Modeling of the Mechanical Behavior of 3D-Bioplotted Scaffolds

Saman Naghieh[1], Mohammad Reza Karamooz-Ravari[2], MD Sarker[1], Adam D McInnes[1], Xiongbiao Chen [1,3]

[1] Division of Biomedical Engineering, College of Engineering, University of Saskatchewan, Saskatoon, SK, Canada

[2] Department of Mechanical Engineering, Graduate University of Advanced Technology, 76318-18356 Kerman, Iran

[3] Department of Mechanical Engineering, College of Engineering, University of Saskatchewan, Saskatoon, SK, Canada

Introduction

Developing of tissues scaffolds to repair the damaged tissues/organs is one of the fundamental goals of tissue engineering [1]. To this end, the design and fabrication of tissue scaffolds have been shown as challenging tasks [2]. One important issue in the design of scaffolds is to achieve the mechanical properties that match those of tissues/organs to be repaired. To address this issue, modeling and numerical simulations of scaffold mechanical properties are of powerful tools but limited by the imperfect representation of the features of fabricated scaffolds. Specifically, due to the fluid nature of scaffold solution for 3D bioplotting, scaffolds are always fabricated with the penetration of strands in one layer into the previous layer. This feature, however, has been ignored in the literature. The significance of the present study rests on the development of a novel model representative of the mechanical behavior of bioplotted scaffolds, by taking into account the aforementioned strand penetration. Once validated by experiments, the model was used to discover the influence of strand penetration, along with other scaffold geometrical features, on the scaffold mechanical behavior, which is also missing in the literature.

Methods

The finite element method was utilized to develop a model for predicting the elastic modulus of 3D bioprinted alginate scaffolds. Compression tests were performed to calculate the elastic modulus of the scaffolds.

Results

Experimental results were compared with the numerical model and it was concluded that the model can predict the mechanical behavior of alginate with 8% difference. Then, the effect of strand penetration and other geometrical features on the elastic modulus of bioplotted scaffolds was studied using this model.

Conclusions

In this study, a novel finite element model is presented to predict the elastic modulus of bioprinted scaffolds. The focus of this model was on the penetration within layers and accordingly, the effects of the number of layers and strand diameter were studied. Results demonstrated 8% difference between model and the experimental findings. Hence, to evaluate the mechanical properties of scaffolds before fabrication, this model can be used to have scaffolds with desired mechanical properties.

References

1. Zehnder, T., et al., Evaluation of an alginate-gelatine crosslinked hydrogel for bioplotting. *Biofabrication* **7,** (2015).
2. Chen, X. B. Dispensed-Based Bio Manufacturing Scaffolds for Tissue Engineering Applications. *Int. J. Eng. Appl.* **2,** 10–19 (2014).