**Knee model (in)consistency between inverse and forward dynamics musculoskeletal simulations**

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## Introduction

A deformable knee joint is required to go from a subject's kinematics and kinetics data to tissue loading. Multibody deformable models have been used for this purpose in forward simulations [1] and in inverse simulations with force dependent kinematics [2] or co-simulations [3]. Additionally, multiscale modeling solutions exist that put a Finite Element (FE) model in series with the multibody model. Meanwhile, the sequential FE simulation is quasi-static and the primary kinematics of the joint is prescribed to avoid the problems caused by inconsistency of joint models [4]. The current study aims to investigate how does a forward dynamic deformable model of the lower limb react if we drive it with musculotendon forces obtained from an inverse dynamics simulation using a multibody musculoskeletal (MS) model built from the same subject's geometry.

## Methods

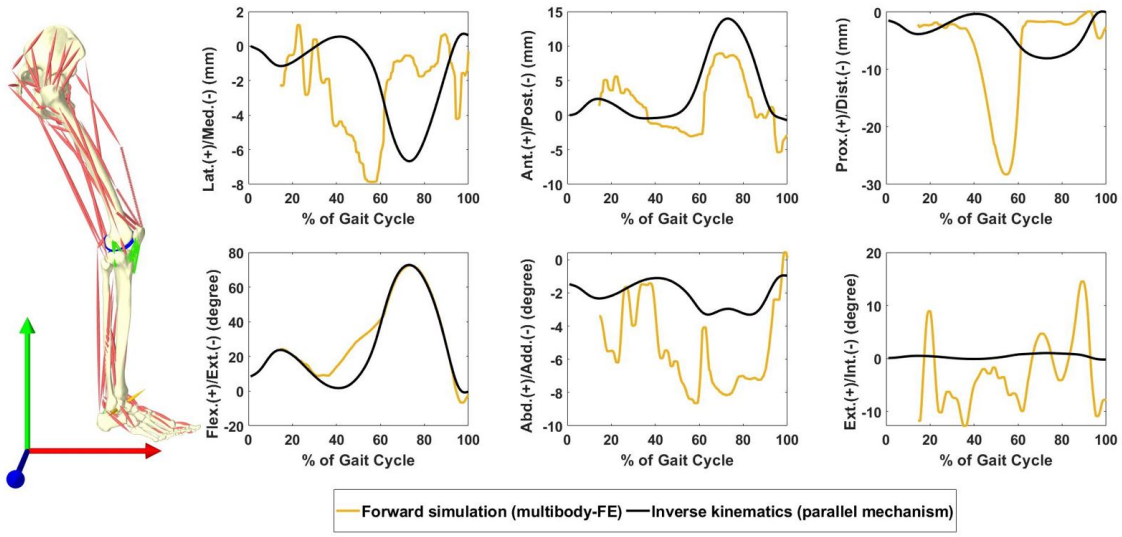
Computed tomography (CT) and Magnetic Resonance Imaging (MRI) data of a male subject was collected to extract the bone and joint geometries and muscle line of actions. These geometries were used to build a multibody model with personalized knee parallel mechanism in Matlab [5] and a forward dynamic MS model with a deformable knee joint including FE cartilages in Artisynth combined multibody-FE platform [6]. Gait motion capture data of the subject (skin marker trajectories and Ground Reaction Force (GRF)) was used to run the inverse model and compute the musculotendon forces minimizing their sum of squares. Musculotendon forces, position of pelvis, initial velocities and GRF directly applied to the center of pressure were used as inputs of the forward dynamics. The initial frame in forward dynamics was chosen to match the knee flexion angle during MRI acquisition.

## Results

The knee kinematics results of the forward and inverse dynamics were compared as presented in the figure.

## Discussion

This purposively naïve investigation showed that the force-driven forward simulation with a deformable knee could converge when a personalized joint geometry (parallel mechanism) is used at the inverse step but leads to different kinematics and instabilities in all secondary degrees of freedom and in flexion between 30% and 60% of gait cycle. Observing the musculotendon forces revealed that deviated kinematics could be due to muscle force sharing and could be enhanced with choosing a better criterion (e.g. with stability constraints [7]).




## References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