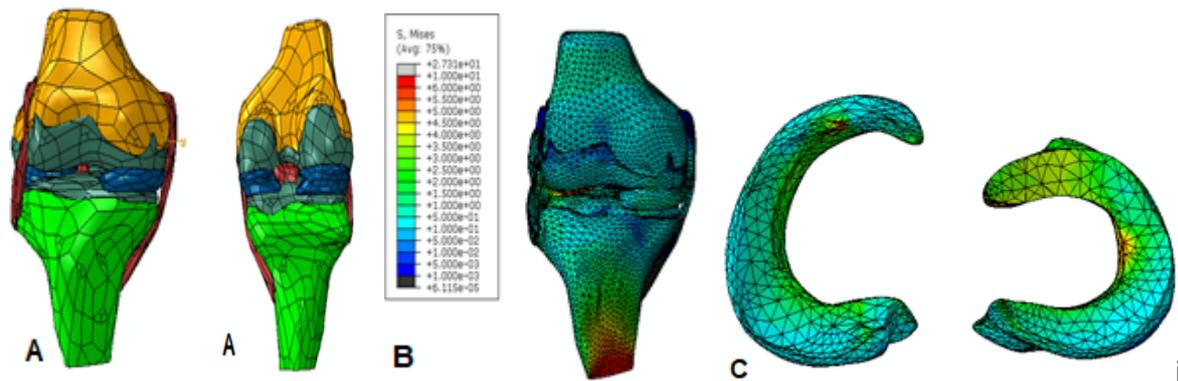


Towards a three-dimensional Finite Element model of the Knee Osteoarthritis

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Abstract

A three-dimensional FE model of a knee joint is presented. The main structure includes femur, tibia, ligaments (ACL, PCL, LCL and MCL), menisci (lateral and medial) and tibiofemoral cartilage. The model is validated against the literature. The main goal is to understand the distribution of stresses over the cartilage and meniscus and its relationship to Osteoarthritis (OA). This complex bio-realistic model of a knee joint was reconstructed from medical MR images of a subject with healthy knee (24 years old, with no history of lower limb extremities) having interval separation of 1.5 mm in sagittal, coronal and axial planes with 0° of knee flexion. The MRI scan data were collected on a 1.5 Tesla Phillips Intera system using T1 3D Gradient Echo sequence (TR/TE = 57 ms/21 ms, spatial resolution with voxels size of $0.7 \times 0.7 \times 0.7 \text{ mm}^3$). The segmentation and thresholding of each part, including femur, tibia, fibula, ligaments, patella, patella tendon, menisci and cartilages were done with the SCANIP software (Synopsys, Mountain View, USA). The segmented parts were then exported and assembled to form the three-dimensional FE model of the knee joint. The model was analysed in ABAQUS software (version 2016) (DASSAULT SYSTEMES, U.S.A). The material properties were taken from literature. For assigning the boundary conditions, the model was assumed to be fixed at the base of the tibia. The rotation was fixed on the femur and the displacements were free in all directions. A vertical force of 1150 N was applied at the top of the femur which corresponds to the force of full extension position in gait cycle [2]. Under the compressive load of 1150 N, the stresses transfer from the femur to its cartilage and menisci down to the Tibia. The results show deformation of the lateral meniscus which caused the model to curve outward forming a valgus which is one of the symptoms that can lead to OA. The maximum stress on the lateral meniscus that can be measured is 5.5 MPa which is comparable with the results presented in the literature [3].



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