Tibial Tuberosity Advancement: Use of the Common Tangent Method for Determining Appropriate Advancement Cage Size

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The most common cause of lameness in the hindlimb of the canine is unarguably ruptured cranial cruciate ligament. Many techniques have surfaced in the veterinary literature over the years describing various techniques for stabilization of the knee through intracapsular or extracapsular techniques. Tibial Plateau Leveling Osteotomy was released in 1993 by Slocum and Devine, and despite lack of scientific proof of it being superior to other techniques, has become the gold standard by which other techniques have been compared. More recently, Tibial Tuberosity Advancement (TTA) has become a suitable and perhaps simpler alternative to the TPLO with little clinical reasoning to not perform it over the TPLO procedure.

In the simplest of terms, during extension of the stifle joint, the pull of the quadriceps mechanism is in a cranial direction (cranial shearing). As flexion of the stifle joint increases, the direction of this shear force changes to a more caudal direction once the stifle joint passes through approximately 90 degrees of flexion. TTA takes advantage of this phenomenon in the canine stifle joint by moving this “cross-over” point out to an extension of the stifle joint of approximately 135 degrees, the standing angle phase of the canine gait.

With the introduction of the TTA in 2004 by Tepic et al, time and use has brought about some minor, yet important changes to the procedure to help it maintain clinical use in veterinary surgery. Specifically, current methods of assessing the stifle joint for adequate advancement of the tibial tuberosity and proper advancement cage sizing have historically involved measuring the tibial plateau slope. This technique involves identifying nonarticular landmarks, the cranial and caudal cruciate insertion points, as the borders of the medial tibial plateau, and hence, its slope (TPS) in degrees relative to the tibial long axis (TLA). According to Tepic, the patellar tendon must be perpendicular to the tibial plateau at a stifle angle of 135 degrees for proper reduction of cranial tibial thrust (CTT) and stabilization of the stifle joint. Consistent and proper identification of these landmarks has proven difficult for some practitioners due to the development of osteophytosis in the stifle joint, poor radiographic technique, and improper positioning of the stifle joint. The conventional method of assessment may lead the veterinary surgeon to place an advancement cage that is too large resulting in poor clinical outcome.

Accurate assessment of the tibial plateau is difficult for a number of reasons. The knee joint being assessed is not normal and in fact, affected radiographically with many radiographic changes. With the lack of a cranial cruciate ligament, the stifle joint is most likely in some degree of rotation as evidenced by the “double condylar sign”. The presence of this rotation

will cause erroneous assessment of the TPS. CTT is very often present in the knee during the radiographic procedure and can be difficult to reduce. The presence of osteoarthritis and sclerosis of the joint makes identification of the cruciate landmarks difficult and highly variable amongst different assessors. Lastly, these insertion points do not represent the true articulating surface of the tibia. Compared with anatomic measurements of the tibial plateau slope, current radiographic measurements underestimate the TPS and the direction of CTT.

The current (conventional) overlay provided by TTA implant companies contains 5% magnification within the sizing. Surgeons with digital radiography often have difficulty in obtaining 100-105% sizing in their radiographs on the computer screen, and have to result to using the graphical software built in to their systems to evaluate not only the advancement required, but the plate size as well. The inaccuracies in this technique may be decreased by the use of radiographic markers of a known size that can assist the surgeon in expanding the film on the screen to an appropriate size. Many surgeons may not have assessed the accuracy in their conventional radiograph machines at reproducing film images at 100%.

Improper advancement of the tibial tuberosity will most likely result in less-than-expected clinical results with the TTA procedure. Specifically, too large of an advancement cage may cause anterior patellar luxation, an increased strain on the caudal cruciate ligament, and possibly increase joint forces in the caudal margins of the joint. Too small of an advancement cage will certainly result in poor reduction of cranial tibial thrust. An improperly sized cage has the potential to lead to chronic and difficult to diagnose meniscal problems.

Recent studies have found that by drawing a line tangential to the cranial linear portion of the medial tibial plateau at the tibial femoral contact point more accurately assesses the TPS and hence the vector of the CTT. In fact, measurements of the TPS with this alternative technique did not differ from anatomic measurements of the same stifle joints. Advantages to utilization of this common tangent method include; higher reproducibility, increased accuracy of cage selection, and less dependency on the angle of the stifle joint at which the radiograph was taken.

The common tangent method assesses the cranial linear portion of the medial tibial condyle in a plane that starts at the tibial femoral contact point. This plane is thought to more accurately represent that of CTT in the cruciate deficient stifle joint. This technique has brought about a slight change in our explanation of how the TTA works, in that the flexion angle of the stifle joint at which the patellar tendon is perpendicular to the tibial plateau is more accurately 110 degrees. Thus, at 110 degrees of stifle flexion, the net tibial femoral shear force in the joint should be zero. Applying this concept clinically to the dog tells us that our current methods overestimated this angle by 20 degrees, and that stifle joints may have been overcorrected utilizing the current method of assessment.

The common tangent method involves a slightly complicated method of radiographic assessment to determine the required TTA advancement. The technique requires a medial to lateral view of the stifle joint taken at an angle of approximately 135 degrees. A circle is drawn around the articulating surface of the femur. A second circle is drawn around the articulating surface of the tibia. These two circles should touch. A line is next drawn connecting the two center points of these circles. A line must be drawn that is tangential to the circles and perpendicular to previous line connecting the center points of the circles. It is this line that is called the common tangent and represents the tibial plateau slope and direction of cranial tibial thrust.

To determine the appropriate advancement cage size, a line must now be drawn from the distal pole of the patella where the patellar tendon originates in a distal direction to cross the common tangent line at 90 degrees. Lastly, the distance for advancement is found by measuring between the tibial tuberosity and this (red) line.

In a radiograph in which the stifle is extended greater than 135 degrees, the conventional method of assessment will generate a cage size that is too large, and if less than 135 degrees, a cage that is too small. The common tangent method will produce more accurate and consistent

results independent of the stifle angle, though you must still stride for 135 degrees. Conceptually, this author has recommended using ideal body weight and plate size to help the veterinary surgeon determine the appropriate cage size with very good clinical results. Nonetheless, it is suggested that you utilize this method of advancement cage selection in dogs in which you may feel the plate or cage may be of inappropriate size.

A potential measurement problem that appears to exist in both methods of assessment is also evident. Each method measures the advancement to take place at the tibial tuberosity. Yet, the advancement cage is placed well above that point, above the plate entirely and just below the joint. Placement of the cage at the tibial tuberosity is known to potentially lead to fracture of the tibial tuberosity postoperatively. The contribution of this concept to a potentially smaller than adequate cage has not been evaluated.

Intraoperatively, and/or postoperatively, one can assess the adequacy of reduction & neutralization of cranial tibial thrust through use of examination techniques that elicit cranial tibial thrust. Utilization of the Henderson-Milton tibial compression test requires the use of the metatarsus as a moment arm generates an internal stifle force that is parallel to the TLA. By simply applying a force to the footpad of the operated limb with the stifle in approximately 135 degrees of extension, the internal stifle forces generated are more parallel to the patellar tendon and thus, more accurately assesses the reduction of CTT by the TTA.

Postoperatively, ideally before the patient is awoken from anesthesia, the radiographic procedure described above should be repeated and the measurements again applied to document adequate reduction of tibial thrust.

References:

Tibial Tuberosity Advancement: A step-by-step approach to using the common tangent method for determining advancement in cranial cruciate deficient stifles, Randy Boudrieau, DVM, ACVS, ECVS, Cummings School of Veterinary Medicine, white paper, June 2009.

Inclination of the patellar ligament in relation to flexion angle in stifle joints of dogs without degenerative joint disease. Dennler, R; et al. AJVR, 67; 11, Nov 2006.