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# Micromechanics of brain white matter tissue: a fiber-reinforced hyperelastic model using embedded element technique

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**Abstract**

A transverse-plane hyperelastic micromechanical model of brain white matter tissue was developed using the embedded element technique (EET). The model consisted of a histology-informed probabilistic distribution of axonal fibers embedded within an extracellular matrix, both described using the generalized Ogden hyperelastic material model. A correcting method, based on the strain energy density function, was formulated to resolve the stiffness redundancy problem of the EET in large deformation regime. The model was then used to predict the homogenized tissue behavior and the associated localized responses of the axonal fibers under quasi-static, transverse, large deformations. Results indicated that with a sufficiently large representative volume element (RVE) and fine mesh, the statistically randomized microstructure implemented in the RVE exhibits directional independency in transverse plane, and the model predictions for the overall and local tissue responses, characterized by the normalized strain energy density and Cauchy and von Mises stresses, are independent from the modeling parameters. Comparison of the responses of the probabilistic model with that of a simple uniform RVE revealed that only the first one is capable of representing the localized behavior of the tissue constituents. The validity test of the model predictions for the corona radiata against experimental data from the literature indicated a very close agreement. In comparison with the conventional direct meshing method, the model provided almost the same results after correcting the stiffness redundancy, however, with much less computational cost and facilitated geometrical modeling, meshing, and boundary conditions imposing. It was concluded that the EET can be used effectively for detailed probabilistic micromechanical modeling of the white matter in order



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