Short Communication

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European Journal of Applied Engineering and Scientific Research, 2020, Volume 8 issue 2

ISSN: 2278-0041

3D Printing 2020 - Biomimetic 3D bioprinting of cellular laden nano-composite scaffold through co-axial and core-co-cultured structure

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There is a need to recapitulate the native complexity of bone structure within engineered 3D structures with tailored biological and mechanical properties. In this study, we suggest an innovative cell-printing process, supplemented with core/shell nozzle and co-cultured/mono-cultured methods, to achieve 3D osteon-like structures through cell-laden bioinks using an extrusion-based 3D bioprinter in one-step. In this study, vascularization promoting and osteogenic bioinks were developed based on different concentration of GelMA-alginate hydrogels with the incorporation of hydroxyapatite nanoparticles. These hydrogels were chosen due to their suitable mechanical stability, swelling ratio, and printability. To obtain a core/shell osteon-like structure (CSBP), we used a vascularization bioink combined HUVECs in the core region, and used osteogenic- MC3T3-E1 cells-laden bioinks in the shell region. Pure gelatin was concentration in all bioinks to support both of core and shell structures during 3D bioprinting. Core-co-cultured osteon-like structure (CCBP) was fabricated through co-culturing of HUVECs and MC3T3 cells within bioink in the core region. Mono-cultured printed structure composed of single cell lines served as a control. The fabricated 3D-core-cocultured of HUVECs-MC3T3 cells showed significantly higher cell viability (84%) compared to that (78%) of a 3D-core/shell of HUVECs/MC3T3 cells. Both fabricated structures exhibited outstanding cell viability in comparison with (65%) of mono-cultured 3D cell-laden scaffold (control). In addition, significant increases in osteogenic properties were observed in the co-culture samples versus the mono-culture controls. We demonstrated that both co-culture configurations were able to promote mineral deposition in the absence of exogenous osteogenic factors. Although the CSBP configuration displayed less viability than CCBP, this structure still exhibited good osteogenic and angiogenic properties. In conclusion, this investigation provided highlighted the potential of both structures as biomimetic bone scaffolds for complex bone tissue and other tissue engineering application.

Introduction:

In the second step, the liquid mixture of cells, matrix, and nutrients known as bioinks are placed in a printer cartridge and deposited using the patients' medical scans. When a bioprinted pre-tissue is transferred to an incubator, this cell-based pre-tissue matures into a tissue.

3D bioprinting for fabricating biological constructs typically involves dispensing cells onto a biocompatible scaffold using a successive layer-by-layer approach to generate tissue-like three-dimensional structures. Artificial organs such as livers and kidneys made by 3D bioprinting have been shown to lack crucial elements that affect the body such as working blood vessels, tubules for collecting urine, and the growth of billions of cells required for these organs. Without these components the body has no way to get the essential nutrients and oxygen deep within their interiors. Given that every tissue in the body is naturally composed of different cell types, many technologies for printing these cells vary in their ability to ensure stability and viability of the cells during the manufacturing process. Some of the methods that are used for 3D bioprinting of cells are photolithography, magnetic bioprinting, stereolithography, and direct cell extrusion.

Note: This work is partly presented at 3rd international conference on 3dprinting and additive manufacturing (May 22, 2020 Paris, France)

3D bioprinting contributes to significant advances in the medical field of tissue engineering by allowing for research to be done on innovative materials called biomaterials. Biomaterials are the materials adapted and used for printing three-dimensional objects. Some of the most notable bioengineered substances are usually stronger than the average bodily materials, including soft tissue and bone. These constituents can act as future substitutes, even improvements, for the original body materials. Alginate, for example, is an anionic polymer with many biomedical implications including feasibility, strong biocompatibility, low toxicity, and stronger structural ability in comparison to some of the body's structural material. Synthetic hydrogels are also commonplace, including PV-based gels. The combination of acid with a UV-initiated PV-based cross-linker has been evaluated by the Wake Forest Institute of Medicine and determined to be a suitable biomaterial. Engineers are also exploring other options such as printing micro-channels that can maximize the diffusion of nutrients and oxygen from neighboring tissues. In addition, the Defense Threat Reduction Agency aims to print mini organs such as hearts, livers, and lungs as the potential to test new drugs more accurately and perhaps eliminate the need for testing in animals.

Pre-bioprinting: Pre-bioprinting is the process of creating a model that the printer will later create and choosing the materials that will be used. One of the first steps is to obtain a biopsy of the organ. Common technologies used for bioprinting are computed tomography (CT) and magnetic resonance imaging (MRI). To print with a layer-by-layer approach, tomographic reconstruction is done on the images. The now-2D images are then sent to the printer to be made. Once the image is created, certain cells are isolated and multiplied. These cells are then mixed with a special liquefied material that provides oxygen and other nutrients to keep them alive. In some processes, the cells are encapsulated in cellular spheroids 500μm in diameter. This aggregation of cells does not require a scaffold, and are required for placing in the tubular-like tissue fusion for processes such as extrusion.

Post-bioprinting: The post-bioprinting process is necessary to create a stable structure from the biological material. If this process is not well-maintained, the mechanical integrity and function of the 3D printed object is at risk. To maintain the object, both mechanical and chemical stimulations are needed. These stimulations send signals to the cells to control the remodeling and growth of tissues. In addition, in recent development, bioreactor technologies have allowed the rapid maturation of tissues, vascularization of tissues and the ability to survive transplants.

Bioreactors work in either providing convective nutrient transport, creating microgravity environments, changing the pressure causing solution to flow through the cells, or add compression for dynamic or static loading. Each type of bioreactor is ideal for different types of tissue, for example compression bioreactors are ideal for cartilage tissue.

References:

1. *Singh, Deepti; Thomas, Daniel (2018-05-18). "Advances in medical polymer technology towards the panacea of complex 3D tissue and organ manufacture". American Journal of Surgery.*
2. *Hinton TJ, Jallerat Q, Palchesko RN, Park JH, Grodzicki MS, Shue HJ, Ramadan MH, Hudson AR, Feinberg AW (23 October 2015*
3. *Thomas, Daniel J. (August 2016).*
4. *Nakashima, Yasuharu; Okazak, Ken; Nakayama, Koichiet; Okada, Seiji; Mizu-uchi, Hideki (January 2017). "Bone and Joint Diseases in Present and Future". Fukuoka Igaku Zasshi = Hukuoka Acta Medica.*
5. *Shafiee, Ashkan; Atala, Anthony (2016-03-01). "Printing Technologies for Medical Applications".*
6. *Ozbolat, Ibrahim T. (2015-07-01). "Bioprinting scale-up tissue and organ constructs for transplantation". Trends in Biotechnology.*

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