Priority Statement Title: Subject specific modeling to improve clinical outcome through individualized treatment

Priority Statement Code: CJ3A

Domain: Functional/Body/Joint/Tissue/Cell

Priority Statement

Background and Relevance

From musculoskeletal movement simulations to finite element analysis of joints, tissues, and cells, the accuracy of model predictions (hence the perceived confidence in simulation results) can significantly benefit from subject-specific representation of the anatomy, material and physiological properties, and functional loading and boundary conditions.Our current practice to generalize or utmost scale a single model likely hinders our capability to obtain clinically applicable model predictions.

Subject-specific modeling for simulation-based medicine has the potential to address uncertainties in predictive analysis that may be associated with leap-of-faith generalizations. Clinical decision making or population-specific research, i.e. on diseased joints, will benefit from increased precision, provided by subject-specificity. These models can accommodate case-specific decisions, that being selecting orthopedic surgery, evaluating medical devices, and assessing therapeutic interventions. Outliers are not left out. It is also possible to estimate subject-specific risk of injury. Combined with multiscale modeling, mechanical risk factors, and their convoluted relationship, for early onset of diseases such as osteoarthritis can be identified at multiple levels, from body to cell.

Significant barriers to rapidly develop and affirm the adequacy of subject-specific models for decision making, i.e., realizing their clinical application, certainly exist. Sustaining difficulties in automated processing of image data to generate subject-specific geometric models and meshes, limited technology to noninvasively identify material and physiological characteristics, high computational cost conflicting with clinical urgency are a few. Most importantly, lack of procedures to evaluate the predictive accuracy of models and simulation results to increase confidence in at least comparison of interventions hinders the acceptance of routine utilization of models in medicine.

Objectives

- employ and demonstrate the utility of subject-specific models for clinical diagnosis, decision making and outcome prediction
- define guidelines and procedures for determining minimal complexity in models, required model parameters and necessary validation
- stimulate data dissemination and standardization to promote model sharing

Recommended Actions

- facilitate effective discussion and promotion of subject-specific modeling; examples are an online entity and/or a hands-on consortium supported by workshops for updating and maintaining guidelines and standards, promoting organization between researchers, and training
- establish guidelines for minimum required information for model complexity, verification & validation as it relates to clinical applicability
- perform clinical studies to establish the validity of simulation predictions for improving clinical outcomes

- develop widely accessible tools for building subject-specific models more rapidly and improve simulation performance
- develop non-invasive techniques to obtain material properties and other relevant physiological properties