Key Points

- Palpation of functional cranial tibial thrust instability during weight-bearing is used to assess knee stability pre- and post-operatively.
- Variation in radiographic landmarks to determine stifle flexion angle (SFA) leads to variable TTA cage size recommendations. Use of the Long Axes Method leads to larger advancement recommendations than Kinematic or Eminence Methods.
- Variation in radiographic landmarks to determine patellar tendon angle (PTA) leads to variable advancement recommendations. Use of tibial plateau landmarks leads to larger advancement recommendations than common tangent landmarks.
- Variation in measurement methods leads to variable advancement recommendations. Use of virtual TTA planning software leads to larger advancement recommendations than does the transparent overlay method.

Cruciate ligament rupture (CrCLR) is a frequently diagnosed orthopedic disease in the dog with large economic impact. Many surgical procedures, including Tibial Tuberosity Advancement (TTA) have been proposed to alleviate the cranial tibial subluxation (CTS) that results from CrCLR. It is estimated that more than 70,000 TTA procedures have been performed to date. TTA seeks to control CTS via elimination of cranial tibial thrust by orienting the patellar tendon angle (PTA) to $\leq 90^\circ$ during the weight-bearing phase of the gait. Since in vitro studies have confirmed that achieving this PTA is foundational to the procedure’s ability to control CTS, consistency and predictability in attaining that postoperative geometric outcome seems paramount.

Palpation of functional cranial tibial thrust instability during weight-bearing is used to assess pre- and post-operative knee stability. This examination is performed with the patient standing. The examiner places his thumb behind the lateral fabella and index finger on the tibial tuberosity to reduce the cranially-subluxated tibia. The examiner then shifts the patient’s weight on to the examined limb while feeling for CTS. Early in the author’s experience with TTA, his subjective impression was that an unsuitable number of dogs had functional cranial tibial thrust instability detected during their postoperative convalescence. While it is possible that this observation was the result of TTA being based upon a flawed concept, in vitro data suggest otherwise. With the assumption that the concept of TTA is correct, other possibilities are: (1) the pre-operative planning process is flawed, or (2) the execution of the TTA plan is flawed, or (3) a combination of the above.

Preoperative TTA planning in clinical practice currently uses various different anatomic landmarks and techniques to measure the advancement required to establish PTA = 90°. The effect that these variations in preoperative planning have on the recommended advancement has recently been scrutinized.1-3

The Effect of Radiographic Stifle Flexion Angle (SFA) Landmarks on TTA Cage Size

The average stifle flexion angle of dogs during mid-stance phase of the gait is $135^\circ$. This was determined from a kinematic analysis using topographical palpable landmarks (greater trochanter of the femur, lateral malleolus of the fibula, and a point of rotation between the fibular
head and the femoral condyle). In clinical practice, there has been no consistency as to how these palpable landmarks are translated to radiographic landmarks for measurement of SFA used on pre-operative TTA planning radiographs. Since PTA is strongly affected by SFA, it is not surprising that variation in radiographic landmarks used for SFA measurement affect the recommended TTA cage size. Though the design of the study did not permit authors to make a recommendation for SFA landmarks, they noted that use of the so-called Long Axes Method resulted in greater recommended TTA cage sizes than the Eminence Method or Kinematic Methods. While the latter two methods had relatively specific landmarks, the Long Axes Method seemed more subjective in this author’s opinion.

The Effect of Pre-Operative Planning Method on TTA Cage Size Recommendation

In the originally described pre-operative planning method, a transparent template is superimposed on the radiographic image to determine the tibial tuberosity advancement necessary to achieve a post-operative 90° PTA. This transparency assumes a translational advancement along a line parallel to the tibial plateau. However, since the TTA osteotomy is not perpendicular to the tibial plateau, the advancement is not parallel to the plateau, and there is a limit to proximal translation of the tibial tuberosity, the actual advancement is likely to be less than planned. In a theoretic geometric analysis, the discrepancy between desired tibial tuberosity advancement and actual advancement increases as the tibial plateau angle and the desired advancement increase. In another study, the transparency method was compared to a method that utilized software measure the advancement at the level of the proposed site of TTA cage placement after performing a virtual TTA that resulted in the a PTA = 90°. Larger tibial tuberosity advancement recommendations resulted from the virtual TTA software method compared to the original transparency method. Though anatomic tibial plateau landmarks were originally used in the measurement of PTA, use of the common tangent of the femoral and tibial condyles has been advocated as it may be less influenced by variations in stifle flexion. When the effect of these landmarks on the tibial tuberosity advancement recommendation were compared, investigators found larger advancement recommendations associated with the use of tibial plateau landmarks. The same study used these 2 sets of landmarks and the 2 advancement measurement techniques (transparency and virtual software) to compare the final TTA cage size recommendation for 4 combinations of pre-operative planning methods and concluded pre-operative planning techniques currently practiced lead to variable TTA cage size recommendations and may be a source of inconsistent outcomes.

Is Patient Size a Good Indicator of Appropriate Cage Size?

The TTA procedure is based upon a logical, scientific concept of achieving a 90° PTA during weight-bearing and there is supportive in vitro “proof of concept” evidence. Some veterinarians, however, practice a method of selecting TTA cage size based on patient size (as determined by body weight, subjective visual assessment as “medium-breed”, etc). This method cannot be advocated as it has no logic basis in the procedure’s base concept.

Conclusions

No study to date has definitively determined which radiographic stifle flexion angle landmarks (Long Axes, Eminence, Kinematic), which planning method (transparency vs. virtual software), and which PTA landmarks (tibial plateau vs common tangent) are most effective for restoring optimal post-operative patient function. Clinicians are encouraged to evaluate
functional cranial tibial thrust instability in the standing, weight-bearing patient in addition to other functional outcome measures (lameness scores, sit test, etc) to assess the adequacy of their pre-operative planning and its surgical execution.

References