Femoral and tibial deformities associated with patellar luxation (frontal plane, sagittal plane, torsion)

Massimo Petazzoni, DVM
Milano

INTRODUCTION
Patellar luxation is a frequent cause of lameness in the dog and its clinical severity can vary significantly and be asymptomatic or symptomatic intermittently or be symptomatic continuously up to the fourth grade where the patella is permanently luxated. Medial patella luxation is the condition that is most frequently diagnosed independently from the breed size while lateral luxation is less common in small breed dogs and is more frequent in large and giant breeds. Patella luxation has been defined as congenital/developmental because it is diagnosed in the first stages of the development of a puppy. Patella luxation has been classified in four degrees but this classification is based solely on clinical findings. Because this classification is independent from the kind of anatomical malformations that cause the patella luxation it is useless in the surgical preoperative planning process. Classically, the main surgical techniques for patellar luxation are trochleoplasty, tibial crest transposition, joint capsule imbrication, medial release of the joint capsule retinaculum or quadriceps muscle group alignment. Following a proper radiographic diagnosis corrective osteotomies allow to treat hind limb abnormalities.

DEFINITIONS
Anatomic planes: the position of the part of the body of interest can be identified spatially in reference to three anatomic planes which are perpendicular to each other: the sagittal, the frontal and the transverse plane. The sagittal plane is oriented in a cranio-caudal position. The frontal plane courses in a lateral-lateral orientation while the transverse plane divides the body (or the limb) into dorsal and ventral parts. The anatomic axis of a bone segment is a line that passes through the center of the bone through the epiphysis, metaphysis and the diaphysis. The mechanical axis is a straight line connecting the center of the proximal and distal joints.

The varus deformity is the deformity in which the bone is deflected inward toward the sagittal median plane of the body while the valgus deformity is the deformity in which the bone is deflected outward away from the sagittal median plane of the body. The procurvatum deformity is the deformity in which the bone is deflected caudally while the recurvatum deformity is the deformity in which the bone is deflected cranially.

Rottweiler, male, 9 months, 30 Kg.
Lateral patellar luxation. Diagnosis: external rotation of the tibia. 3D reconstruction. OsiriX.
nially. Torsion is the deviation around the long axis of the bone. In a proximal to distal direction torsion can be either internal or external. Rotation is the deviation inside the joint.

STANDARD MEASUREMENTS

Femur
The femoral anatomical axis in the frontal plane is represented by a single line, in the center of the medial and lateral cortices throughout the length of the bone. In the dog, the femoral anatomic axis does not follow a single straight line, but two straight lines, which can be defined as the Proximal Anatomic Axis and Distal Anatomic Axis. The femoral anatomical axis in the sagittal plane is a single line coursing through the cranio-caudal midpoint of the bone, from the center of the head of the femur to the center of the femoral condyles. The femoral anatomic torsion is the orientation angle of the femoral neck in the transverse plane in relation to the femoral condyles. The joint orientation line of the proximal femur in the frontal plane is represented by a line connecting the distal most aspect of the cranial and caudal cortices of the femur. The joint orientation line of the distal femur in the frontal plane is represented by a straight line passing through the most distal convexities of the femoral condyles.

Tibia
The tibial anatomic axis in the frontal plane is represented by a single contoured line centered between the medial and lateral cortices throughout the length of the bone. The joint orientation line of the proximal tibia in the frontal plane is represented by a line passing through the distal points of the concavities of the tibial condyles. The joint orientation line of the distal tibia in the frontal plane is represented by a single line passing through the proximal points of the medial and lateral concavities of the tibial cochlea. The tibial anatomic axis in the sagittal plane is represented by a single contoured line centered between the cranial and caudal cortices of the tibia. The joint orientation line of the proximal tibia in the sagittal plane is represented by a single contoured line centered between the cranial and caudal cortices of the tibia. The joint orientation line of the distal tibia in the sagittal plane is represented by a line passing through the cranial and caudal extents of the tibial plateau. The joint orientation line of the proximal femur in the frontal plane is represented by a line connecting the proximal points of the medial and lateral cortices of the femur.

Patellar luxation
The patella is a sesamoid bone that develops inside the tendon of the of the quadriceps muscle. It lies along the extensor axis of the quadriceps muscle, that is the vector result of the traction force of the 4 muscles that compose the quadriceps muscle unit (the rectus femoris, the vastus medialis, the vastus lateralis and the vastus intermedius). The rectus femoris inserts distally on the apex of the tibial tuberosity and proximally from the eminentia ileopubica. The vastus medialis muscle arises in the craniomedial surface of the proximal fifth of the femur. Vastus intermedius and vastus lateralis arise from the craniolateral part of the proximal fourth of the femur. Patella is always along the origin and the distal insertion of the quadriceps muscles. For this reason, in a normal dog, the trochlear sulcus is always on the same sagittal plane of the distal anatomical axis of the femur. During the growing period, because of the traction that these muscles exert, the patella generates a depression on the metaphyseal curvature of the distal femur, the femoral trochlea. Any modification to the femur, to the proximal tibia and to the relationship between the femur and the tibia and a combination of the above mentioned variation bring to a subluxation or to a luxation of the distal portion of the femur relative to the patella. From these considerations it is clear that the patellar luxations, either medially or laterally, can be the result of relatively few causes: 1. an internal or an external tibial rotation in respect to the femur; 2. an internal or an external tibial torsion; 3. a torsion of the distal femoral extremity (internally or externally) that produces the distal femur subluxating in respect to the patella; 4. a distal axial deviation of the femur in varus or valgus 5. a combination of the previous. In general, varus of the distal metaphysis of the femur brings to the “so called” medial luxation of the patella as well as the external torsion of the femur while the distal valgus of the femur and the internal torsion of the femur predispose to the “so called” lateral patella luxation. Malformations of the proximal tibia (varus, valgus or torsion) with or without the femoral malformations mentioned above can cause patella luxation. Torsion indicates a bone malformation in which the distal articular surface is rotated internally or externally along the bone axis. This means the twisting of one end of the bone while the other end is held fixed. This is generally the result of an abnormal meta/epiphysial development or secondary to an abnormal physeal growth during the developing period or secondary to a bone fracture or to a malunion. Rotation indicates malalignment in which two contiguous bones rotate one in respect to the other around the joint plane. It can be the result of muscular and tendinous contracture or of ligamentous shortenings or of a bone malformation. Torsion and rotations can be combined contributing to the same malalignment.
The determination of hind limb alignment requires accurate diagnostic imaging evaluations. Radiography, computed tomography and magnetic resonance were described. In veterinary medicine radiographic survey was traditionally performed to diagnose hindlimb malformations but few positioning mistakes could determine significant artifacts or mistakes. Congenital, developmental malformations can produce an alternate alignment of the femoral axis. To my knowledge no studies have documented a developmental malformation of the tibial tuberosity alone without a concomitant femoral and/or tibial deformity. For these reasons, surgery should be addressed to re-establish the anatomy focusing on exactly where the malformation is. Tibial tuberosity transposition should be performed only when tibial tuberosity is not where it should be.

Acknowledgements: Gayle H. Jaeger