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TIBIAL TUBEROSITY ADVANCEMENT (TTA) FOR CRANIAL CRUCIATE LIGAMENT DISEASE
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INTRODUCTION
Cranial cruciate ligament (CrCL) disease is a frequent cause of hind limb lameness. This presentation aims to relate the chronological developments made at the Vetsuisse Faculty of Zurich for this disease. It includes the documentation of the chronicity of this deficiency, the biomechanics in presence, their radiographical and in vitro studies, the surgical treatment by TTA, and its functional and radiographical results.

CHRONICITY OF THE DISEASE,1 (1966)
Acute ruptures of the cranial cruciate ligament were histologically studied, revealing the presence of hyaline degeneration, dystrophic calcification, and disruption of the ligament fibers. They resulted from chronic degenerative processes where multiple micro traumas ended causing the rupture of the ligament.

PARTIAL CRANIAL CRUCIATE LIGAMENT RUPTURE,2 (1987)
The clinical and radiographical aspects with partial cranial cruciate ligament rupture were described in 8 young large breed dogs. Those stifles had no anterior drawer sign, and no meniscal damage was present intra-operatively.

ADVANCEMENT AND CRANIALISATION OF THE TIBIAL TUBEROSITY,3 (1993)
This technique has been used on human patients by Maquet. It was modified to treat small animals suffering of the patellar luxation with presence of retropatellar chondromalacia to reduce the femoro-patellar pressure.

A biomechanical model of the joint forces in the canine stifle was developed (Figure 1). After considering the ground reaction force, the analysis of the tibiofemoral shear force (FS) was determined by the angle between the total force being almost parallel to the patellar ligament (Figure 2). Moving the patellar ligament at 90° to the tibial plateau at full extension of the joint (45° flexion) would annihilate the cranial shear and the cranial tibial thrust. This was the basis for the tibial tuberosity advancement (TTA; Figure 3).
TTA,5,6 (2002)
The surgical modification of the basic joint geometry of the proximal tibia without changing the range of motion of the stifle was introduced to produce the TTA effect. A tension-band plate and a cage stabilize the advanced tibial tuberosity. Later modifications were developed to make the technique reliable and successful.

*In vitro* radiographical measurements were made for the angle between the patellar ligament with the tibial plateau or its common tangent at the tibiofemoral point of contact throughout the full range of motion of the canine stifle. The shear force shifts the loading from the cranial cruciate ligament to the caudal cruciate ligament at 90° of flexion of the stifle (crossover point).

A group of healthy dogs and 50 partially torn cranial ligament animals had their angle between patellar ligament and tibial plateau measured and were compared. The angle in dogs with partial rupture was 5° larger and the joint flexion was 10° greater to reach the crossover point defined in healthy dogs.

EFFECT ON CONFORMATION OF THE DISTAL FEMUR AND PROXIMAL TIBIA ON THE PATHOGENESIS OF CRANIAL CRUCIATE DISEASE,9 (2007)
The radiological conformation of the distal femur and the proximal portion of the tibia were compared between larger groups (50 each) of normal dogs, and dogs affected with partial cruciate rupture. The
underdevelopment of the tibial tuberosity and the shape in convexity of the tibial condyles were relevant in the pathogenesis of the cranial cruciate ligament disease.

**TTA TESTED IN VITRO** (2008)

An in vitro study in 16 animals was performed with loaded stifles in minimal flexion. It demonstrated that TTA could restore the physiological position of the stifles after transection of the cranial cruciate ligament.

**POSTOPERATIVE RESULTS OF TTA ASSESSED WITH FORCE PLATE GAIT ANALYSIS** (2008)

The functional outcome in 37 dogs with 40 TTA surgeries using first generation implants was evaluated. Complete ligament rupture was identified in 28 limbs, and partial rupture in 12 limbs. Medial meniscus was damaged in 21 stifles. Implants or fixation failure occurred in four cases, fissure of the tibia in one case, infection in two cases. Two dogs had a late meniscal tear and were re-operated. The results reached about 90% vertical forces of a normal dog, 6 months postoperatively.

**RADIOGRAPHIC CHANGES AFTER TTA** (SUBMITTED)

A group of 35 dogs were evaluated radiologically 6 months after TTA, as well as their functional outcome. Criteria for osteoarthritis remained unchanged in 14 joints, and markedly progressive in 7 joints, especially in dogs with severe cartilage lesions at the time of surgery. The degenerative changes did not provide information to the status of the joint.

**BONE GRAFTING AND TTA** (SUBMITTED)

No difference in healing time was found between autografted TTAs compared to non-grafted TTAs at 6 weeks, and 4 months after the surgery. This was also observed in all later non-grafted TTAs.

**RETROPATELLAR AREA AND JOINT ALIGNMENT AFTER TTA** (SUBMITTED)

The retropatellar area of the stifles and stifle alignment were compared in vitro under load in normal condition, after transection of the cranial cruciate, and after TTA treatment with digital pressure sensors measurements. After surgery, no changes were observed in the contact area, but a significant decrease of the mean contact pressure (20%), and a decrease of the total retropatellar force (20%) were evident. After treatment, both femoropatellar and tibiofemoral joint restored their alignments.

**CONCLUSIONS**

TTA surgery restores the physiological position of stifles with cranial cruciate deficiencies and reduces the femoropatellar pressure in osteoarthritic stifles while preserving the normal alignments of the joint. The technique has a steep learning curve. Larger stabilization cages than measured are preferred especially in larger dogs, to prevent later meniscal damage.

**REFERENCES**