Clinical and Computational Collaboration in Orthopaedic Biomechanics

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The mission of the Comparative Orthopaedic Laboratory at the University of Missouri-Columbia (COL-UMC) is three-fold:

1. To design and conduct the highest quality hypothesis-driven research focused on orthopaedic disorders of diarthrodial joints.
2. To implement a comparative approach to investigation of joint disease in order to most efficiently and comprehensively address identified problems.
3. To apply basic science research to the clinical situation in order to span the gap that often limits the usefulness of scientific discoveries.

The mission of the Musculoskeletal Biomechanics Research Laboratory (MBRL) at the University of Missouri – Kansas City is to:

> Discover, disseminate, and utilize knowledge pertaining to the loading of joint tissues during dynamic activity.

The (COL-UMC) includes an internationally recognized team of scientists and clinicians while the MBRL, in conjunction with the UMKC Human Motion Laboratory, is comprised of biomedical engineers focused on musculoskeletal tissue mechanics and movement simulation. Collaboration between the two labs can provide great benefit for both research programs by combining clinical, computational, and experimental research efforts.

The COL-UMC and the MBRL are currently working together on a Missouri Life Sciences Research Board funded project titled, *"Computational Simulation of Canine Biomechanically Induced Unicompartmental Osteoarthritis: a Concurrent Multiscale Approach"*. This work combines the internationally recognized expertise in canine osteoarthritis and tissue engineering of the COL-UMC with the musculoskeletal biomechanics expertise and innovative multiscale modeling techniques of the MBRL. Osteoarthritis is a debilitating disease that is not completely understood, but evidence links the severity, progression, and treatment

of the disease to the mechanical environment in the knee during everyday activities such as walking, running, and stair climbing. The natural response of articular cartilage to insult or injury is an outcome of complex interconnected factors that include anatomy, biology, and muscle forces. The goal of this project is to develop a predictive, computationally efficient, patient level simulation tool of mechanical osteoarthritis indicators. Specifically, the project is developing computational models of the canine knee that include surrogate models of cartilage tissue behavior. This model is then combined with neuromusculoskeletal models of movement and validated through in-vivo canine models of osteoarthritis. The project addresses a key area in osteoarthritis research that has largely been neglected, the role of muscles in osteoarthritis pathomechanics. Several engineering students from UMKC and medical students from UMC are working on the project and excellent progress has been made in the first year. Project work includes:

1) Mechanical testing to determine material properties of the canine menisci and articular cartilage
2) Magnetic Resonance Imaging and generation of hind limb bone, cartilage, ligament, muscle, and menisci geometries
3) Development of knee and musculoskeletal models of the hind limb
4) Meniscal release procedure to induce unicompartmental osteoarthritis
5) Gait testing at the UMKC Human Motion lab both pre-surgery and post-surgery
6) Hind limb testing to validate developed musculoskeletal models
7) Development of tissue level finite element models of cartilage indentation testing for tissue level surrogates