Computer Simulations of Total Knee Joint Replacement

Anne Schmitz, Heidi Ploeg, Darryl Thelen

21st Annual Colloquium on Aging

Knee osteoarthritis (OA) is one of the most common joint diseases in older adults. At the end stage of the disease process, treatment typically involves a total joint replacement (TJR). While TRJ procedures are generally successful in reducing pain, restoration of function can depend on a number of factors at the surgeon's discretion. In particular, the placement and alignment of the implant and tensioning of the medial collateral (MCL) and/or lateral collateral ligament (LCL) will affect both the joint range of motion and stability of the joint. This project aims to use computational biomechanical models to systematically investigate the influence that ligament tensioning has on joint mechanics during functional tasks such as walking.

Creating an accurate computational model is a complex engineering task that involves five steps. First, a three-dimensional computer model of the geometry of the knee bones and surrounding soft tissues are created from high resolution medical images. Second, the material properties of the bones, ligaments, and cartilage are defined using data obtained from the literature. Third, three-dimensional motion and force data are recorded from a person performing a specific activity. Fourth, muscle coordination patterns are computed and drive the computer model to walk in a manner consistent with the measured motion. Finally, TJR surgery is simulated in the computer model with various ligament tensions to investigate how knee motion and mechanics will change. The goal is to better understand the sensitivity of functional outcomes to surgical parameters, so as to focus effort on factors that can optimally restore normal knee motion after surgery.