Collagen-nanoclay hydrogels for stiffness enhancement of the extracellular matrix: the effect on spheroid growth

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Introduction

The extrace llular matrix (ECM) is crucial for regulating cellular functions and maintaining tissue inte grity. Alte rations in ECM stiffness are associated with various pathological conditions, including cance r and cardiovascular disease. Therefore, being able to tailor and customize ECM stiffne ss could revolutionize pe rsonalized research and the rapies in tissue engineering. Clay nanomaterials are an emerging class of biomaterials with unique properties that make them promising candidates for biomedical applications.

Methods

In this study, we investigated the potential of laponite nanoclays (LapNC) to enhance the mechanical properties of collagen hydroge ls without increasing the collagen amount. Collagen hydrogels of different concentrations (2.5, 4, and 6 mg/ml) were supplemented with LapNC, and the resulting hydrogels were thoroughly characterized using rheology, scanning electron microscopy (SEM) and other assays to quantify additional physical parameters, such as the permeability and swelling potential. In this study, we investigated the potential application of the customized hydrogels as 3D cancer culture systems for tumor spheroid growth. To this end, we quantified the spheroid are a over time by culturing three cancer cell line s in the supplemented and non-supplemented matrices. Moreover, we assessed the migration capacity of the spheroids with respect to the initial cluster formation.

Results

Our results confirmed that LapNC solution could be successfully incorporated into the culture media without clay aggre gation. The supplemented hydroge ls e xhibited enhanced mechanical properties without compromising cellular viability or causing collage n collapse. Regardless of the collagen concentration, LapNC-supplemented hydrogels showed higher storage moduli and lower perme ability than control hydrogels, which was qualitatively corroborated by SEM visualization of the porosity. Furthermore, the addition of LapNC resulted in the formation of larger spheroids at every collagen concentration. The sefindings have significant implications for tissue engineering applications, particularly in cancer spheroid analysis.

Conclusions

The successful incorporation of LapNC into collagen hydrogels as nanofillers to modify the rheological and structural properties highlights their potential for tissue engineering applications. Our results demonstrate that the mechanical properties of collagen hydrogels can be enhanced by the addition of LapNC without increasing collagen density. This may provide a powerful method for personalized research and therapies in multiple fields of tissue engineering. In particular, our study suggests that LapNC-supplemented hydrogels can serve as 3D cancer culture systems for stiffness-dependent tumor spheroid growth, opening up new avenues for cancer research and therapy.