Poly(Vinyl Alcohol)-Gelatin Interpenetrating Network Hydrogels for Tissue Engineering Applications

Emily J. Miller
Mechanical Engineering Program
University of Vermont
Burlington, United States of America

Rachael A. Oldinski
Mechanical Engineering Program
Bioengineering Program
Department of Orthopaedics and Rehabilitation
University of Vermont
Burlington, United States of America

Abstract: Erosion of articular cartilage results in subsequent destruction of subchondral bone, generating an osteochondral defect. Osteochondral tissue engineering would benefit from the use of multi-phasic biomimetic scaffolds to promote simultaneous regeneration of articular cartilage and subchondral bone.

I. INTRODUCTION

Osteoarthritis is a degenerative inflammatory disease exemplified by the degradation of osteochondral tissue, which consists of articular cartilage and underlying subchondral bone. Osteochondral tissue diseases and injuries are becoming more prevalent. Tissue destruction can be reduced through the use of engineered biomimetic scaffolds. Osteochondral tissue engineering offers an alternative to traditional surgical procedures by developing 3D scaffolds that promote hybrid regeneration of bone and cartilage tissues.

II. MATERIALS AND METHODS

A. Fabrication of Polymer-Gelatin Hydrogels

PVA-PEG-gelatin hydrogels were prepared by varying molecular weights and concentrations of PVA, PEG and gelatin. PVA (Mw = 145kg/mol) was combined with PEG (Mw = 400 or 600g/mol) in a 1:1 weight ratio to form 18% (w/v) PVA and 18% PEG solutions. Five and 7% (w/v) gelatin was then added to some solutions. The polymer blend solutions were autoclaved for 1 hour then transferred to a glass mold pre-heated at 90°C and allowed to cool to room temperature for 24 hours. The hydrogel was then dialyzed in DI water for 3 days to remove PEG.

B. Characterization of PVA-Gelatin Hydrogels

Samples were lyophilized for scanning electron microscopy (SEM) characterization and swell ratio experiments. Swell ratio was calculated as the percentage of wet weight divided by dry weight after hydrating in buffered saline pH 7.4 for 24 hours and lyopholizing. Hydrogels were tested in unconfined compression up to 20% axial strain using a TA AR2000 Rheometer. The compressive elastic moduli were calculated via linear regression of 5-15% strain (n = 4). Scaffolds were stained with Von Geison solution to verify retention of gelatin within the hydrogels. Hydrogel cytotoxicity was determined using a MTT-based in vitro viability assay after 24 hours of culture with human mesenchymal stem cell (MSC) in standard growth medium (alpha-MEM, 10% MSC-screened fetal bovine serum, 1% antibiotic/antimicotic).

III. RESULTS

Increasing molecular weight of PEG resulted in larger pores within scaffolds. Adding gelatin increased pore size further, confirmed through SEM (Fig.1). Increasing the concentration of gelatin allowed for a more solid and stiffer hydrogel (Fig.2). The control hydrogels that did not contain gelatin were very soft and compressive moduli were not obtained. PVA hydrogels with and without gelatin did not exhibit significant differences in swell ratio, between 500 and 720%. Von Geison staining verified that gelatin was retained in the hydrogels after dialysis (gelatin samples stained red, PVA controls did not; Fig.3). All of the PVA hydrogels, with and without gelatin, maintained cell viability (> 100%) (Fig.4).

IV. CONCLUSION

Through a systemic solidification process, interpenetrating network hydrogels were obtained from the physical crosslinking of PVA and gelatin and the diffusion of PEG for pore formation. Varying PEG molecular weight and concentration of gelatin optimized pore size. These bio-synthetic hydrogels are promising candidate for osteochondral tissue engineering scaffolds and warrant further investigation. Further work will include examination of PVA molecular weight, concentrations and strength of collagen, and PEG
molecular weight. Future in vitro experiments will examine human MSC chondrogenic and osteogenic differentiation on bi-layered scaffolds for the regeneration of osteochondral tissue. Individual layers will vary in pore size, collagen type and concentration, and mechanical properties.

ACKNOWLEDGMENT

The authors thank the College of Engineering and Mathematical Sciences at UVM for funding, and members of the Microscopy Imaging Center for SEM assistance.

REFERENCES


