Acoustic small-diameter vascular scaffolds enabling contactless and facile 3D endothelialization

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Background, Motivation and Objective

Rapid formation of a confluent endothelial monolayer is essential to the success of small-diameter vascular scaffolds, which is crucial for treating dangerous vascular disorders. However, it is still challenging for 3D endothelialization to homogenously locate endothelial cells onto the lumen of small-diameter tubular scaffolds. Here, we report acoustic small-diameter vascular scaffolds, which enable facile 3D endothelialization in a contamination-free and biocompatible manner.

Statement of Contribution/Methods

Fig. 1(a) schematically shows the system consisting of a glass capillary with 120 μm inner radius, 150 μm outer radius and 10mm in length. The scaffold is immersed in water confined by a PDMS channel. A PZT is an actuator for generating ultrasonic wave. The normal transmission spectrum and acoustic radiation force distribution of this system are calculated by using the COMSOL Multiphysics software with Gaussian beam along the bottom boundary, expressed as $p(x) = p_0 \exp\left(-(x - x_c)^2 / w_0^2\right)$, where $p_0 = 1$[Pa]. As shown in Fig. 1(b), there is a transmission dip at frequency of 0.698MHz. The pressure field around the scaffold at the resonance frequency is illustrated in Fig. 1(c), which illustrates that acoustic field is the 2-nd of circumferential mode and confined around the surface of the scaffold. Furthermore, the numerical map of acoustic radiation forces exerted on endothelial cells near the surface of scaffold are shown in Fig. 1(d), which indicates that endothelial cells may suffer the acoustic trapping forces, moving towards the inner surface of the scaffold.

Results/discussion

To investigate the 3D endothelialization and cytocompatibility of the proposed scaffold, rat brain microvascular endothelial cells BEnd.3 were injected into the scaffold and then stained by calcium AM (Live, Green) /PI (Dead, Red) after cell attachment and 24 h cell culture. Results (Fig. 1(e), (f)) suggested that the scaffold exhibited desirable cell attachment and cytocompatibility. The proposed scaffolds bring the convenience to build advanced vascular grafts with confluent endothelial monolayer mimicking the native blood vessel, therefore holding great promise for promoting small-diameter vascular tissue engineering and building biomimetic in vitro endothelial models for drug screening.

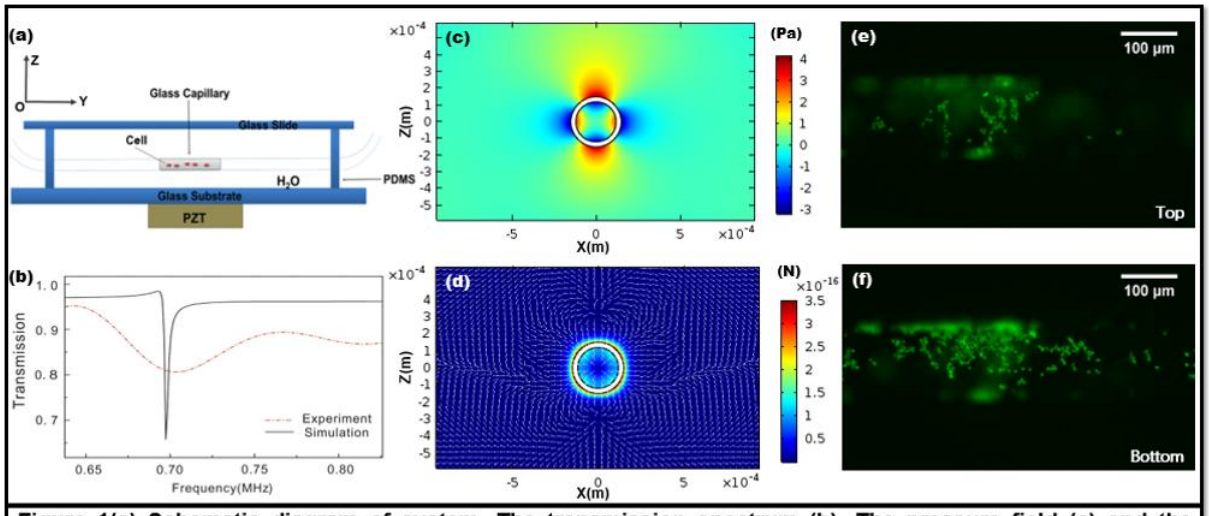

Figure 1(a) Schematic diagram of system. The transmission spectrum (b). The pressure field (c) and the acoustic radiation forces distributions (d) at resonance frequency. The fluorescence images of BEnd.3 cells at the top and bottom after cell attachment and 24 h cell culture. Almost all of the cells emit green fluorescence, and only few cells emit red fluorescence.