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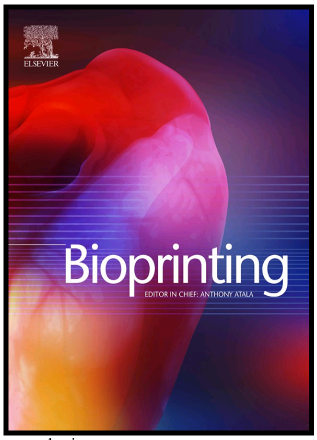

www.elsevier.com

PII: S2405-8866(17)30014-3
DOI: http://dx.doi.org/10.1016/j.bprint.2017.09.001
Reference: BPRINT16

To appear in: *Bioprinting*

Received date: 7 July 2017
Revised date: 1 September 2017
Accepted date: 8 September 2017

Cite this article as: Braeden Webb and Barry Doyle, Parameter optimization for 3D bioprinting of hydrogels, *Bioprinting,* http://dx.doi.org/10.1016/j.bprint.2017.09.001

Parameter optimization for 3D bioprinting of hydrogels

Braeden Webb[1,2], Barry Doyle[1,2,3*]

[1]Vascular Engineering Laboratory, Harry Perkins Institute of Medical Research, QEII Medical Centre, Nedlands and Centre for Medical Research, The University of Western Australia.

[2]School of Mechanical and Chemical Engineering, The University of Western Australia.

[3]BHF Centre for Cardiovascular Science, The University of Edinburgh.

Corresponding author. Harry Perkins Institute of Medical Research, 6 Verdun Street, Nedlands, Perth, WA 6009, Australia. Tel.: +61 81 6151 1084

Abstract

Successful bioprinting of hydrogels relies on geometric accuracy and cell viability, both of which are influenced by a number of variable printing parameters. Despite much research aimed at the resulting quality of bioprinted structures, there is no standard method of comparing bioprint results. In this study, we have developed a simple method of assessing the bioprint results from a range of printing parameters in a standardized manner applicable to extrusion-based bioinks. The purpose of the parameter optimization index (POI) is to minimize the shear stress acting on the bioink, and thus on the encapsulated cells, while ensuring the maximum geometric accuracy is obtained. Here we demonstrate the use of the POI on a blend of 7% alginate and 8% gelatin, and test the printing achieved through 25, 27, and 30 gauge print nozzles at 1 – 6 mm/s print speeds, and at 100 – 250 kPa print pressures. In total, we tested 72 printing configurations. Our data shows that for this particular hydrogel blend, the optimum print is obtained with a 30 gauge nozzle, 100 kPa print pressure and 4 mm/s print speed. The POI is intuitive and easy to assess, and could be a useful method across a wide range of 3D bioprinting research and development applications.

Keywords: bioprinting; hydrogel; optimization

1 Introduction

Three dimensional (3D) bioprinting relies on cell viability and geometric accuracy. Both these characteristics depend on the properties of the biomaterial being used and are both influenced by the bioprinting parameters (Chan et al., 2012; Nair et al., 2009). Printing parameters include nozzle temperature, printing time, dispensing pressure, printing speed, and nozzle diameter (Chang et al., 2011; Panwar and Tan, 2016), all of which directly influence the precision and accuracy of bioink deposition. Furthermore, these parameters also directly impact cell viability as they determine the shear forces within the bioink during the printing process. Increasing nozzle diameter decreases shear stress, therefore reducing cell injury, although this comes at the cost of reduced resolution (Murphy and Atala, 2014). Increasing the dispensing pressure has a similar effect to that of decreasing the nozzle diameter, although is proven to have an even more detrimental effect on cell viability (Murphy and Atala, 2014; Nair et al., 2009; Panwar and Tan, 2016).