AbstractID: 6708 Title: A Novel Continuum Mechanics Approach towards Multiscale, Stochastic Tumor Modeling Based on Multimodality Imaging

Purpose: Current tumor simulation models describe either microscopic or macroscopic behavior and do not efficiently use information available on both levels. Furthermore, they are based on simplifying assumptions rather than observable data. To overcome both these deficiencies, we incorporated an existing microscopic, stochastic tumor model based on radiobiological properties and PET/CT imaging data into a multiscale tumor model.

Method and Materials: In the microscopic model, biological parameters accounting for micro- and macroscopic tumor characteristics complement anatomical information, thereby enabling simulating tumor development voxel-by-voxel. Resulting changes in voxel density and microenvironmental conditions are passed on to the superior tissue level where a finite element analysis method is used to determine tumor deformation based on a thermo-elastic continuum mechanics analogy. Deformation tensors are then applied to the initial input geometry to calculate the final morphology in image space, allowing for comparison to clinical data.

Results: Simulation results based on murine squamous cell carcinoma xenograft µPET/CT data show good qualitative agreement with tumor behavior pre- and post-radiotherapy. Due to tight integration between the simulation levels, relevant biological properties are conserved to within 2% error. Since biological parameters are monitored at a voxel level, this approach is computationally superior to classic single-cell-based models. However, a limitation of voxel discretization is that growth may be discontinuous across adjacent voxels, causing residual stresses within the tumor that are easily detectable during the simulation.

Conclusion: Our results indicate the ability of the proposed model as a platform to simulate tumor behavior while allowing for integration of and comparison to (pre-) clinical data. All required input variables can be directly accessed through experiments and multimodality imaging. Tensiometric properties and anatomical constraints influencing mechanical interaction of the tumor can be easily added, allowing for a calibration in future investigation of more complex clinical cases to improve reliability.