

Designing and processing hydrogel bioinks for 3D printing applications

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Hydrogels represent a class of biomaterials that have great promise for the repair of tissues, particularly due to our ability to engineer their biophysical and biochemical properties¹. 3D printing approaches are now being developed to process hydrogels into structures with the appropriate shapes and patterns for tissue repair²; however, printing processes are often not compatible with hydrogels optimized for a desired cell response. Thus, we have developed techniques to both screen hydrogels for a desired cell response and to process these materials into printable bioinks. Towards MSC chondrogenesis, we have developed a screening platform using the patterning of photocrosslinkable norbornene-modified hyaluronic acid hydrogels with biochemical signals³. These include peptides that mediate cell-matrix adhesion (i.e., RGD) or cell-cell adhesion (i.e., HAVDI). When cells are encapsulated within the hydrogels incorporating orthogonal gradients, optimal formulations can be identified through imaging of MSC differentiation markers (e.g., Sox9, aggrecan). As these are non-viscous precursor solutions, they are difficult to 3D print using traditional printing approaches, such as extrusion-based printing. With extrusion-based printing, a bioink must flow during extrusion, but then be rapidly stabilized post-extrusion to maintain the desired printed structure. To address this, we have developed two approaches to 3D print non-viscous bioinks: (i) curing the material with light through a transparent conduit immediately prior to extrusion⁴, and (ii) processing the materials into microgels using microfluidics that can be jammed and printed as solids. Both of these approaches have been successful in the processing of non-viscous hydrogel precursors into stable structures and have been used to encapsulate cells with high cell viability. Ultimately, the design of new bioinks and printing processes will lead to successful applications of 3D printing in the repair of tissues.

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