Ethiopathogenesis of patellar luxation

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The patella is the small ovoid shaped bone located at the front of the knee (stifle) joint. It is located within the tendon of the powerful quadriceps muscle and slides within a groove on the lower end of the femur, known as the femoral trochlea.

Patella luxation is a condition in which the patella dislocates or moves out of its normal location. It may occur in an inward (medial) direction which is more common, or an outward (lateral) direction. Medial patellar luxation (MPL), described as the most common orthopedic disease affecting the canine stifle, occurs bilaterally in 52.4-65% of affected dogs. MPL has been recognised as the most common congenital pathology (7.2%) in 1679 immature dogs.

Small-breed dogs are 12 times more likely to develop MPL than large breed dogs and breed predisposition has been reported in the Boston Terrier, Chihuahua, Pomeranian, Miniature Poodle, and Yorkshire Terrier.

A grading system based on the findings at physical examination has been developed for the classification of patellar luxation,

- Grade 0: patella luxation is normal and the patella will not luxate during the physical examination
- Grade 1 patellar luxation: is one in which the patella will luxate when digital pressure is applied, usually with the stifle in extension, but will immediately return to its normal position when the pressure is removed!
- Grade 2 patellar luxation: is one in which the patella will readily luxate with digital pressure and tends to remain luxated. However, it can be returned to the trochlear groove and will remain in place most of the time
- Grade 3 patellar luxation is one where the patella is in the luxated position most of the time, although it can be returned temporarily to the trochlear groove with digital pressure
- Grade 4 patellar luxation is one where the patella is in the luxated position at all times and cannot be returned to the trochlear groove

The cause of MPL remains unclear. Diagnosis of bilateral MPL, unrelated to trauma, is suggestive of congenital or developmental misalignment. Specific abnormalities in MPL include coxo-femoral joint conformation (abnormal angles of inclination and anteversion, decreased acetabular coverage, and hip dysplasia), distal femoral torsion and angulation, deviation of the tibial crest, tightness/atrophy of the quadriceps muscles, and a shallow femoral trochlear groove.

Congenital MPL is not considered an isolated disease of the stifle, but rather a sequelae of complex skeletal anomalies affecting overall limb alignment.

During the growth phase abnormal direction and intensity of the forces on the growth plates can lead to abnormal activity of the growth plate itself, accordingly to Heuter-Volkmann law. These condition can promote further skeletal deformities.

Angular limb deformities result in maldistribution of forces across the adjacent joints, joint, malalignment, and potentially subluxation, which may result in osteoarthritis, lameness and pain. An abnormal conformation
of the hip joint or pelvis has been suggested as the origin of the disease. Deformities in the distal femur and tibia are thought to be caused by the bowstring effect of atrophic quadriceps muscles.

Angular limb deformities are often apparent on gross inspection of limb conformation. However, radiographic examination is essential to quantify the deformity for surgical planning.

Limb deformities have been suggested to be causes of lateral patella luxation as well.

Coxa valga associated with distal femoral valgus and external tibial torsion are frequently associated with most severe degree of LPL.

When surgical intervention is chosen, proper planning is necessary before surgical correction. Most often, surgical planning entails gross and radiographic examination of the affected limb to assess frontal and sagittal plane, and rotational malalignment. Limb variables may be measured from standard orthogonal radiographs and compared with the normal contralateral limb or published normal values for a particular limb.

Research has been directed at quantifying and defining the discrepancies between skeletal and quadriceps/patellar alignment.

References


Physical examination and patient selection for PL treatment

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Introduction

Patellar luxation is one of the most common orthopedic problems in the dog. Medial patellar luxation is more common (80%) than lateral patellar luxation (20%).

Small breeds are usually affected by medial patellar luxation, but large breeds like Labrador, Rottweiler, Boxer, Bullmastiff, Pitbulls can be affected too. Other large and giant breeds (Newfoundland, Great Dane, St. Bernard, Caucasian shepherd dogs and others) are more predisposed to lateral patellar luxation. While in small breeds minor degrees of patellar luxation can be tolerated for years of even for ever, in large and giant breeds patellar luxation most of the times results in invalidating conditions. In small dogs minor degrees (1° and 2°) of patellar luxation cause erosion of joint cartilage and predispose to cruciate tears, while major degrees (3° and 4°) result in severe debilitating conditions.

Surgical treatment of patellar luxation is a very common procedure but has a high percentage (20% or more) of failure and recurrence. Understanding the underlying predisposing factors for patellar luxation in each patient and addressing them with custom-made treatments can help in improving the success of the surgical treatment.

Physical examination

Physical examination of the dog lying on his side is performed with the following method, repeating the procedure on the opposite side:

- the clinician holds the hock with one hand and palpate the patella with the other hand;
- keeping the hip and the knee fully extended, he checks the stability of the patella inside the femoral trochlea;
- keeping the hip extended and the knee extended, he inward rotates the hock and checks for medial patella luxation;
- keeping the hip fully flexed and the knee flexed, he outward rotates the hock and checks for lateral patella luxation;
- he repeats the procedure three to four times and if the patella luxes he checks if it return in place extending the knee and keeping the hock straight.

Different treatment for patella luxation

Several surgical procedures are used to treat patellar luxation, alone or in combination, including joint capsule capsulorrhaphy, ipsilateral retinacular and joint capsule desmotomy, trochleoplasty (wedge or en-block), patelloplasty, distal femoral osteotomy for varus-valgus and torsion, tibial tuberosity transposition (TTT), proximal tibial osteotomy for varus-valgus and torsional correction, and femoral trochlea prosthesis. The surgical treatment should be personalized, according to the individual underlying conditions. Typically, the surgical treatment for patellar luxation is called “a la carte”, according to age of the patient, body size and weight, degree of luxation, medial versus lateral, severity of skeletal alterations, chronicity and degree of cartilage degeneration.
Conservative treatment

Conservative management of patellar luxation is usually indicated in toy and small breed dogs and cats with 1° degree patellar luxation. Conservative management can also be considered in 2° degree patellar luxation in toy and small dogs without clinical signs and not intended for sport activities, as a temporary solution.

In medium to large breed dogs conservative management is rarely indicated; it can be considered only in 1° degree patellar luxation without underlying skeletal alteration, when patellar luxation is usually traumatic.

Surgical treatment

Patients with patellar luxation, both for medial and for lateral lunation could be summarized into four groups:

For each group the following surgical treatments are usually indicated:

1. Growing dogs with open physis (3-5 months of age), with minimal skeletal alterations, 2° and 3° degrees PL. Deepening trocleoplasty & patelloplasty, overlapping capsulorrhaphy (retinacular desmotomy only if required). The aims are to stabilize the patella and realign the quadriceps mechanism, promoting a spontaneous skeletal realignment. Patient must be re-evaluated at skeletal maturity for further procedures in case of recurrence.

2. Growing dogs with open physis (3-5 months of age), with severe skeletal alterations, 4° degree. Corrective osteotomies (varus-valgus-detorsion) of distal femur and/or proximal tibia, saving the physis. No Tibial Tuberosity Transposition (resulting in patella baja). Deepening trocleoplasty & patelloplasty, overlapping capsulorrhaphy, opposite side reticular desmotomy to release tension.

3. Young dogs with closed physis and adult dogs, with minimal skeletal alterations, 1° and 2° (3°) degrees. Deepening trocleoplasty & patelloplasty, lateral or medial TTT, compromise for more complex detorsional tibia osteotomy, overlapping capsulorrhaphy, opposite side reticular desmotomy to release tension (3° degree PL). These procedures might lead to 10-15% recurrence risk, but are more simple solutions, compromise vs more safe, but more complex and expensive surgeries.

4. Young dogs with closed physis and adult dogs, with severe skeletal alterations, 3° and 4° degrees. Patients affected by skeletal deformities >8°-10° to normal values. Corrective osteotomies (varus-valgus-detorsion) of femur and/or tibia, deepening trocleoplasty, overlapping capsulorrhaphy, opposite side reticular desmotomy to release tension. These procedures might lead to a <5% recurrence risk.

Recurrence

Recurrence of patellar luxation is the most undesirable complication after surgical treatment of patellar luxation. The reported incidence is from 8 to 29% and it’s more common in large breed dogs. In case of recurrence, the first question to be answered is WHY it recurred, performing a critical re-evaluation of the underlying limb deformities, if they were properly addressed or if some mistakes or surgical complication did occur.

Concurrent cruciate ligament rupture could be a predisposing factor for recurrence. Then a more personalized planning should be done, addressing the limb deformities and other alterations overlooked in the first surgery.
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MPL treated by means of tibial tuberosity transposition

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Historically, the indications for treatment of patellar luxation were given by the degree of patellar displacement according to Putnam and Singleton classification. According to this classification, grade I luxation occurs when the patella is consistently located into the trochlea but can be dislocated manually by the surgeon during the clinical examination. The luxation is classified as grade II when is intermittent. Grade III when the patella is permanently dislocated but may still be repositioned in place by the surgeon and grade IV when the patella is displaced and can not even be repositioned by the surgeon. This classification is based on clinical signs, and it is not a diagnosis. To make a treatment decision we need a diagnosis. It would be like to choose the antibiotic for an infection by measuring how many degrees of body temperature has the patient. It is evident that this practice should be abandoned. The diagnosis is determining where the anatomical malformation that causes patellar dislocation is located.

Patellar luxation, in my experience, is secondary only to deformities of the femur in the frontal and transverse plane (excessive varus or valgus or distal torsion, internal or external) and to deformities of the tibia in the transverse plane (rotation or torsion of the tibia). Excess valgus and varus of the proximal tibia do not affect the positioning of the patella. Deformities in the sagittal plane of the femur and the tibia do not affect the patella to dislocate.

During the growing period, anything abnormal can happen so femur and tibia may miss their anatomical identity. The tibia may undergo an abnormal twist, internal or external. The external torsion is much more frequent. It is possible that the torque is influenced by the pulling that quadriceps femoris muscle exerts on the apex of the tibial tuberosity during the growing period. If this is the case, it becomes clear that it can’t be just a medialization of the tibial tuberosity, but the twist should occur across the proximal tibia that rotates related to its most distal part. It is also possible that being the fulcrum the centroid of the triangular section of the tibia at the tibial tuberosity level, and being still the pediatric bone very “malleable”, the twist is not homogeneous, and the outer part (tibial crest) is more twisted than his central part (Tibial Plateau). If this hypothesis is true when the tibial tuberosity is repositioned the tibial plateau is left behind (twisted). Therefore, the patella and the quadriceps mechanism would be repositioned, but the tibial plateau would still operate wrong, obliquely, in the transverse plane.

The literature shows that up to the grade II of Putnam/Singleton grade of luxation, transposition of the tibial tuberosity still has a high success rate whatever the anatomical deformity (or not any). Up to grade II patellar luxation, that in my experience corresponds to 20° of torsion, moving the tibial tuberosity in the transverse plane can still reduce the patella in place. It is possible that up to that severity collaterals, cruciates and menisci allow the tibia to rotate to adapt, to accommodate the relocation of the patella that is even more constrained when sulcoplasty is performed.

My personal suggestion is to make a radiographic diagnosis (or CT) to determine what is the deformity that causes patellar dislocation. If the dislocation is exclusively or predominantly secondary to tibial torsion treatment by transposition of the tuberosity tibial may give therapeutic satisfaction if the twist is equal to or
lower than 20° (maximum grade II of Putnam/Singleton classification). The suggestion is to proceed with a PTO (Proximal Tibial Osteotomy) whenever the torsion is greater than 20°.

When a tibial tuberosity (TT) deviates, causing medial patellar luxation (MPL), its transposition to an adequate position realigns the extensor mechanism. Two methods have been proposed for tibial tuberosity transposition (TTT): 1- TT osteotomy is performed in the frontal plane. Bone and periosteum distal to the TT are completely detached, allowing the TT to be moved; 2- A partial osteotomy is performed - distal bone and periosteum are left intact. The tibial crest is swiveled before pin fixation. This technique improves graft’s stability and shortens surgical time (1). This procedure does not use a distal cerclage wire, but it is only feasible in cases where tibial tuberosity transposition is limited. Acute swiveling may fracture the distal TT attachment, requiring a cerclage wire to avoid TT avulsion caused by the pulling of the quadriceps muscle. Tibial tuberosity is usually held in position via temporary pin fixation through the TT or using reduction forceps while verifying patellar tracking before final fixation. Temporary pin fixation may weaken the tuberosity while forceps may cause soft tissue damage caudally to the tibia. Final TT fixation is performed using pins fixed trough tubercle. In dogs, the overall frequency of post-op complications following MPL surgical treatment is 18%-43%. TTT major complications range from 13% to 18%. Implant-associated complications, recurrence, and TT avulsion are the most common post-op complications. No tuberosity avulsion has been reported in stifles when stabilized using tension band and pinning. Increased risk of complications includes large breeds and bodyweight. TT avulsion was 11 times more likely using a single Kirschner wire than with two K-wires in a study. Regardless of the number of K-wires used, the more caudo-distally the wires were directed, the higher the risk of TT avulsion. Recurrences are reported in 8%-36% of cases. Cases of post-op lateral patellar luxation have been reported.

TTTT, Tibial Tuberosity Transposition Tool technique provides a method for proximal TT shifting after partial TT osteotomy, without TT pinning, distal cerclage wiring, or a method for holding the transposed TT in position to verify patellar tracking before final bone fixation. A tool was designed to achieve slow bone bending allowing the TT to be moved laterally, maintaining the shifted portion in position until patellar tracking is checked prior to final fixation. TT is fixed by inserting a pin between the TT and the medial cortex of the osteotomised tibia, working as a spacer, to prevent the TT from returning due to bone’s elastic memory until bony union. Clinical and radiographic outcomes of surgical TTTT technique will be provided.

Bibliography

MPL treated by means of proximal tibial osteotomies PTO

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Patellar luxation is recognized as one of the most common cause of lameness in dogs. The etiopathogenesis of canine patellar luxation has been extensively reviewed but is still poorly understood. While medial patellar luxation has been reported to affect with the same frequency either in small or large breed, lateral patellar luxation seems to be more common in large breed. Patellar luxation has been classified into four grades according to its clinical findings. This classification fails into giving any relevant information on the possible presence of underlying bone deformity causing the disease. A variety of surgical techniques have been proposed with the aim of restoring the position of the patella in the center of the condyles. These different techniques, ranging from soft tissue procedures, femoral trochleoplasty and tibial tuberosity transposition, are usually either or not combined according to the severity of the luxation. Patellar luxation is primarily a developmental condition with traumatic luxations being less common. Congenital, developmental or post-traumatic deformities can affect the path of the quadriceps mechanism and its tendon leading to patellar luxation. For this reason in recent years an increasing number of surgeons proposed the hind limb alignment as an elective method of treatment for patellar luxation. This new approach is based on a complete radiographic examination of the affected limb for the pre-op evaluation of the level of the deformity/ies leading to the patellar luxation.

Radiographic survey of the pelvic alignment is indicated in every case we are considering surgical correction of a deformity. A complete radiographic survey can include the following projections:

- ventro-dorsal projection of the pelvis. This projection allows for an evaluation of femoral symmetry and alignment in the frontal plane as well as the potential for concurrent malalignment of the lumbosacral joint, transitional vertebrae, and hip dysplasia.
- medial-lateral projections of the femurs with superimposition of the femoral condyles. Information can be obtained regarding the femur in the sagittal plane. The position of the femoral head and its relationship to the greater trochanter can give an indication of the presence of femoral torsion.
- cranio-caudal femoral projections (sitting dog position) with the femurs parallel with the table top. This gives information in regards to the frontal plane. Radiographs should be taken of each femur individually with the distal femoral condyles symmetrical with one another. The relationship between the position of the femoral head and greater trochanter can give information regarding femoral torsion. The objective in positioning for this radiographic projection is not to center the patella within the femoral trochelar groove (the patella should not be used as a reference point for femoral alignment since it is independent from the femur) but for the femoral condyles to be symmetric.
- axial projections of the femurs. This projection gives information regarding the degree of femoral torsion.
- mediolateral projections of the tibiae. This projection describes the sagittal plane and information regarding the tibial plateau angle.
- caudocranial views of the tibias. This projection gives information related to the frontal plane and gives clues to a potential deformity in the transverse plane.
- caudocranial projections of the tarsus. These are optional views that should be considered in breeds pre-disposed to metatarsal rotation: Bernese Mountain Dog, Great Dane, Beauceron, Dogue de Bordeaux, Italian Spinone, Poodle, Rottweiler, Saint Bernard, Napoletan Mastiff, Maremma Shepherd, Briard, Australian Shepherd.

- craniocaudal projections of the entire pelvic limb with the dog in a sitting position. This projection gives information regarding the relationship of the tibia to the femur as well as the mechanical axis of the pelvic limb.

There are only normal reference values available for some specific breeds of dog. The ideal case when planning for a deformity correction, are those that only have one limb affected and the contralateral limb can be considered normal and can be used as a template for correction. The patient can be affected with a bilateral deformity. In these cases we should compare our radiographs to those of normal dogs of the same breed. In the case of mixed breed dogs with bilateral deformities, we should do our comparisons on dogs from breeds morphologically close to the dog of interest. The next step after obtaining the radiographic survey is measuring the radiographs. Measurements can be made using dedicated software in digital imaging programs or manually from printed or conventional radiographs with the aid of a pencil and eraser, ruler, and goniometer. The articulation angle is determined from the intersection between the joint orientation line and the anatomic axis of the bone. Joint angles provide information regarding alignment in the frontal plane, sagittal and transverse plane. They don’t, however, provide information regarding the relationship between two bone segments. Following the nomenclature proposed by Paley, the angle of articulation is composed of a 5-letter acronym. The first letter refers to the mechanical (m) or anatomic (a) axis of the bone. The second letter indicates if the angle is medial (M) or lateral (L). The third letter indicates if the angle is Proximal (P) or Distal (D) in a given bone, the fourth letter indicates the bone of interest (F=Femur, T-Tibia, etc.) while the final letter indicates that we are referring to an angle. For example, if we want to refer to the valgus angle of the proximal tibia, we would use mMPTA (mechanical Medial Proximal Tibial Angle). Using this nomenclature helps to have a standard way to communicate and express how a bone is oriented. The mechanical and anatomic axes are useful to identify the center of rotation and angulation (CORA) of a bone and determine the plane of deformity. Determining the CORA is useful to locate the origin of the deformity, how many deformities there are (uniapical, biapical or multiapical), the severity of the deformity and which direction they occur. The first step to determine the CORA or plane of deformity is to identify the joint orientation lines and the proximal and distal anatomic axis of the bone of interest. The intersection between the proximal and distal anatomic axis gives the location of the CORA in that particular plane (in uniapical deformities). The angle measured at this intersection is the magnitude of the CORA, corresponding to the severity of the deformity. After defining the location of the CORA and its magnitude, we need to determine its direction of the deformity. In cases where the deformity exists in more than one plane and the location of the CORA is the same on different planes, a vector method is used to determine the direction and magnitude of the deformity in order to correct the deformity using a single osteotomy.

When we make an osteotomy for alignment correction, we change the relationship between the proximal and distal segments. If the corrective osteotomy only changes these angulation between these two segments, this is referred by Paley as an angulation only osteotomy. This can occur with or without translation of the two segments relative to each other. The relationship between these two segments is along a single axis, termed the Angulation Correction Axis (ACA). Paley’s rules of osteotomy state: Rule 1, if the osteotomy line and the ACA pass through the same CORA, the bone ends will angulate relative to each other without displacement. Rule 2,
When the ACA is through the CORA, but the ostetomy is at a different level, the axis will realign by angulation and translation at the ostetomy site. Rule 3, When the ostetomy and the ACA are at a level above or below the CORA, a translation deformity will result.

Thin plates are ideal for distal extremities treatments where there is less soft tissue coverage (for example performing distal tibial ostetomy to correct pes varus in dachshunds). For additional stabilization, two plates can be placed side by side or a second plate can be added orthogonally to the first although this has been rarely a necessity in my experience performing corrective ostetomies. The locked position of the screws into the plate prevents compression between the bone segments. Compression can be achieved during surgery by using a Jig (Slocum Enterprises, Synthes, Securos, Intrauma) or the Deformity Reduction Device, DRD, (Hofmann s.r.l. Monza Italy). Several examples using Fixin plates will be given during this lecture including proximal and distal tibial alignments in small, medium, large and giant dogs.
The use of dynamic reduction device jig in corrective osteotomy execution

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Introduction

Distal femoral osteotomy (DFO) is an elective surgical procedure for patients affected by patellar luxation secondary to femoral deformity. Additional surgical techniques, such as tibial tuberosity transposition, trocleoplasty, soft tissue imbrication, can be added as necessary. The DFO is usually performed using a Slocum jig to provide temporary fixation at the osteotomy site and to maintain the rotational alignment. The most critical issue is bone segments instability following the osteotomy. To achieve stability during plate application, point reduction forceps can be used, along with Kirschner wires, temporarily inserted through the osteotomy site. Torsional correction can be achieved by jig pin bending, in a fashion similar to that of the TPLO procedure. Nevertheless the center of rotation will be located outside of the bone with potential translation of the bone segments.

The purposes of our study were:

1. To design a new jig, named Deformity Reduction Device (DRD), that is basically a hybrid external fixator that can be applied to the bone by means of 4 pins (2 for each bone segment). The aim of the DRD device is to allow predictable correction of complex deformities in dogs over 20 kg and to provide adequate temporary stabilisation of the osteotomy site during plate application.
2. To standardize the DFO surgical technique by means of the DRD.

Materials and methods

1. Description of the DRD device:
   a. Features and components:
      ○ Length: 13/11 cm
      ○ Rod: diameter 4 mm, length 6 cm and 4 cm
      ○ Hinge
      ○ 120° slotted arch, inner diameter 70 mm
      ○ Rotational mechanism of the arch
      ○ Meynard clamps that allow placement of 2 mm, 3 mm and 4 mm pins
   b. Mechanical movements:
      All the DRD components (rod, hinge and arch) can be moved precisely and independently through the adjustment of micrometric screws. Hinge: allows 120° of angulation of the rod towards the arch. Can be moved +/-60° from neutral position (arch perpendicular to the rod). When the DRD-jig is applied on the frontal plane of the bone, the hinge allows correction of varus and valgus deformity. The central screw of the hinge is cannulated to permit the insertion of 1.5 mm K-wire that represent the Angulation Correction Axis (ACA). Adjusting the dedicated micrometric screw, the hinge can be translated toward the arch medially or laterally by as much as 3 cm (+/-1, 5 cm), making it possible to change the position of the ACA.
      Rod: It supports the two proximal pins, inserted in the femoral diaphyseal segment. Two clamps are used to connect the pins to the rod. By adjusting the dedicated retaining screw, the rod can be trans-
lated medially or laterally with a 3 cm range of motion (+/- 1.5 cm). This translation mechanism is useful to adjust fragment apposition before plate application.

Slotted arch: it allows 90° degrees of rotation, 45° clockwise and 45° counterclockwise from neutral. Two pins are inserted from the arch in the para-throclear zone of the femur. To perform accurate rotational osteotomy without any translation, the center of the arch must be aligned with the center of the bone.

2. **DFO by means of the DRD: Standardization of the surgical procedure**

Lateral closing wedge osteotomy (10° degrees) and internal torsional correction (10° degrees) has been performed on 6 normal femurs of canine cadavers, ranging between 20 and 40 kg.

3. **Preparation of DRD jig:** the device is settled with the same amount of varus estimated upon radiographic examination. Observing the femur on the frontal plane, the hinge must be placed at the level of the CORA and can be translated medially or laterally to change the position of the ACA. The rod must overlay the femoral anatomical axis (fig.2)

### Results

The size of the animals and the surgical approach were both adequate for DRD application. The amount of correction planned was consistently achieved with satisfactory reduction. The osteotomy site was stable during plate application.

After the results of the cadaveric study, the DFO DRD jig assisted procedure was successfully applied in a case series of 36 canine patients affected by either medial and lateral patella luxation. Nowadays this technique represent our standard procedure for DFO.

### Discussion conclusion

This cadaveric study demonstrated the applicability of DRD to achieve predictable correction in the frontal and axial plane. To avoid a wide surgical approach proximally, we found it preferable to insert a smooth pin through the skin and muscle, instead of a threaded one. The two pins in the para-trochlearis region can both be applied on the opposite side of the luxation to evaluate patellar reduction before plate fixation. If the amount of correction is not satisfactory, it is possible to modify the position of the segments through the use of the regulation screws of the jig. The arch allow torsional correction while minimizing the translation of the segments because the center of rotation is superimposed with the center of the bone. The application of the plate was performed while the osteotomy site was in a stable condition without the use of reduction forceps.

We believe that DRD jig assisted surgery represents an effective alternative to standard techniques, achieving predictable correction of the deformity. The surgeon can perform corrective osteotomy to be consistent with the preoperative measurements. Precise torsional correction can be achieved in a simple way through the graduate scale. The DRD can be potentially applied in all types deformities, and in other anatomic segments as well. Similarly to human orthopaedics, we think that the DRD could improve the precision and predictability of deformity correction.

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Evolution of ccl surgery and concepts behind TPLO

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The cranial cruciate ligament rupture is the first non-traumatic cause of lameness in the adult dog, independently from its size. Over the last decades several surgical techniques have been devised to restore joint stability secondary to CrCL rupture and regardless of the surgical procedure more than 80% of good to excellent results have been reported despite the inability of either type of procedure to stop osteoarthritis progression and to maintain long-term joint stability.

The lateral suture stabilization procedure was introduced in the seventies. There have been numerous modifications of the original procedure but the basic principles of the procedure remain the same. An extra-articular constraint on the lateral side of the stifle joint that prevents cranial tibial thrust. Continued functioning is provided by the development of peri-articular fibrous connective tissue to stabilize the joint long-term. The original description that is still the most popular is passing this extra-articular restraint from the lateral fabella to the tibial crest. Another lateral suture technique was proposed in 2008 by Cook, the TightRope® (Arthrex), where the points of suture anchorage are postulated to be placed at isometric positions. The material used (FiberWire®, FiberTape®) has been shown to have significantly superior strength compared to previously utilized non-absorbable suture materials.

The major advantages offered by this method of stabilization include its simplicity and ease of the surgical technique, short operative time, low complication rate and lower costs with respect to osteotomy techniques.

Intra-articular stabilization was first introduced by Paatsama. Fascia lata was used as a replacement for the CrCL in dogs. Numerous modifications were performed with various tendons and ligaments. The technique got greater popularity in the eighties after Arnoczky reported using the medial one-third of the patella tendon and fascia lata, passed over-the-top of the lateral femoral condyle. This popularity decreased, as despite a revascularization and remodeling of the autograft, mechanical stability did not always return to normal function. This technique was a technically difficult procedure to perform as originally described using the patellar tendon. Various ligament augmentation devices have been proposed to increase graft strength but they did not meet the expected success. Regardless of the method, and despite few anecdotal reports of good success, there are no published reports of long-term outcome of these techniques. This technique no longer seems to be routinely performed in dogs.

The TPLO was introduced in the nineties by Barclay Slocum and Theresa Devine Slocum, and the TTA in years 2000 by Pierre Montavon and Slobodan Tepic. These techniques are supposed to be comparable and offer a better alternative to the lateral suture stabilization procedures. These two techniques, and others, as the cranial closing wedge osteotomy (CCWO), triple tibial osteotomy (TTO), circular Tibial Tuberosity Advancement (cTTA) all provide stifle joint stability by modifying the stifle joint biomechanics, attempting to take advantage of the forces to intrinsically neutralize cranial tibial thrust. Although their mechanisms of action may appear to be different, it seems that they all are effective based upon a single mechanism as the alteration of the patellar...
tendon angle, which modify the tibio-femoral shear forces eliminating the cranial tibio-femoral shear force in the stifle.

The TPLO (Tibial Plateau Leveling Osteotomy) “eliminates” the cranial tibial thrust secondary to the incompetence of the cruciate ligament, which sustained a partial or total tear. This procedure is intended to functionally stabilize the CrCL-deficient canine stifle during weight bearing by reducing the tibial plateau slope and thereby neutralizing the tibial thrust force. Leveling of the tibial plateau is performed by the creation of a cylindrical-shaped tibial osteotomy. The radial osteotomy has the benefit of a continuous degree of tibial correction with compression improving stability and healing. After the osteotomy, the tibial plateau is rotated around its sagittal plane until a tibial plateau angle (TPA) of about 5-6° is achieved. Plate and screws are applied to maintain fixation of the tibial plateau.

Reported overall complication rates of dogs undergoing TPLO surgery vary between 15% and 28%. Major complications include osteomyelitis, fractures of the tibia or fibula, tibial tuberosity fracture, intra-articular or intra-osteotomy screw placement, and patellar tendon desmitis. The implant-associated complication rate is 1%, with loosening and/or breakage of 1 or more of the proximal screws being the most common mode of failure. Locking systems function as internal fixators achieving stability by locking the screw to the plate. Locking screw fixation increased stabilization of TPA during TPLO healing and provided improved radiographic evidence of osteotomy healing in one study in large breed dogs. Disadvantages in using pure locking plates include fixed angle screw fixation and inability to compress at the osteotomy site. Some locking plates provide combined holes or compression holes to perform compression at the osteotomy site.

Bibliography


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