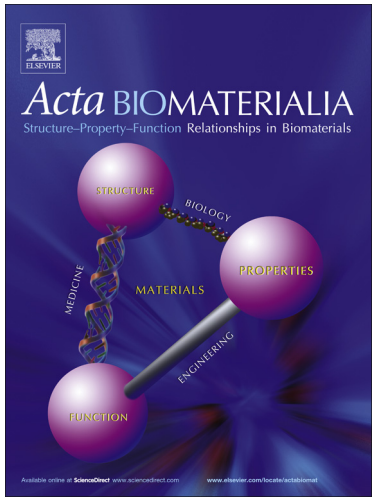

Cell Structure, Stiffness and Permeability of Freeze-dried Collagen Scaffolds in Dry and Hydrated States

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Abstract

Scaffolds for tissue engineering applications should be highly permeable to support mass transfer requirements while providing a 3-D template for the encapsulated biological cells. High porosity and cell interconnectivity result in highly compliant scaffolds. Overstraining occurs easily with such compliant materials and can produce misleading results. In this paper, the cell structure of freeze-dried collagen scaffolds, in both dry and hydrated states, was characterised using X-ray tomography and 2-photon confocal microscopy respectively. Measurements have been made of the scaffold's Young's modulus using conventional mechanical testing and a customised see-saw testing configuration. Specific permeability was measured under constant pressure gradient and compared with predictions. The collagen scaffolds investigated here have a coarse cell size (~100-150 μm) and extensive connectivity between adjacent cells (~10-30 μm) in both dry and hydrated states. The Young's modulus is very low, of the order of 10 kPa when dry and 1 kPa when hydrated. There is only a single previous study concerning the specific permeability of (hydrated) collagen scaffolds, despite its importance in nutrient diffusion, waste removal and cell migration. The experimentally measured value reported here (5×10^{-10} m^2) is in good agreement with predictions based on Computational Fluid Dynamics simulation and broadly consistent with the Carman-Kozeny empirical estimate. It is however about three orders of magnitude higher than the single previously-