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Finite element modeling of the intervertebral disc

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The objective is to create an accurate finite element model of the intervertebral disc. Major deficiencies in current models are due to oversimplifications in regards to geometry and material properties. My task is to develop a patient-specific model in which minimizes these oversimplifications and accurately models the behavior of the intervertebral disc under any loading condition. The surface geometry is segmented from an individual patient's MRI and CT of the lumbar spine. This data is then used to mesh the solid individual components of the L4-L5 lumbar motion segment which include the annulus fibrosis and the nucleus pulposus of the intervertebral disc and the cartilaginous endplates, the cortical bone, and cancellous bone of the adjacent intervertebral bodies. Complications arise in modeling the intervertebral disc due to the geometric and mechanical complexity of the two-composite structure of the annulus fibrosis. The annulus consists of layers of a poroelastic material reinforced with collagen fibers in which surround the nucleus pulposus. The fiber density and angle of orientation both have a linear relationship with respect to the depth percentage within the annulus from the outer layer inward towards the nucleus pulposus boundary. A program is written using FORTRAN which determines the depth percentage of each node in the annulus model. An Abaqus subroutine is then created to assign the corresponding material properties to each element within the annulus. Finally, flexion, extension, and lateral bending moments are simulated using Abaqus, and the results are compared to in-vitro studies. Benefits of this model include applications such as patient-specific prosthetic disc design, better understanding of the mechanisms that lead to back pain, and determining the potential outcome of treatment options.