Novel Rotobot Testing Platform Enables Accurate Reproduction of *In Vivo* Motion for Quantification of Ovine Joint and Ligament Function

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Introduction: The knee joint is a sophisticated organ involved in locomotion. Its function is often sustained for a lifetime, at a rate of over 1 million loading/motion cycles per year. The knee features complex 3D motion that stems from the interdependence and balance of its component tissues. Following injury, this balance is upset and difficult to restore. In order to treat successfully injuries to the knee the biomechanical responses of joint structures is necessary. Making accurate estimations of forces that occur in a living system's locomotive apparatus is a significant challenge in orthopedic biomechanics requiring the kinematic relationships between the motion segments (bones) of the joint to be measured and maintained. Any relative motion between the testing platform and its rigid fixation to the motion segments will introduce error in measured loads. Therefore, much of the challenge lies in providing a rigid testing platform and accurate registration of the joint. The objective of the work described in this abstract is to validate the rigidity of a newly developed Rotobot Testing Platform and to present preliminary results of forces in the structures of the joint during gait (**Figure 1**).

Methods: Stiffness of the load frame was determined in bending, compression, tension, and torsion with a system of pulleys, weights and turn buckle. Stiffness was tested in a symmetric position and also in a joint testing configuration under axial compression. A preliminary test was performed and the joint positions following the test, force in joint structures, and trajectory of the rotobot were recorded to validate the new Rotobot Testing Platform.

Results: Stiffness was highest in tension and compression and lower in bending (**Table 1**). Tibial Bone Fixture slop in this system is 0.015 mm. Measurements of joint position with a CMM following tested showed that the joint movement was, < 0.5 mm under ≈1kN of load. Forces in the structures of the joint demonstrate Anterior Cruciate Ligament forces below 100N and forces in the Lateral Collateral Ligament and Medial Meniscus were the highest during gait (**Figure 2**). *In situ* joint trajectories demonstrated a similar pattern to those recorded during *in vivo* motion and were within the resolution of the motion analysis system 0.5 mm and the standard deviation (gray region) of *in vivo* data (**Figure 3**).

Conclusions: The rigidity of the Rotobot Testing Platform has allowed for the quantification of forces in joint structures through accurate re-creation and re-application of joint motion measured *in vivo*. This has provide greater understanding of the biomechanical function of a variety of joint structures during gait, in turn enabling more successful treatment of Osteoarthritis and trauma such as ligament rupture.

References:

Howard, 2004, MSc Thesis, University of Calgary

Table 1. Tibial Bone Fixture Stiffness N/mm & N*m/°

Axial Compression		34290	Symmetric
		29820	Joint Test
Axial Tension		266160	Symmetric
Bending	Vertical	43330	Symmetric
	Lateral	17400	Symmetric
Torsion		15080	Symmetric

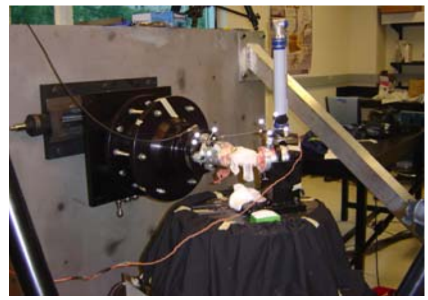

Figure 1. Rotobot Testing Platform - joint mounted

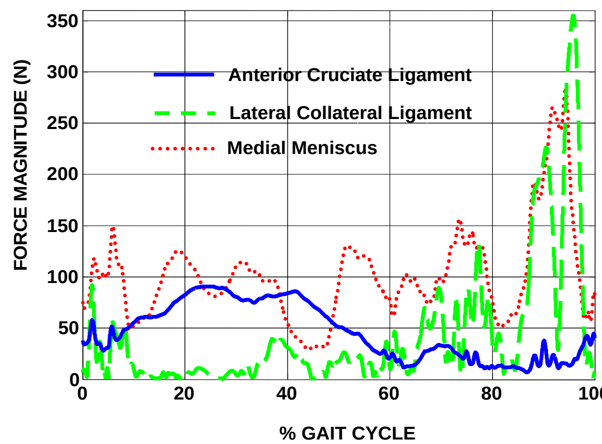

Figure 2. Force in Stifle joint force during gait

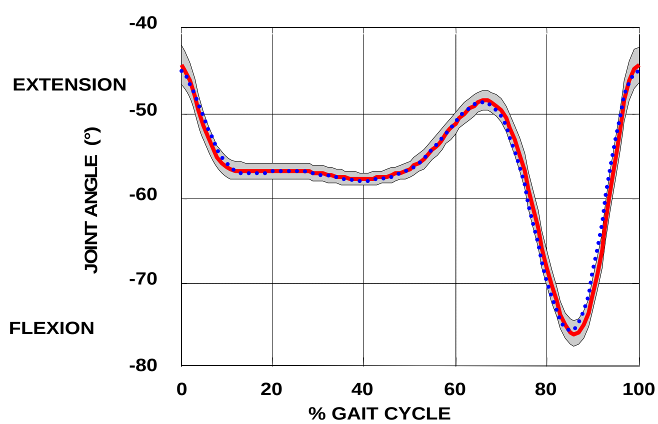

Figure 3. *In situ* (dotted line) & *in vivo* (solid line) joint trajectory

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