Monthly Update
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Tibial Tuberosity Advancement for CCL Injuries

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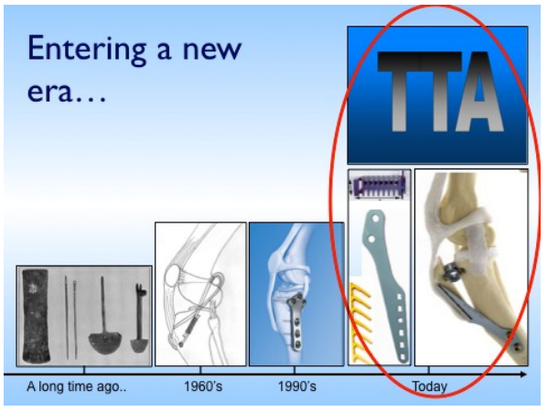

16th…….Mid/Late 20th..21st Century

HISTORY

Advancement of the tibial tuberosity was first described by Maquet in human medicine. The premise of the procedure was that an increase in the efficiency of the quadriceps mechanism would subsequently decrease retropatellar pressure, thus alleviating pain associated with the patellofemoral joint.1 Other possible effects on the biomechanics of the tibiofemoral joint included evidence that a variable tibiofemoral shear force was present in the knee joint, which was either anteriorly or posteriorly directed depending upon the angle of knee joint extension or flexion (and patellar tendon angle - PTA).[2] The magnitude and direction of the tibiofemoral shear force was determined by the PTA.3 The Marquet proceedure was found to be effective in decreasing the femoral tibial contact forces in stifle extension and decreased retropatellar pressure.4 A relationship between tibial tuberosity advancement, knee joint flexion/extension, tibiofemoral shear force, retropatellar pressure (including femorotibial contact forces) and patellar tendon force has been suggested and supported by a variety of experimental studies.[1-4]

BIOMECHANICS

Based upon the data published by Maquet and Nisell, Montavon and Tepic proposed that a similar situation existed in the dog, and tibial tuberosity advancement (TTA) was proposed to neutralize cranial tibial femoral shear force in a cranial cruciate ligament (CCL) deficient stifle joint in the dog. A PTA of 90 degrees was suggested as the crossover point at 135 degrees of stifle joint extension, thus the TTA technique was developed so as to achieve this PTA. These assumptions have since been validated in experimental models. These models were used to evaluate cranial tibial femoral shear force either indirectly with cranial tibial subluxation or directly with cranial tibial thrust under varying loading conditions.[3,4,5]

Continued next page

CT Scan Diagnostics

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3. CT Scan, Out patient $985.00 **(case sent to CCVS exclusively for a CT; this includes charges for doctor overseeing case, IV catheter, and fluids post CT).
4. CT "Met Check" $590.00
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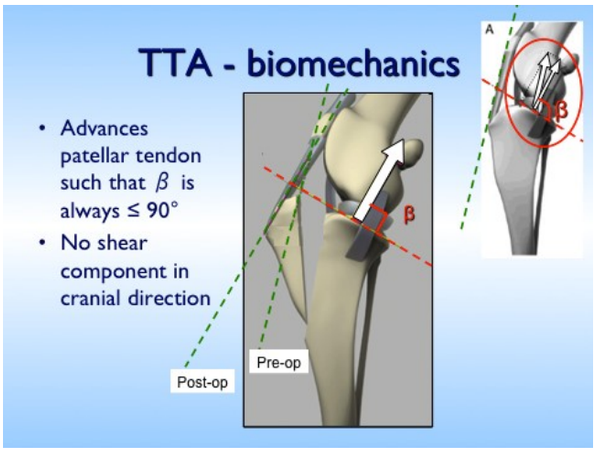

Figure 1: The TTA procedure consists in advancing the tibial tuberosity forward, in order to change the orientation of the patellar tendon such that beta is 90 degrees or less throughout the normal range of motion of the stifle. The result is that there is no cranial shear component.[15]

A decrease in retropatellar pressure after a TTA has recently been demonstrated experimentally in the dog.[5,12] In theory this diminished force can protect the articular cartilage of both the patella and the femur from subsequent damage. Femorotibial contact pressure and location have been evaluated in vitro using an experimental model of a CCL deficient stifle joint, which demonstrated a 40% decrease in contact area with an associated 100% increase in peak pressure; furthermore, the positioning of the peak pressure was found to shift caudally.[5] The TTA appeared to restore the normal femorotibial contact and pressure, which may spare the meniscus from risk of trauma after TTA. This study also suggested that because TTA did not change the geometry of the joint, and the pressure distributions essentially remained unchanged, there may be less development of osteoarthritis. All of these findings may support the clinical studies that implied an absence of problems with the patellar tendon and the joint surfaces after TTA.[6,7,8]

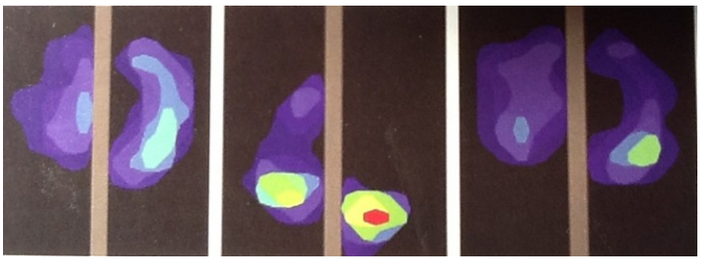

Figure 2: These are contact maps of the tibial plateau. The left image is a normal stifle. The middle image is a CCL deficient knee in a dog. The right image is a TTA knee. The tibial plateau contact maps are similar in the normal and TTA knee joints while the transected CCL resulted in caudal shift and an increased pressure of femorotibial contact.[5]

As the resultant PTA is crucial to the determination of the amount of TTA, there has been a recent suggestion that the PTA is more accurately determined by the method of the common tangent (PTACT)as opposed to the method using the tibial plateau angle (PTATPA). The former method has been proposed to be clinically more accurate as it takes into account the anatomic relationship between the femoral condyles and tibial plateau, as opposed to a static relationship of the tibial plateau with the patellar tendon. Based upon these suppositions, this method has been recommended for clinical use. Support for this concept has been demonstrated experimentally whereby less variability was observed with PTACT vs. PTATPA when compared to the target PTA of 90 degrees.[10,11]

CASE SELECTION

There are FIVE primary considerations when selecting the appropriate case for a TTA/CCL repair. The FIRST is the location of the patellar tendon insertion, low vs.high. The tibial tuberosity is at greater risk of fracture with a TTA in a case with a low patellar tendon insertion point. This anatomy necessitates a smaller plate be applied to the tibial crest. Then the usual position of the interspersed cage is above the most proximal position of the plate resulting in little bone to support it. With that anatomy a TPLO would be a better application for the CCL repair in those cases. Dogs with a high insertion point a TTA/CCL repair is ideal because a larger TTA plate can be applied leaving adequate bone to support the cage.

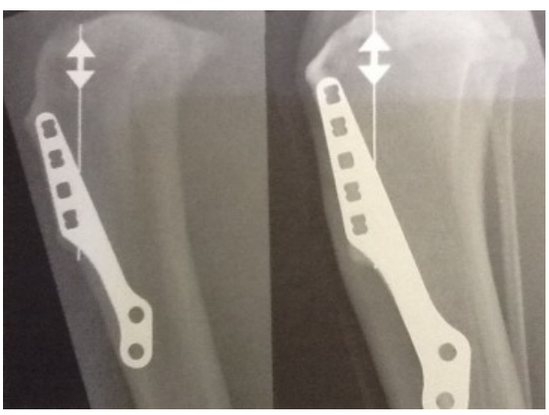

Figure 3: Left low patellar tendon insertion. Right high patellar tendon insertion which is ideal for a TTA.[9]

The SECOND consideration is if the tibial plateau slope/angle (TPA) is excessive. The target TPA is 90 degrees, but achieving this angle in cases with excessive TPA would likely require advancement beyond that obtained with the currently available implants (current maximum cage size 16 mm, Securos). There is a conformational deformity of the joint with excessive tibial plateau angle that places it in a relative angle of hyperextension despite the limb itself not being in the extended position. The TTA does not address this malformation. The maximal tibial plateau angle to perform a TTA has yet to be determined. No data have been published regarding the range of tibial plateau angles in dogs with TTA, although it has been presented that successful procedures have been performed in dogs with a TPS of greater than 30 degrees and anecdotally proposed that angles greater than 30 degrees probably are not well suited for a TTA. We await more objective data.

Figure 4: Left 43 degree TPA; Right 25 degree TPA

The THIRD consideration is angular and torsional limb deformities may not be treated with TTA. However, a TPLO does allow for correction of some concomitant limb deformities (varus, valgus, torsion).

The FOURTH is patellar luxation requiring tibial tuberosity transposition may be very well suited for a TTA, as any desired transposition may be simultaneously performed with the advancement. With concomitant patellar luxation, the TTA plate is slightly over-bent to conform to the new laterally (or medially) transposed tibial crest. The alteration in the surgical technique occurs with cage application. For example, in a medial patellar luxation, where the tibial crest is moved laterally, either the caudal "ear" of the cage is recessed into the proximal tibia, or the cranial "ear" of the cage elevated above the surface of the tibial tuberosity by interposing some washers, or both. Ancillary fixation generally is unnecessary.

The FIFTH is patient size. Initially, in our practices, we were not doing many dogs over 100#'s. We have since done many dogs in the 100-200# range with a minimal complication rate. TTA has been performed in our practices primarily in the 35# to 200 # dogs. Size limitation is dependent upon availability of appropriately sized implants (2- to 8-hole plates, and 3 mm to 16 mm cage widths. The implants are produced in a variety of sizes such that they can be used in almost any sized dog. In some instances, in the very large breeds of dogs a limitation of the TTA may be the large distance (>16 mm) of tibial tuberosity advancement that is required (not necessarily the heavier dogs, but rather the taller dogs, e.g., Great Danes).[9] The widest cage currently available to support the osteotomy gap is 16 mm, which only became available in early 2009 (prior to this time a 12-mm cage was the widest available).

TTA SURGERY

Figure 5: We have already discussed the recommended approach to ligament remnants and the medial meniscus. Next the proximal medial tibia is exposed and the osteotomy is started. The osteotomy must be straight across from the medial side to the lateral side. Oblique osteotomies are undesirable. The osteotomy must be caudal enough such that the tibialtuberosity fragment is big enough to allow safe placement of the fork and the cage screw without risk of fracture. It must be cranial enough to avoid the long digital extensor tendon and the menisci.[15]

IMPLANTS

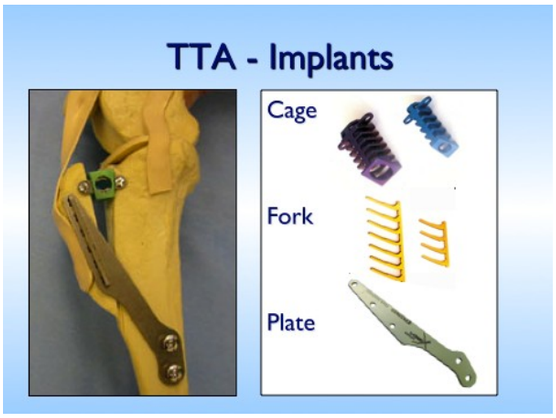

Figure 6: To achieve this, the osteotomised tuberosity is held in the advanced position by titanium, plate, fork, screws, and cage.These are very light weight and have minimal temperature conductivity in their exposed (no muscle coverage on the proximal medial tibia). Subjectively large stainless steel TPLO plates may cause cold climate intermittent lameness.[15]

PLANNING

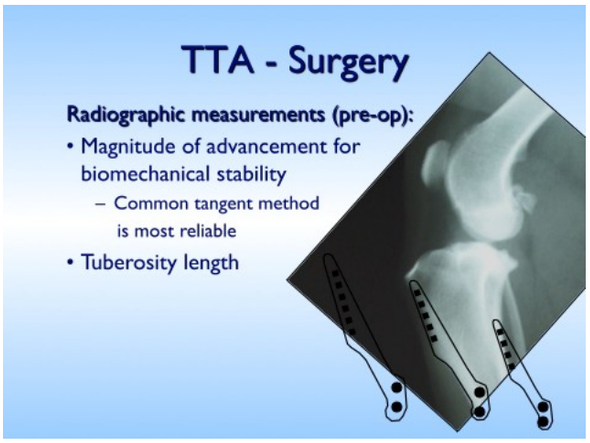

Figure 7: The length of the tibial tuberosity is then measured to determine plate and fork size.[15]

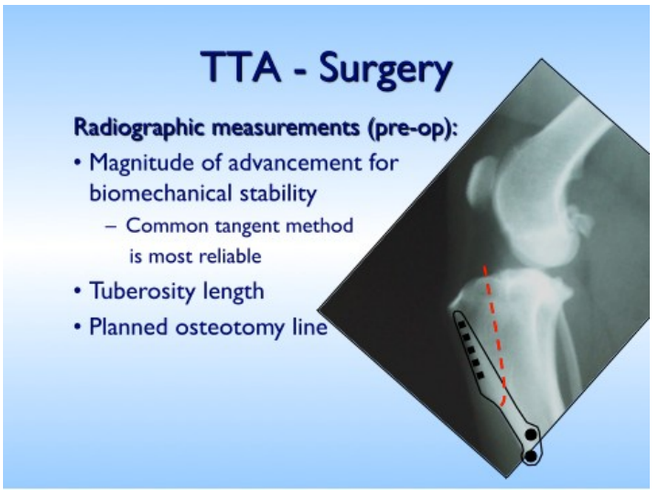

Figure 8: The landmarks for the osteotomy should also be found. These are the tubercle of Gerdi proximally to a point 1/3rd of the way between the last hole of the fork and the first screw hole.[15]

OUTCOME/COMPLICATION RATE

The TTA has been in general use for <10 years. There are anecdotal reports of good to excellent results, and 3 early clinical results published.[6,7,8] The latter are the early experiences of a number of surgeons, which remain biased with the respective learning curves for these individuals. These 3 studies (249 total cases) report an overall complication rate of 20.0%-59.0% in CrCL-deficient stifle joints repaired using the TTA. A number of minor complications were reported in these studies, including postoperative swelling and bruising accounting for 19.3-21.0% of these complications. The major complications accounted for 12.3- 38.0%. A re-operation rate of 11.3-14.0% was reported. Combining the data, these complications, in order of frequency, were as follows: meniscal tears (7.6%, or 16.5% of the intact menisci), infection (4.0%), medial patellar luxation (0.4%), tibial fractures (0.08%) and catastrophic implant failure (0.08%). The primary discrepancies between these reports were the frequency of meniscal tears (16-21.7%) and technical failures (22%).9 In a more recent large series meniscal injury and small cage size, caused the greatest complications.[13]

Radiographic healing was reported to be partially complete by 7-8 weeks postoperatively and fully complete as early as 8-10 weeks postoperatively. In one report, bridging bone at one site in greater than 94% of the cases, and at a mean of 9.4 weeks postoperatively in the other report. Overall function (outcome and lameness) of the dogs postoperatively was reported to be good to excellent in >90% of the dogs.[9]

In all studies, two major points are discussed: early technical errors with the procedure and meniscal injury. Elimination of technical errors, which were associated with the early learning curve in performing this surgical procedure, would have significantly reduced the number of major complications; attention to the technical details of the procedure is paramount. The issue with the meniscus is more confounding, as there is much controversy as to the best method of approach: meniscal release or no meniscal release. The TTA was originally performed without a meniscal release, but it appears that the majority of complications occurring postoperatively in two of the studies were because of meniscal tears, either those that may have been missed at the time of the original surgery or those that subsequently occurred. A suggestion was made that meniscal release may eliminate this issue. Furthermore, it was reported that dogs with/without meniscal debridement (meniscal tears or not) were not different based upon clinical outcome. Therefore, it was suggested a meniscal release might be appropriate as minimal morbidity could be expected; however, this supposition needs to be further evaluated with long- term follow-up.Whatever the opposing mechanisms proposed regarding the meniscus, debate remains as to whether or not to perform a medial meniscal release. It appears there are two opposing opinions regarding the necessity of meniscal release at this time with TTA.[9]

PERSONAL EXPERIENCE (BVS and CCVS)

TTA's in the hands of our three surgeons BVS/CCVS with over 6 years experience and well over a 1500 cases the complication rate is very low. We have no residents in training so all the cases are done by very experienced surgeons. The consensus among the three surgeons is to do a medial meniscal ligament release which greatly minimizes to post-operative complication rate. Our major complication rate is consistent with previously published (infection, tibial fractures, meniscal injury, and catastrophic implant failure), is very low. Because all the TTA implants are titanium they almost never require removal due metallurgical reaction. All our TTA cases are examined at 2, 4, 8-10, or 10-12 weeks post- op depending on the surgeon's preference and the age of the patient. Post-operative confinement for 8-10 weeks is restricted to short leash walks , no off leash running or jumping, and confinement to a crate, child's play area, pantry, half bathroom when alone indoors. All TTA cases are sedated and radiographed at 10-12 weeks post-op to confirm the osteotomy is healed. Bilateral CCL injuries are often repaired at a 6 week interval. Autogenous cancellous graft material is harvested from the adjacent proximal caudal tibial metaphyseal bone and placed in the adjacent osteotomy gap below the cage. However, a recent publication would indicate bone grafting does not enhance osteotomy healing.[14] Subjectively, weight bearing occurs earlier and more normally than in TPLOs. We currently do many more TTAs than TPLOs each week.

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TECH TIP

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