

VALIDATION OF AN EXPERIMENTAL DEVICE SIMULATING THE STANCE PHASE OF A CANINE HINDLIMB AT TROT IN THE CRANIAL CRUCIATE DEFICIENT STIFLE: 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]. 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 use a validated experimental device simulating a quasi-dynamic model of the stance phase at trot of the canine hind limb under near physiologic conditions in the cranial cruciate ligament deficient stifle (CCLDS). Our hypotheses are as follows: 1) the device allows reliable measures with low intra-specimen and inter-specimen variability; 2) the kinematics generated by the device are representative of reported *in vivo* 3D kinematics in dogs with CCLDS [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

Six paired 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 a previously validated experimental 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 motion and flexion-extension respectively. The stance phase of the gait at walk was simulated three times on each hind limb. Then, with the limbs still mounted in the device, the cranial cruciate ligament (CCL) was transected through a small medial arthrotomy which was closed using a simple continuous pattern. A positive drawer sign confirmed complete transection of the CCL. Kinematics of the tibia and femur was measured in the 2 situations (intact and CCLDS) with an optoelectronic system. Kinematics' curves were generated using Euler angles with the method of Grood and Suntay [5]. Vertical ground reaction forces were measured with a 2.5 kN axial/torsion force transducer. 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

The comparison of the six average curves of motion collected on the tested stifles to those from *in vivo* trials reveals similar patterns [3]. Data recorded during *in vitro* simulations in CCLDS highlighted the following changes between intact and CCLDS: an increase in flexion (4°), abduction (2°), internal rotation (3°), cranial translation (4mm), medial translation (1,5mm) and proximal displacement (3mm) of the tibia were recorded. These changes are compatible with those reported *in vivo* [3].

However, the amplitude of changes is slightly greater on *in vivo* curves. 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 in CCLDS reported in the literature. This model could be used to evaluate the impact of surgical correction of CCLDS and compare different surgical techniques. It could also be used 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.

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