Knee Model

The SIMM Generic Knee Model is a high resolution anatomical and kinematic model of the knee derived from plastic bone models and MRI data and designed specifically for SIMM users. The Knee Model consists of four bones (femur, tibia, fibula, and patella), five ligaments (anterior and posterior cruciate, medial and lateral collateral, and patellar ligaments), and the lateral and medial menisci. The bones and menisci are modeled as rigid polyhedra and the ligaments as deformable polyhedra.

The Knee Model has two degrees of freedom that represent flexion-extension and varus-valgus motions. The femur is the fixed bone and the tibia moves relative to it, while the patella and the menisci move relative to the tibia.

Joint Kinematics

The 3D motion of the tibia is described by several functions that are dependent upon knee angle. These kinematic functions of the tibia are defined such that during flexion, the screw home motion (external rotation of the tibia relative to the femur in the final 20 degrees of knee extension)[1] and the rolling-to-sliding ratio of the motion of the femoral condyles on the tibial plateau[2] conform to values described in the literature. The patella motions are defined such that the patella surface conform to the femoral trochlear notch. The resulting angle of the patellar ligament and patella relative to the long axis of the tibia conforms to literature values.

Kinematic functions defining the varus-valgus motion of the tibia force it to rotate about the center of the lateral tibial plateau during valgus motion and about the center of the medial tibial plateau during varus motion. The kinematics of the knee can easily be modified in SIMM to include new degrees of freedom or to represent new experimental data.

Each ligament is constructed of numerous line elements; the placement and number of line elements are based upon the ligaments digitized from the knee made available by Samso, Inc. The representation of the anterior cruciate ligaments was also based on detailed mappings of the individual fibers of the ligament.[4] The cruciate ligaments are composed of
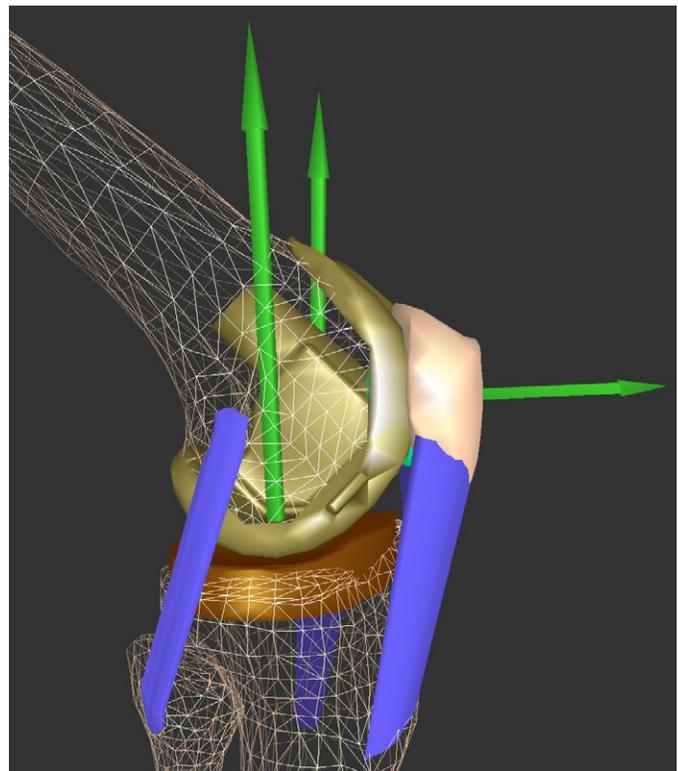
straight line elements only, i.e. there is no bending in the ligament between the points of origin and insertion. However, the elements connect in a complex manner between the bones, so the shape of the ligament changes considerably throughout knee motion. The collateral ligaments contain "via" or "wrapping points" along the paths of the line elements. These "via" points are necessary because the collaterals do not follow a straight path from origin to insertion, but instead, wrap over the outer surfaces of the femur and tibia.

Menisci

The menisci in the Generic Knee are stationary relative to the tibia. Coordinate systems have been included in the Knee Model to allow the motion of the menisci either individually or together. For the present combination of knee kinematics there is no need to move the menisci, since the menisci do not penetrate the femoral condyles. One literature study[5] indicates that each of the menisci slide relative to the tibia, but this motion is not present in the SIMM Generic Knee Model.