INVESTIGATION OF DEPENDENCIES BETWEEN PRINTING PARAMETERS IN ADDITIVE MANUFACTURING AND PROPERTIES OF MATERIALS USED FOR IT

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Introduction

A bioprinting, especially direct bioprinting, gives great hopes and possibilities in the work on natural tissues and organs fabrication. The development of the new materials for additive 3D printing methods gives new possibilities for the bioprinting, but at the same time forces the changes and development of the design of the printers themselves. The continuous development of the 3D printing industry also contributes to the development of bioprinting giving new opportunities. When constructions and materials are developed simultaneously, then the best results are achievable. Therefore, the topic that contributed to the development of materials and devices used in the bioprinting was taken up.

Materials and Methods

In this work optimal parameters of additive printing were developed with selection of proper material parameters of the printed hydrogel. For this purpose, a fully functional 3D printer construction for printing with high viscosity hydrogels was created. The design of the machine took into consideration optimal construction components to achieve best possible results when it comes to quality of the print. To obtain it, nozzle length and diameter were chosen with the use of numerical simulation. What is more, a peristaltic pump to pump hydrogels was designed and manufactured with use of 3D printing techniques. Hydrogel crosslinking method with division into thermal and ionic crosslinking was customized to fit perfectly sodium alginate and gelatin mixture. Moreover, investigations were made to illustrate the capabilities of the constructed machine and the correctness of the printing parameters with chosen material. Configuration tests such as single line and three dimensional lattice prints were performed. Those tests allowed to configure all movement of the printer in order to achieve correctness of prints with the usage of chosen material.

Results and Discussion

In this work both 3D printer construction and parameters of material used for printing were focused on direct bioprinting. In order to make the optimum selection of the nozzle in relation to the planned bioink, numerical simulation of the material flow was carried out by a pre-selected nozzle. The literature indicates a fairly wide range of nozzle diameters used in the bioprinting: from 0.15 mm to 0.55 mm [1]. If a smaller diameter of the needle is used, a high pressure is required to pump the hydrogel. It may cause damage to the cells included in the hydrogel. In the case of a large diameter nozzle, spontaneous flow of material may occur and thus the printout will be losing accuracy. The simulations of the hydrogel flow through capillary allowed to verify and confirm the correctness of the needle with a diameter of 0.32 mm (FIG. 1).

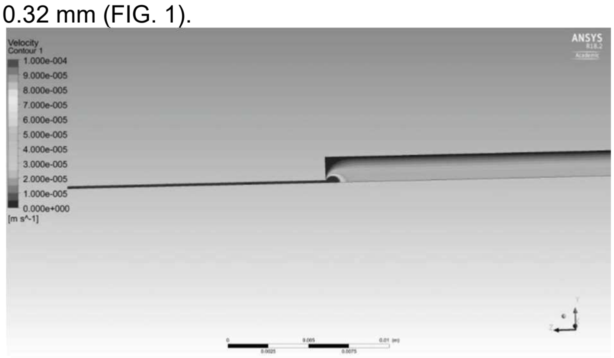

FIG. 4. The result of simulation of flow velocity through the capillary.

A lattice visible on FIG. 2 was printed. Model parameters were set so that each wall was a single print line. This allows for the best observation of individual printed lines, and thus to adjust the optimum print performance.

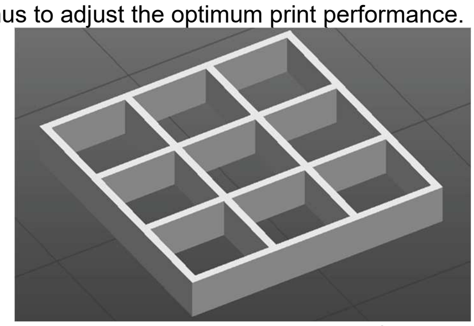

FIG. 5. A multi-layered grid model for testing the accuracy and correctness of spatial prints.

Conclusions

Well determined printing parameters adjusted to the defined material allow to obtain very good printouts on a given device. Worked out custom 3D bioprinter takes into account all the crucial properties of the bioink, which must be included to ensure cells viability before, during and after the direct printing. This system allows direct and indirect (scaffolds) printing for biomedical application.

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References

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