Screen printing hydrogel constructs for fabricating high throughput *in vitro* models

Bryan Ibarra, James Dolgin, Stephen Farias
Materic Group, Baltimore, MD, 21230

Statement of Purpose: The fabrication of tissue models has met various challenges using conventional 3D bioprinting techniques. Extrusion, laser-assisted, and inkjet bioprinting induce a shear force that reduces the viability of printed cells within hydrogels and expose them to radiation that could influence their phenotypes. Screen printing is a technique that has been around for thousands of years and allows for the deposition of various types of viscoelastic materials onto a substrate below, such colored inks onto fabric. Screen printing is also typically used in the manufacturing of electronic circuits, where micro-scale structures can be achieved. Recently, screen printing was demonstrated as a simple and inexpensive tool for printing cells within 3D scaffolds that supports their growth.[1] Screen printed cell-hydrogel constructs have the potential for studying tissue models on a greater scale, assessing cell health with high throughput screenings, and forming multiple complex 3D structures at once. However, screen printing of cells is a nascent technology that, while suitable for academic research, must be modernized to compete with other commercial bioprinting techniques. Specifically, facility of reproducibility, minimization of print-to-print variability, and methods for characterizing printed structures were improved upon in this project.

Methods: Screen printing tools were designed on Solidworks and printed using a selective laser sintering (SLS) 3D printer. First, polyester meshes were stretched over and glued to the 3D printed frames. Then, the mesh was thinly coated with photo-emulsion and left to dry overnight. The photomask pattern was printed on a transparency that was overlaid on the emulsion coated mesh and exposed to UV light for a controlled duration. The unexposed emulsion was washed out, revealing the screen mask. The screen mask was situated on the 3D-printed base structure where microscope slides spin-coated with a test material were firmly placed underneath the screen mask. Gelatin was screen printed as the second layer (the spin-coated test material was the first). Morphology of the print was assessed from images taken using a camera with a macro lens. Thickness of the screen and printed structures were assessed using optical coherence tomography (OCT).

Results: 3D-printed frames with taut polyester meshes were fabricated more than 3 times more quickly than the original procedure to fabricate frames in-house. Optimal values for UV exposure, washing pressure, and gelatin curing time before printing were recorded for ensuring reproducibility. From photographic (Fig. 2) and OCT (Fig. 3) images taken, fidelity to the pattern on the screen mask was improved while screen printing variability of gelatin was reduced.

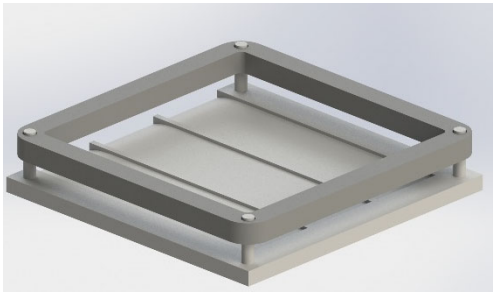

Figure 1. Rendering of 3D-printed slide holder and frame.

Figure 2. Screen mask and corresponding printed gelatin structure. Diameter of largest circle = 2.5 cm.

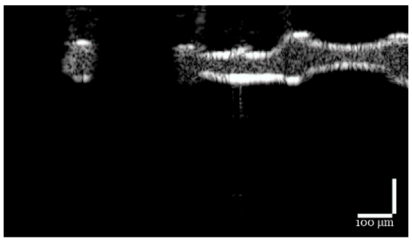

Figure 3. OCT image of screen without (left of image) and with (right of image) emulsion coating after washing out unexposed emulsion after UV exposure.

Conclusion: Facility of reproducibility and print-to-print variability were noticeably improved thanks to the use of 3D-printed tools. Characterization of printed patterns using a macro lens and OCT was successful and were useful in further optimizing printing parameters. Using these improved tools, screen printing applications can be expanded to commercial applications that require more standardization compared to academic projects.

References:

1. Pandala N. et al. ACS Applied Bio Materials.2020;3:8113–8120.

This work is supported by NSF Grant #2111981.