Master-Thesis Medical Engineering

Feasibility Study of LCD 3D Printing for Producing Microfluidic Retina Phantoms

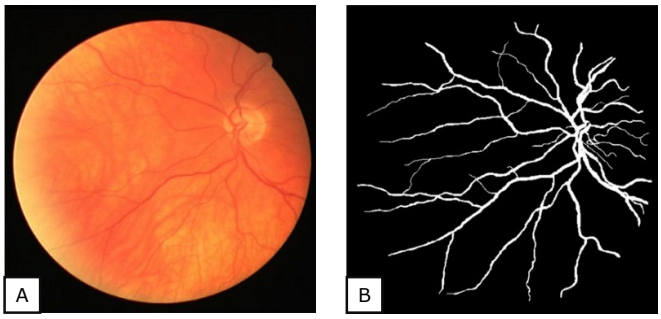

Figure 1: Typical image of a retina and its structure (A). The corresponding blood vessels are illustrated in (B), where the static tissue appears in black and the moving blood is shown in white. (Abdulsahib et al., 2021)

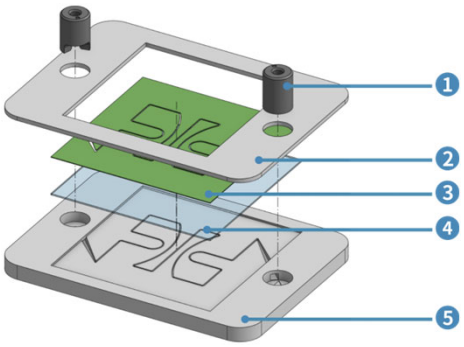

Figure 2: Final glass bonding approach with the bottom part of the chip (5) and tubing ports (1). Grey parts were printed as one unit. The green top layer (3) is a sacrificial connection for the glass plate (4), later removed with acetone.

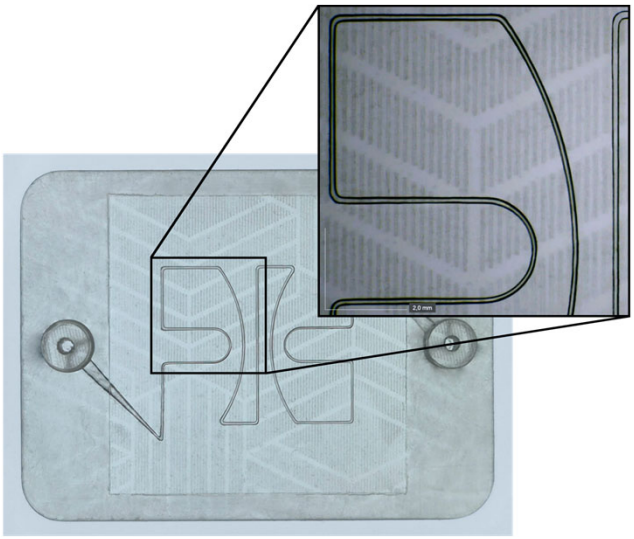

Figure 3: Final produced microfluidic 200 µm retina phantom chips with bonded glass coverslips and Liqcreate Bio-Med Clear resin.

Problem Statement

Retinal diseases are a leading cause of vision loss worldwide. They include diabetic retinopathy, age-related macular degeneration, and vascular occlusions, which all affect the retinal microvasculature (Abdulsahib et al., 2021).

Optical Coherence Tomography Angiography (OCTA) is a key imaging method for diagnosis and follow-up, but its performance depends on phantoms that realistically reproduce microvascular structures. Commercial phantoms often lack vessel sizes and flow conditions close to physiology, which reduces their value for testing new imaging protocols.

This thesis aimed to investigate the feasibility of fabricating such phantoms with LCD-based 3D printing. This low-cost and flexible method enables direct control of channel geometry. Microchannels between 50 and 200 µm were targeted as they match physiological capillaries, venules, and arterioles. By proving reproducibility and accuracy, this work provides a basis for OCTA-compatible retinal vessel phantoms.

Approach

Three UV resins and different fabrication methods were tested using LCD 3D printing. Closed channels were directly printed, while open channels were sealed with laminate or glass covers. Test structures between 50 and 500 µm were produced and measured with a high-resolution microscope. Accuracy, reproducibility, and material properties were compared to identify the most suitable method.

Results

The experiments showed that 200 µm channels could be fabricated within the defined tolerance and reproduced across several samples. This demonstrates their suitability for representing larger retinal vessels (Fig. 3). Smaller channels of 50 µm, however, were often obstructed due to overpolymerization and incomplete clearance of uncured resin. Among the tested fabrication methods, the combination of Liqcreate Bio-Med Clear resin with a bonded glass cover proved to be the most stable and reliable solution (Fig. 2). phantoms of the retinal vessel system.

Applying a linear correction strategy further improved dimensional accuracy. Material use per chip was low, with costs under 1 CHF for glass slides and resin. Overall, the study confirms the feasibility of LCD 3D printing for producing microfluidic phantoms.

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