
Biomechanical and biological characterization of brain tissue-inspired hydrogels: Focus on porous material properties for tissue engineering applications

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Abstract

Soft biomaterials intended for implants or soft tissue engineering must meet a number of properties to ensure compatibility with host tissues. The mechanical match between biomaterial and host tissue is crucial to avoid adverse reactions and prevent rejection of the material or device, especially in ultrasoft tissues such as the human brain (1). In addition to stiffness, the most important properties include microstructure-dependent permeability and porosity, which are crucial for effective integration. In addition, biocompatibility needs to be thoroughly assessed, either with animal models for implants or with relevant cell types for tissue engineering purposes.

This work presents a series of hydrogels that mimic brain tissue (2), produced through sterile processes, focusing on their microstructural, mechanical and biocompatibility properties. Two new experimental approaches have been developed to specifically study the behavior of porous materials, targeting the effective porosity and fluid permeability that are fundamental to fluid and nutrient exchange in soft tissue engineering applications. Mechanical characterization was conducted using a combination of cyclic compression-tension experiments and consolidation, while biointegration was assessed by pull-off tests after five days of incubation in a chick *'ex ovo'* chorioallantoic membrane (CAM) model.

Histological analysis of cryosectioned samples revealed notable interactions at the hydrogel-membrane interface, including ectoderm alterations and cell infiltration into the hydrogels. Softer hydrogels, characterized by less dense polymer networks, promoted enhanced biointegration, which was strongly correlated with their lower stiffness and higher porosity. The biocompatibility of the materials was also confirmed by cytotoxicity assays and by culture of multiple cell types representative of soft tissue.

Our findings suggest that hydrogels with tailored mechanical and porous properties are promising candidates for implant substrates, coatings, and tissue engineering scaffolds (3). The strong correlation between material stiffness, porosity and biointegrability underscores the importance of designing biomaterials that correspond as closely as possible to the physiological conditions of the target tissue.

References

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