INTRODUCTION: The study of tibio-femoral dynamics during stressful activities is necessary to understand the relationships between anterior cruciate ligament (ACL) injury and long term joint degeneration (ostearthrosis). Assessment of the nature of interaction at the articulating surfaces of the joint is especially important. Generic and patient-specific three dimensional (3D) finite element knee models were developed using reconstructed data from Computed Tomography (CT), magnetic resonance imaging (MRI) and validated with high-accuracy in vivo knee kinematics from a cine-radiographic method. Implementation of improved cartilage and meniscal in-vivo geometry based on a series of specialized MRI scanning modalities allowed for improvements on several model uncertainties. Cartilage, menisci and joint contact behavior were studied by focusing on the response of both intact and ACL reconstructed knee to the imposed 3D femoral kinematics and ground reaction forces during the impact phase of single-legged hopping.  

METHODS: One subject (Male: 56 yrs) with unilateral ACL injury and healthy contralateral knee was selected from an ongoing study of ACL reconstruction (approved by our institutional IRB). After obtaining informed consent, 1.6mm tantalum beads were implanted in the distal femurs and proximal tibias of each joint (3 per bone) at the time of ACL reconstruction surgery. In-vivo 3D knee kinematics was acquired 4 months after ACL reconstruction during one-legged forward hopping (sub-maximal, hop distance 50% of lower limb length) using a biplane radiographic system (RSA). 3D coordinates of implanted markers were determined at 250 frames/s with dynamic accuracy of ±0.1mm.

The generic model has been previously described in detail. To construct the patient specific model a CT system was used to scan the knee in 0.5 mm increments. Two plastic tube-rods filled with solution of Cupric Sulfate with paramagnetic properties were externally fixed in the femur and tibia. This along with the tantalum beads allowed for co-registration of bony geometry from CT with soft tissue geometry from MR. MRI measurements were performed using a GE 3 T system. The registration of bony geometry from CT with soft tissue geometry from MRI was performed using a GE 3 T system. The registration of bony geometry from CT with soft tissue geometry from MRI. The subjects were scanned in-vivo, dynamic joint contact forces: an experimentally driven subject-specific FE analysis (49thORS meeting, New Orleans LA, 2003).