flexing from full extension with tibial internal and external rotation - these are the positions most likely to cause luxation.

PATELLAR LUXATION SHOULD BE RESOLVED PRIOR TO SOFT TISSUE CLOSURE - DO NOT RELY ON SOFT TISSUE CLOSURE TO ENSURE PATELLAR STABILITY.

**Tibial Tuberosity Transposition**

Assess the need for tibial tuberosity transposition; prior to surgery, an indication will have been derived from the physical examination, radiographs or CT scan. The dog should be in dorsal recumbency. Stand at the foot of the dog, looking up the pelvic limb (Fig 3 & 4). Hold the stifle in full extension. Observe the orientation and position of the patellar ligament, patella and tibial tuberosity whilst the stifle is extended and flexed and the tibia is rotated internally and externally; the most likely position for patellar luxation is flexing with internal tibial rotation. If patellar ligament orientation is not neutral and patellar luxation occurs, tibial tuberosity transposition is indicated.

As an example, (Fig 22) shows the relative positions of the patella (reduced and luxated), the position of the tibial tuberosity and the medial orientation of the patella, patellar ligament and tibial tuberosity.

**Tibial Tuberosity Transposition Surgery**

1. Using a #11 blade, score the highest points of the medial and lateral trochlear ridges of the femur; this identifies the cutting points. Using an fine X-ACTO saw, create an osteochondral wedge from the trochlear sulcus.

2. Carefully remove the cut wedge from the femoral trochlea.

3. Recess the wedge by removing a further thin section of subchondral bone; either from the exposed femoral trochlear sulcus which is best, or from the wedge itself but the latter is more difficult and will make the wedge narrower and lose more articular cartilage.

4. Replace the osteochondral wedge in the recessed femoral sulcus and review for closeness or fit, stability, and depth of trochlear recession achieved. Adjust until satisfactory.
1. Use sharp dissection (#11 blade and periosteal elevator) to expose the medial aspect of the tibial tuberosity.

2. If necessary, sharply dissect and elevate the cranial tibial muscle from the lateral tibial tuberosity. Ensure that the most proximal attachments of the muscle are not severed i.e. the muscle should only be partially elevated to minimise damage from the saw blade, but not fully elevated.

3. Using a powered oscillating saw, hand saw, bone cutters or osteotome, perform an osteotomy of the tibial tuberosity (Fig 23). An oscillating saw gives the most controlled and precise cut. Place a Freer elevator or Gelpi retractor under the patellar ligament to protect it from the saw.

4. The size of tibial tuberosity and position of osteotomy is important to minimise the chance of fracture. As a guide, the cranio-caudal depth of the osteotomised tibial tuberosity should be about 30% the cranio-caudal dimensions of the tibia at that point. The osteotomy should go between the proximal tibia and the base of the tibial tuberosity, preserving the periosteum intact distally. Fig 24 shows pre-operative planning for size and position of the tuberosity osteotomy; a sterile ruler can be used during surgery to replicate the measurements and ensure the osteotomy is in the correct position. Fig 25 shows a post-operative radiograph with a good size of tibial tuberosity. If the osteotomy is made in the wrong position, either the tibial tuberosity or the tibia are at risk of fracture.

5. The tibial tuberosity should now be partially mobile (medial to lateral) whilst the distal bone and periosteal attachments should be intact. Using a periosteal elevator, gently and minimally elevate the tibial tuberosity from the tibia and transpose it laterally to a position that achieves neutral orientation of the patellar ligament and quadriceps mechanism (Fig 26). If the tuberosity is not readily mobile, this usually means the osteotomy is not quite enough and needs slightly more work distally. Some surgeons like to prepare the graft bed prior to tibial tuberosity fixation; to do this, the ridge from the lateral edge of the parent tibial tuberosity site is removed using rongeurs.

6. Using a power drive where available, place a K-wire into the proximal tibial tuberosity just proximal to the distal insertion point of the patellar ligament, to immobilise the tibial tuberosity in its new laterally transposed position (Fig 27, 28 & 29). The K-wire should be directed slightly cranio-lateral to caudo-medial. In bouncy or active dogs, or if the tibial tuberosity was detached from the tibia and has insufficient inherent stability, application of a figure-of-8 tension band is advisable; care must be taken during placement to not damage the soft tissues, particularly the patellar ligament. The size of K-wire should be appropriate to the patient, and 2 K-wires may be advisable for additional security (Fig 31 & 32). A Jacobs chuck can be used to drive the K-wires but this is more challenging to successfully drive the wire through the bone without slippage and wire bending.

7. Looking from the position of the dog’s foot, review the orientation of the patellar ligament and the position of the tibial tuberosity.

The patellar ligament should be in a neutral position; internal and external rotation of the tibia should cause equal medial and lateral orientation of the patellar ligament with no patellar luxation (Fig 31 & 32) with internal and external rotation respectively; note the changing alignment of the patellar ligament as the tibia is rotated. Fig 33 & 34 show the patella in the correct position.
8. Review the stability of the patella and specifically assess for luxation. Start with the stifle in full extension and slowly flex with the tibia in full internal and then external rotation as these are the positions most likely to cause luxation. The patella should now be stable through a full range of normal physiological movement and should not luxate.

Patellar luxation should be resolved prior to soft tissue closure - do not rely on soft tissue closure to ensure patellar stability.

**Lateral Imbrication**

For the majority of cases of patellar luxation, once sulcoplasty and tibial tuberosity transposition have been performed, the patella should be stable and further surgery (other than routine closure) should not be necessary. If the patella is not stable at this stage, the trochlear sulcoplasty and tibial tuberosity transposition should be critically reviewed, and revised if necessary.

Performing lateral imbrication without adequate trochlear sulcoplasty or tibial tuberosity transposition is not recommended and may be associated with a high failure rate and risk of patellar re-luxation.

Lateral imbrication tightens the soft tissues on the lateral aspect of the stifle joint; the joint capsule and retinaculum can be done separately. Imbrication can be achieved by one of two methods:

- Using Mayo scissors, resect a strip from one edge of the retinaculum and/or joint capsule. Don’t take so much tissue that it can’t then be sutured together. The tissue should close snugly but without tension. Close the joint capsule and retinaculum separately with simple interrupted appositional sutures.
- Or place modified Mayo Mattress (vest over pants) sutures to close the retinaculum and/or joint capsule in an overlying instead of an appositional fashion.

**Closure**

Before considering the surgery complete, once again check patellar stability through a normal physiological range of stifle movement, particularly flexing the stifle from full extension with tibial internal and external rotation. If patellar luxation persists, the surgery needs to be reviewed and revised. The surgical site should be flushed thoroughly and then closed:

- Appose and close the joint capsule incision; unless release was performed, then not on that side.
- Appose and close the reticular incision; unless release was performed, then not on that side.
- Appose and close the subcutaneous fascia - Appose and close the skin.

Post-operative radiographs of the stifle are taken to confirm the patella has been returned to the trochlear sulcus, that the positions of the sulcoplasty and tibial tuberosity transposition are correct and appropriate, and that implants are in the correct position (Fig 35 & 36). Radiographs should be critically assessed for potential problems before the patient is recovered from the anaesthetic.