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Two phase model to study the correlation between brain tumor growth rate and the formation of peritumoral edema

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Patients diagnosed with high-grade gliomas die due to the pressure that the tumor builds in the brain as well as the formation of peritumoral edema (PTE). With the view to investigating the early stages of brain tumor development, and how it impacts the healthy brain environment, we develop a biomechanical model of brain tumor onset. The model is derived using principles of mass and momentum balances and explicitly includes pressure dynamics within the disease brain and the ability/inability of healthy tissue to repair itself in response to these cues. As a first step we assume an implicit tumor that exerts pressure at a healthy boundary causing the boundary to move into healthy tissue with a velocity v (thought of as the tumor growth rate). We investigate three velocity regimes: where v is an order of magnitude slower than the time-scale of healthy brain tissue renormalization (benign tumor); where v is an order of magnitude higher than the time-scale of healthy brain tissue renormalization (high-grade tumor); a transition between these where v is the same magnitude as the time-scale of healthy brain tissue renormalization. Our model shows a correlation between the tumor velocity and the formation of PTE, which is an indicator of tumor malignancy. The resulting model includes time-varying diffusion on a moving domain, which presents unique numerical challenges. We propose a scheme to solve such equations, validating our method with a test problem as well as theoretical analysis using techniques from asymptotic methods in order to complete this research aim.