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Multiscale Mathematical Models for Tendon Tissue Engineering[1]

AMY KENT, PIERRE-ALEXIS MOUTHUY, SARAH WATERS, JON CHAPMAN, JAMES OLIVER, University of Oxford — Tendon tissue engineering aims to grow functional tendon in vitro. In bioreactor chambers, cells growing on a solid scaffold are fed with nutrient-rich media and stimulated by mechanical loads. The Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences is developing a Humanoid Robotic Bioreactor, where cells grow on a flexible fibrous scaffold actuated by a robotic shoulder. Tendon cells modulate their behaviour in response to shear stresses - experimentally, it is desirable to design robotic loading regimes that mimic physiological loads. The shear stresses are generated by flowing cell media; this flow induces deformation of the scaffold which in turn modulates the flow. Here, we capture this fluid-structure interaction using a homogenised model of fluid flow and scaffold deformation in a simplified bioreactor geometry. The homogenised model admits analytical solutions for a broad class of forces representing robotic loading. Given the solution to the microscale problem, we can determine microscale shear stresses at any point in the domain. In this presentation, we will outline the model derivation and discuss the experimental implications of model predictions.

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