15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Plenary Lecture

HYDROGEL AS A MODEL SYSTEM TO STUDY DISSIPATION PHENOMENA IN SOFT TISSUE

Dominique Pioletti

Ecole Polytechnique Fédérale de Lausanne, Switzerland
dominique.pioletti@epfl.ch

Keywords: hydrogel, mechano-biology, dissipation

Summary: The relaxation behaviour of alginate-based hydrogel was shown to influence the differentiation of mesenchimal stem cells. Rapidly relaxing hydrogel favors osteogenic differentiation [1]. We recently observed that dissipation of cartilage can locally induce a temperature increase in this tissue [2] and as a consequence supports chondrogenic gene expression [3]. These two examples highlight a new paradigm on the role of dissipative phenomena in the field of soft tissues and biomaterials. While dissipation has long been identified to play an important role in the mechanical and functional behaviours of musculo-skeletal tissues through viscoelasticity or poro-elasticity considerations, the relation between dissipation and mechanobiology only recently emerges. In parallel to what has been developed with biomaterials considering only elastic (static) parameters such as substrate stiffness to control cell differentiation, the development of new biomaterials incorporating dissipation aspects can allow to engineer in a more refined way the interaction between cells and materials. Indeed dynamical aspects related to the material loading can be uniquely modulated with the consideration of dissipation. This is demonstrated with the two examples mentioned above where the rate (for relaxation) or the combination of duration and frequency (for loading) affect osteogenic differentiation or chondrogenesis. The use of dissipation was also proposed to trigger the controlled release of a drug from a hydrogel [4].
By developing different composite hydrogels based on PEG or HEMA, we were able to control the dissipation properties of these materials and obtain properties that could favour a particular cell differentiation pathway such as chondrogenesis for example as well as tuning in parallel the mechanical properties of the hydrogels.

References

[1]Chaudhuri et al. Nature materials 2016; 15:326-334.
[2]Abdel-Sayed et al. J Mech Behav Biomed Mat 2014; 30:123-130.
[3]Abdel-Sayed et al. Biomaterials 2014; 35:1890-1897.
[4]Moghadam et al. Biomaterials 2014; 35:450-455.