Evaluating Alginate-Nanocellulose Bioinks for 3D Printing Human Ears

Tasmin Nicholson

Swansea Medical School

3D printing has received increasing interest over the last few years. Previously 3D printing was largely restricted to metals and plastics, but recent developments have enabled progression towards 3D printing biomaterials (Jessop, 2019). The ability to 3D prints cartilaginous structures, such as the human ear, could offer a less invasive approach to reconstructive surgery (Jessop, 2019).

This project aims to evaluate three alginate-nanocellulose bioinks: nanocellulose crystals (NCC), nanocellulose fibrils (NCF) and a blend of nanocellulose crystals and fibrils (NCB). These inks have previously been assessed for their rheological properties and show promise as candidates for 3D printing. Here, we aim to assess the printability of each ink, in terms of printing pressure, consistency of line and fidelity to the original design.

Each design was constructed on TinkerCAD, before being loaded onto CellInk's HeartWare programme for slicing. The printing pressure was identified as the point at which a continuous filament was achieved. All bioinks required pressures of $\leq$ 10 kPa which is low enough to allow cells to be integrated into the bioink in future. After printing, each structure was crosslinked with calcium chloride before being measured with digital callipers.

Grid assay measurements demonstrated that NCF had the greatest consistency in border thickness, and NCC had the greatest consistency of gridlines and fidelity to the original design. A ring assay demonstrated NCF to have the greatest consistency of line. However, for the antihelix, NCB offered the greatest fidelity to the original design.

The variable performance of each bioink could be attributable to the unique properties of the ink, or degradation of the ink over time. Further research is needed to confirm this. Nevertheless, these assays have demonstrated the viability of each candidate bioink for 3D printing cartilaginous structures.

Further studies will be conducted to evaluate the use of multiple printheads to combine different bioinks into a single printed structure and to assess the properties of each bioink in combination with cartilage cells.

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