World Academy of Science, Engineering and Technology
International Journal of Bioengineering and Life Sciences
Vol:17, No:05, 2023

Use of 3D Printed Bioscaffolds from Decellularized Umbilical Cord for Cartilage Regeneration

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Abstract : Osteoarthritis, a degenerative condition, affects more than 213 million individuals globally. Since articular cartilage has no or limited vessels, therefore, after deteriorating, it is unable to rejuvenate. Traditional approaches for cartilage repair, like autologous chondrocyte implantation, microfracture and cartilage transplantation are often associated with postoperative complications and lead to further degradation. Decellularized human umbilical cord has gained interest as a viable treatment for cartilage repair. Decellularization removes all cellular contents as well as debris, leaving a biologically active 3D network known as extracellular matrix (ECM). This matrix is biodegradable, non-immunogenic and provides a microenvironment for homeostasis, growth and repair. UC derived bioink function as 3D scaffolding material, not only mediates cell-matrix interactions but also adherence, proliferation and propagation of cells for 3D organoids. This study comprises different physical, chemical and biological approaches to optimize the decellularization of human umbilical cord (UC) tissues followed by the solubilization of these tissues to bioink formation. The decellularization process consisted of two cycles of freeze thaw where the umbilical cord at -20˚C was thawed at room temperature followed by dissection in small sections from 0.5 to 1cm. Similarly decellularization with ionic and non-ionic detergents Sodium dodecyl sulfate (SDS) and Triton-X 100 revealed that both concentrations of SDS i.e 0.1% and 1% were effective in complete removal of cells from the small UC tissues. The results of decellularization was further confirmed by running them on 1% agarose gel. Histological analysis revealed the efficacy of decellularization, which involves paraffin embedded samples of 4µm processed for Hematoxylin-eosin-safran and 4,6-diamidino-2-phenylindole (DAPI). ECM preservation was confirmed by Alcian Blue, and Masson's trichrome staining on consecutive sections and images were obtained. Sulfated GAG's content were determined by 1,9-dimethyl-methylene blue (DMMB) assay, similarly collagen quantification was done by hydroxy proline assay. This 3D bioengineered scaffold will provide a typical atmosphere as in the extracellular matrix of the tissue, which would be seeded with the mesenchymal cells to generate the desired 3D ink for in vitro and in vivo cartilage regeneration applications.

Keywords : umbilical cord, 3d printing, bioink, tissue engineering, cartilage regeneration
Conference Title : ICBRM 2023 : International Conference on Biomaterials and Regenerative Medicine
Conference Location : Montreal, Canada
Conference Dates : May 15-16, 2023