Design and Evaluation of Instrumentation used for Lateral Tibia Impacts

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Background
- Non-fatal pedestrian-vehicle collisions involved 61,000 pedestrians in 2006 [1]. Thirty percent of all injuries incurred by pedestrians involved in this type of collision are to the lower extremities, many of which are to knee ligaments [2].
- Knee injuries are also among the most economically costly sports injuries and are the leading cause of high school sports-related surgeries (nearly 45%). These injuries can require extensive and expensive post-surgery rehabilitation and can increase risk for early onset osteoarthritis [3].
- The medial collateral ligament (MCL) and anterior cruciate ligament (ACL) are often injured under lateral loading conditions.
- The Injury Biomechanics Research Laboratory (IBRL) previously developed instrumentation for anterior tibia impacts, including instrumentation to measure posterior cruciate ligament (PCL) stretch. The goals of this research are to expand on methods from anterior impacts to develop an instrumentation technique for lateral knee impacts, focusing specifically on MCL and ACL stretch and injury.

Objectives
- Accurately measure tibial angular rotation relative to the femur
- Accurately measure ACL and MCL stretch
- Identify the time of injury for ligament and bone failure

Methods
- Four denuded legs from 3 Post-Mortem Human Subjects (PMHS) were used in this study.
- Accelerometers and angular rate sensors were installed on a 3au motion block (Fig 1) and attached to the tibial tuberosity (Fig 2). These were used to determine angular velocity and the angle of the tibia with respect to the femur during loading.
- Micro-differential variable reluctance transducers (Micro-DVRTs) were inserted into the ACL and MCL (Fig 3) to measure stretch of the ligaments.
- Legs were positioned and released at different heights resulting in increasing impact energy. The thigh interacted with an impact plate, causing loading about the knee (Fig 4). Baseline trials at a height of 4 inches were performed between each height increase to test for injury.

Results & Discussion
- Findings are consistent between all 4 legs tested. Results from Subject 1 are summarized here.
- ACL injury occurred to the right leg at a height of 19 inches (0901PED19R09) (Fig 5). Time of injury was determined by using both MCL and ACL data (Fig 7).
- Injury was verified by the following baseline impact (0901PED04R10) in which the response was much different than that of all of the previous baseline tests (Fig 5).
- An additional trial (0901PED19R11) was conducted in which a 5 lb weight was added to the sole of the shoe. Complete tearing of the ACL from the femur occurred as a result. This was confirmed by baseline impact (0901PED04R12).

Conclusions
- Accurately suture DVRT barbs to the ACL and MCL provide repeatable displacement measurements.
- Time of injury can be accurately determined with both MCL and ACL DVRT signals.
- Angular velocity may be able to accurately predict injury.

References