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Research paper

Engineering alginate for intervertebral disc repair

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ABSTRACT

Alginate is frequently studied as a scaffold for intervertebral disc (IVD) repair, since it closely mimics mechanical and cell-adhesive properties of the nucleus pulposus (NP) of the IVD. The aim of this study was to assess the relation between alginate concentration and scaffold stiffness and find preparation conditions where the viscoelastic behaviour mimics that of the NP. In addition, we measured the effect of variations in scaffold stiffness on the expression of extracellular matrix molecules specific to the NP (proteoglycans and collagen) by native NP cells. We prepared sample discs of different concentrations of alginate (1%–6%) by two different methods, diffusion and *in situ* gelation. The stiffness increased with increasing alginate concentration, while the loss tangent (dissipative behaviour) remained constant. The diffusion samples were ten-fold stiffer than samples prepared by *in situ* gelation. Sample discs prepared from 2% alginate by diffusion closely matched the stiffness and loss tangent of the NP. The stiffness of all samples declined upon prolonged incubation in medium, especially for samples prepared by diffusion. The biosynthetic phenotype of native cells isolated from NPs was preserved in alginate matrices up to 4 weeks of culturing. Gene expression levels of extracellular matrix components were insensitive to alginate concentration and corresponding matrix stiffness, likely due to the poor adhesiveness of the cells to alginate. In conclusion, alginate can mimic the viscoelastic properties of the NP and preserve the biosynthetic phenotype of NP cells but certain limitations like long-term stability still have to be addressed.

1. Introduction

Transplantation systems based on scaffolds seeded with stem cells or native cells offer a promising means to repair aged, damaged, or diseased tissues (Hubbell, 2003). Accordingly, there has been much recent effort to design scaffolds that mimic the bioadhesive and physical characteristics of natural extracellular matrices found in tissues and can thus promote tissue-specific cell phenotype (Huebsch and Mooney, 2009; Lutolf et al., 2009). A variety of tissues can already be engineered by this approach, including artery, skin, cartilage, bone, ligament, and tendon. Scaffold stiffness has been recognized as an especially important cue to

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