A DEVICE TO MEASURE IN VIVO TRANSLATIONAL AND ROTATIONAL LAXITY OF RABBIT KNEES

Anneliese Heiner, Jim Rudert, and Todd McKinley
Department of Orthopaedics and Rehabilitation, University of Iowa, Iowa City, IA, 52242
Email: anneliese-heiner@uiowa.edu Web: www.uihealthcare.com/depts/med/orthopaedicsurgery/

INTRODUCTION

Successful orthopaedic management of intra-articular fractures, to forestall post-traumatic osteoarthritis (OA), depends on avoidance of a mechanical environment that is deleterious to articular cartilage. Instability associated with excessive joint laxity is a factor that has been implicated in progression of post-traumatic OA. Work is ongoing to explore the pathomechanics, using New Zealand white rabbits, a well-established OA model in which transections of the anterior cruciate ligament (ACL) induce knee laxity. To measure joint laxity as a function of the degree of ACL transection, we have designed a specialized testing device to determine both translational and rotational stiffness of rabbit knees.

METHODS

The device consists of a main cradle (Figure 1a) with an integral femur clamp, a free-floating tibia clamp, and interchangeable linear stepper motor/load cell modules – one for translational (Figure 1b) and one for rotational (Figure 1c) testing. The rotational test module incorporates a rack-and-pinion linkage to convert linear to rotary motion. Both modules include a method to adjust knee flexion angle to 90 or 135 degrees. Test control and data acquisition are by user-written LabView programs running on a laptop computer.

To prepare a rabbit for testing, coronal plane transverse pins are inserted through the leg, two in the tibia (Figure 1c) and one in the distal femur. The pins are accurately placed using a drill guide, and serve to reproducibly position the leg in the test device for repeated testing at successive time points after ligament transection. During testing, the cradle supports the rabbit on its back, with the femur held fixed vertically. The translational module draws the tibia upward for a specified distance and speed, then returns to the home position. Stepper motor displacement and load data are displayed in real time and recorded (Figure 2). The rotational module rotates the tibia in one direction and then the other, then returns to the home position; test angles, speed, and starting direction are user-defined, and angle and torque data are recorded. As a safeguard, if a preset maximum load is exceeded on either module the test will terminate and return to the home position.

RESULTS AND DISCUSSION

A series of translational tests demonstrated that the testing device can measure the difference in stiffness of a rabbit knee when the ACL is intact, partially transected, and fully transected (Figure 3). It also demonstrated that knee flexion angle affects knee stiffness. Note that the intact knee at 90 degrees reached the preset load limit of 75 N before the full 3 mm test displacement was obtained. Multiple test sessions with this device have shown it to be an accurate and efficient method of determining rabbit knee stiffness in vivo.

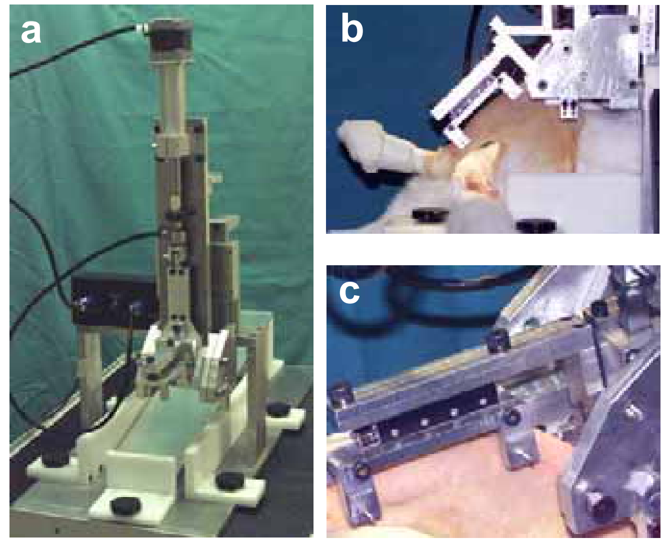

Figure 1: Rabbit knee testing system (a), with translational (b) and rotational (c) modules.

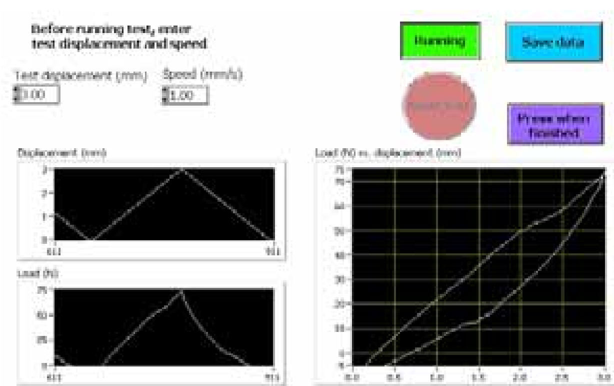

Figure 2: Control menu and screen graphics for translational testing of a rabbit knee.

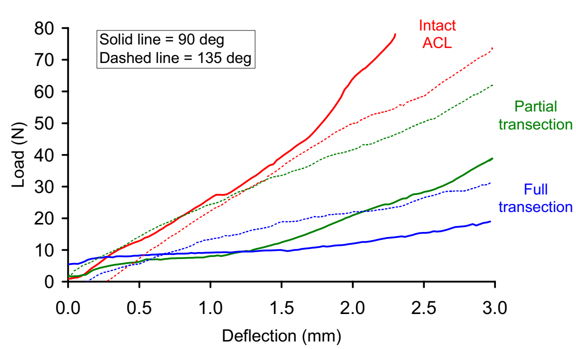

Figure 3: Effect of partial ACL transection and knee flexion angle on translational stiffness.

ACKNOWLEDGEMENT

Supported by award 5 P50 AR048939, NIH Specialized Center of Research for Osteoarthritis.