# Towards Design of 3D Printed Tissue Scaffold for Longitudinal Ultrasound-guided Photoacoustic Imaging

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## Background, Motivation and Objective

Three-dimensional (3D) printing allows for fabrication of patient-specific tissue scaffolds with precise geometrical, mechanical and other properties. Poly-ε-caprolactone (PCL) is widely used for 3D printing due to its biocompatibility and favorable rheological properties. However, once implanted, there is a need for longitudinal monitoring of morphological and mechanical properties of the constructs and their interaction with tissue. This study explores PCL based implants designed and constructed for non-invasive and non-destructive longitudinal ultrasound (US) and photoacoustic (PA) imaging.

## Statement of Contribution/Methods

The 3D printing material was prepared by mixing PCL and an optical absorber (e.g., dye or solid microparticles) at 120°C. The mixture was then allowed to cool before placing it inside a stainless steel syringe of the dispensing head in the 3D printing system. The mixture was melted at 100°C inside the syringe and the filament was extruded through the 300 µm inner diameter nozzle by applying 500 kPa of air pressure to print 8x8x6 mm porous scaffolds that consists of 300 µm lines (Fig. 1A). Scaffolds were then embedded inside a tissue-mimicking polyacrylamide gel phantom with and without acoustical scatters. The phantom was irradiated with 5 ns laser pulses (10 Hz PRF, 1064 nm wavelength) and imaged by an array transducer (L11-4, 7 MHz center frequency). For 3D imaging, US and PA images (Vantage 256) were acquired every 250 µm as the imaging scanhead was mechanically translated using a Newport motor stage (Fig. 1B).

## Results/Discussion

The custom designed tissue implants varying in shape, size and construction were printed as designed (Fig. 1A). In the acoustically scattering background, the constructs were barely visible in US imaging, while high contrast PA images identified geometry of the implants within surrounding material (Fig. 1C). Overall, we have demonstrated the feasibility of creating 3D printed constructs designed for longitudinal USPA imaging. In the on-going studies, we explore biocompatible dyes and particles as contrast agents for PA imaging of tissue scaffolds or implants. Furthermore, hybrid photomagnetic materials are being explored for multimodal PA and magnetic resonance imaging. Future studies will extend the imaging capability to assess the mechanical properties of constructs by using US elasticity imaging.

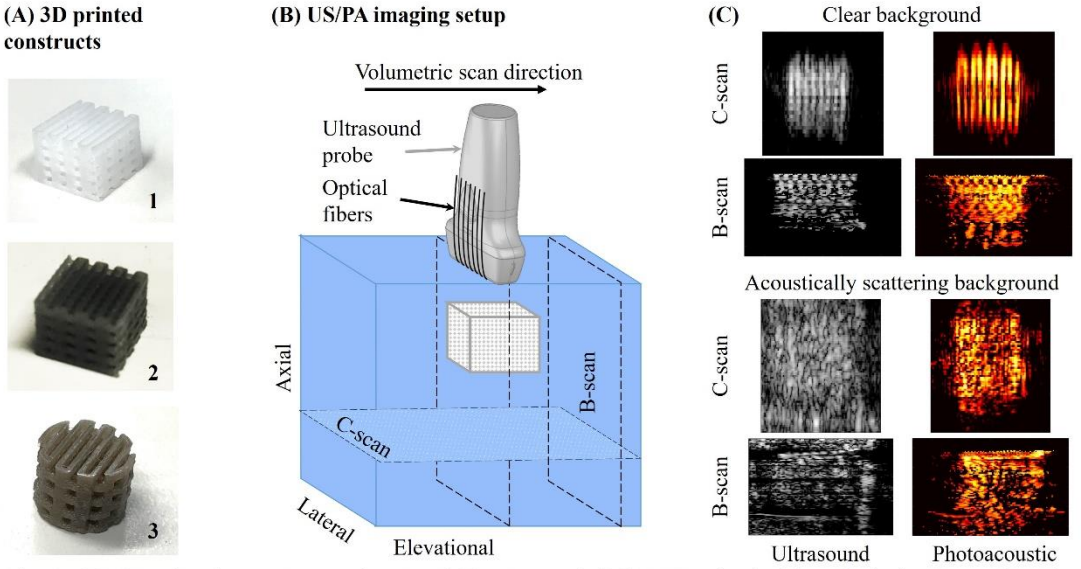


Fig. 1. (A) 3D printed constructs made out of (1) PCL, and (2-3) PLC mixed with optical absorbers. (B) The experimental setup for imaging the constructs embedded in a polyacrylamide phantom. (C) Ultrasound and photoacoustic images of a construct shown in A.2 embedded in a clear polyacrylamide phantom and a polyacrylamide phantom containing acoustic scatters.