Predicting Mechanical Damage from Glioblastoma Tumor Growth

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The invention of medical imaging techniques such as magnetic resonance imaging (MRI) has revolutionized the way doctors locate brain tumors. MR images aid identification of tumor location and provide other important information for radiotherapy and surgery. However, a major limitation of MR images is their inability to evaluate the extent of cell damage due to a growing tumor. Recently, there have been significant developments in mathematical modeling, specifically, poroelastic finite element (PEFE) modeling, which was traditionally used by civil engineers to understand deformation of porous media due to the flow of fluids. This study aimed to use PEFE models to supplement MR images to evaluate damage due to brain tumor growth. The PEFE models were developed using digitized MR images, and the displacement, strain, solid stress, and fluid pressure due to tumor growth was computed. First, the impact of tumor location on brain damage was studied using the model. The model results show that tumor location has significant effects on damage distribution. Second, the impact of brain tissue mechanical properties on the results of a model was studied to understand the most important parameters. Third, two case studies were analyzed to determine whether the model provides valid results. The model accurately predicts increased levels of strain, solid shear stress, and fluid pressure due to growth of the tumor. This project demonstrates that there is a large untapped potential for the combined use of mathematical modeling and MR images to evaluate brain damage due to tumor growth.