

# VALIDATION OF AN EXPERIMENTAL DEVICE SIMULATING THE STANCE PHASE OF A CANINE HINDLIMB AT TROT: AN *IN VITRO* KINEMATICS STUDY

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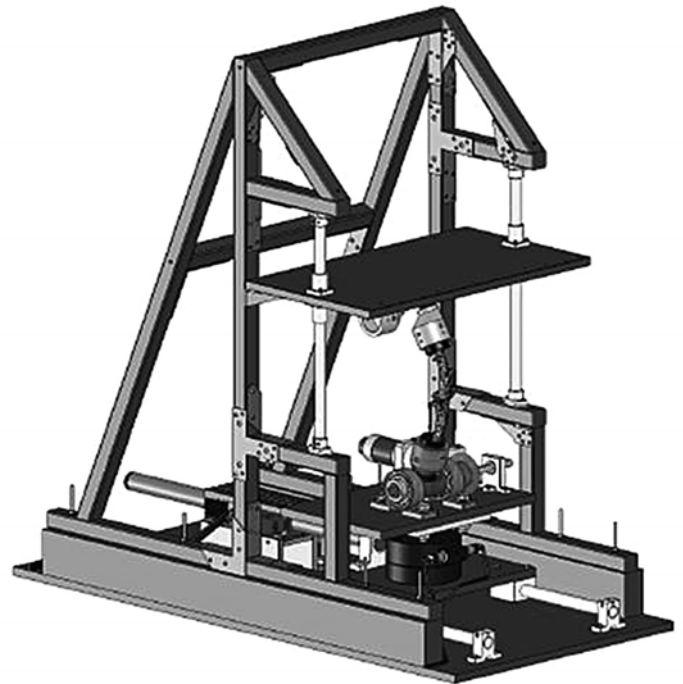
## INTRODUCTION

Rupture of the cranial cruciate ligament (RCCL) is the most common orthopedic disorder afflicting dogs [1]. It modifies the kinematics and internal loads of the stifle and invariably leads to the development of osteoarthritis. Several surgical techniques developed for correction of the CCL-deficient stifle have been reported, but none are able to restore the kinematics of an intact stifle [2]. The outcome of surgical correction of RCCL has so far been conducted by anecdotal reports, retrospective studies, evaluation of limb function by the use of ground reaction forces (GRF), clinical studies, theoretical models of stifle biomechanics and *in vitro* biomechanical cadaver studies. In the past years, the use of *in vitro* models simulating weight bearing has gained popularity. Most *in vitro* studies analyzing kinematics of the canine stifle were made in 2D under low static loads. Gait implies a displacement of the load application at the hip from caudal to cranial, modifying the moments applied to the stifle. Such a motion is qualified as isotonic. To our knowledge, no testing device allows the simulation of this condition. Our goal was to design an experimental device simulating a quasi-dynamic model of the stance phase at trot of the canine hind limb under near physiologic conditions. Our hypotheses are as follows: 1) the device allows reliable measurements with low intra-specimen and inter-specimen variability; 2) the kinematics generated by the device are representative of reported *in vivo* 3D kinematics [3]; 3) peak vertical forces generated by the loaded limbs in the device will be similar to those recorded in the literature for a walking dog during the stance phase [4].

## METHODS

A theoretical model of the canine hind limb was developed in order to calculate relative motion of the femur and tibia during the stance phase. An

Figure 1: Schematic view of the custom made testing rig of the rig (Catia V5 software, IBM corp. USA).



experimental device was built from this model. Six paired (left + right) hind limbs were harvested from 3 adult large breed dogs euthanatized for reasons unrelated to this study. The dogs were similar in age, size and body weight (range, 29.5-31 kg). Clinical and radiographic stifle examinations were performed to exclude any pathology. The limbs were prepared and mounted on the device. Each limb was submitted to vertical loading (9 kg) to the artificial hip joint. The gait was simulated with a computerized sequence using a linear actuator and a rotational motor inducing the artificial ankle's anterior-posterior and flexion-extension respectively. The stance phase of the gait at walk was simulated three times on each hind limb based on previously published sagittal plane kinematics of the ankle, knee and hip in dogs [5]. Kinematics of

the tibia and femur was measured with an optoelectronic system (Optotrak 3020, Norton Digital inc., Waterloo, ON). Kinematics' curves were generated using Euler angles with the method of Grood and Suntay [6]. Vertical ground reaction forces were measured with a 2.5 kN axial/torsion force transducer (MTS Corp., Minneapolis MN). Validation consisted in evaluating intra and inter-specimen variability of the 3D kinematics' curves of the stifle. Amplitude of motion and peak ground reaction forces as well as the general shape of kinematics' curves were also compared with *in vivo* curves described in the literature [3,4].

## RESULTS AND DISCUSSION

Data recorded during *in vitro* simulations highlighted average intra-specimen variability less than 0.8° and 0.7 mm for the three rotations and translations of the stifle respectively, compared with 5.8° and 1.3 mm for the inter-specimen variability. The comparison of the six average curves of motion collected on the tested stifles to those from *in vivo* trials reveals similar patterns in every case. However, amplitude of is slightly greater on *in vivo* curves [5]. Peak vertical forces measured in the device (138±2N) were also similar to *in vivo* trials reported in the literature [4]

## CONCLUSIONS

Results show that the device generates reliable motion on a loaded limb which is representative of the *in vivo* 3D kinematics reported in the literature.

This model could be used to evaluate the effects of cranial cruciate ligament rupture. Moreover, it could be used evaluate different surgical techniques, to determine which surgical procedures have the potential to re-establish normal stifle kinematics. The tools developed in this study might also lead to the design and evaluation of new surgical techniques. Finally, this model could be adapted and used with the human knee

## REFERENCES

1. Johnson JA et al. *Vet Comp Orthop Traumatol* 1994;**7**:56–697.
2. Brinker WO, et al. In: Brinker WO, et al, eds. *Handbook of small animal orthopedics and fracture treatment*. Philadelphia: WB Saunders, 1990:341
3. Korvick DO et al. *J Biomech* 1994. **27**: 77-874.
4. Voss K et al. *Vet Comp Orthop Traumatol* 2007; **20**: 299–304
5. DeCamp CE., et al. *AJVR* 1996. **57**(1): 120-126.
6. Grood ES and W.J Suntay. *J Biomech Eng* 1983., **105**,136-144

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