Electronic Supplementary Material (ESI) for Lab on a Chip.

Supplementary Information

Engineering anastomosis between living capillary networks and endothelial cell-lined microfluidic channels enhances leak-free perfusion

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S1. Burst pressure of communication pore and advancing pressure of chamber-connecting channel

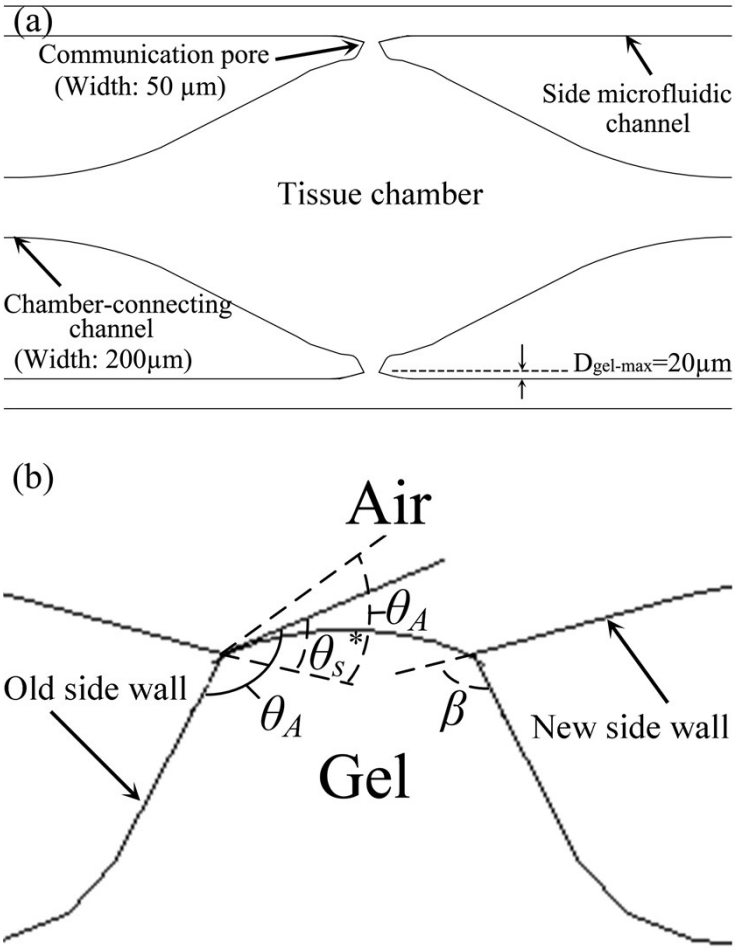

Fig. S1 (a) Schematic and dimensions of one tissue chamber with optimized communication pore design. (b) Different contact angle of gel interface with side walls of designed communication pore and the quantitative analysis of Laplace pressure at the gel-air interface during the loading process.

The pressure difference exerted on the gel-air interface during loading process can be analyzed by Young-Laplace equation expressed as:

$$P_{gel} - P_{air} = -2\gamma(\cos\theta_s / w + \cos\theta_v / h)$$

where P_{gel} is the gel pressure inside loading channel, γ is surface tension, w and h are width and height of microfluidic channel where the interface is located, θ_s is the contact angle formed between gel interface and side walls, and θ_v is the contact angle of gel interface with the top wall and bottom wall.

When the contact angles with all walls exceed the critical advancing contact angle θ_A (i.e. $\theta_S \geq \theta_A$ and $\theta_V \geq \theta_A$), the interface will burst to induce gel movement. Therefore, the pressure difference for gel bursting interface can be given by:

$$P_{gel-burst} - P_{air} = -2\gamma(\cos\theta_A / w + \cos\theta_A / h)$$

Therefore, for chamber-connecting channel of our design with 200 μm in width and 100 μm

in height, its advancing pressure is 1655 Pa by assuming γ=0.072 N m^{-1}, θ_A=140°.

As shown in Fig. S1b, the expanded new side wall with gentle slope is utilized as the capillary burst valve in our design, which can trap the gel as closely as possible to the microfluidic channel. When the meniscus meets the new side wall, its contact angle reduces from θ_A to $\theta_s^*=\theta_A - \beta$, where β is the angle between old side wall and new side wall, thus the gel stops instantly. The gel interface will bulge with the gradually build-up pressure, until its contact angle with new side wall reach up to θ_A, which also means the contact angle with old side wall reaches up to $\theta_A^*=\theta_A + \beta$. It is noted that maximum contact angle for liquid meniscus cannot exceed 180°, thus the critical bursting contact angle with old side wall for capillary burst valve should be θ_A^*=min $\{\theta_A + \beta, 180°\}$. Therefore, the burst pressure for capillary burst valve $P_{valve\text{-}burst}$ can be expressed as:

$$P_{valve-burst} - P_{air} = -2\gamma(\cos\theta_A^* / w + \cos\theta_A / h)$$

Therefore, for communication pore of our design with 50 μm in width and 100 μm in height, its burst pressure is 3983 Pa by assuming γ=0.072 N m^{-1}, θ_A=140° and θ_A^*=180°.

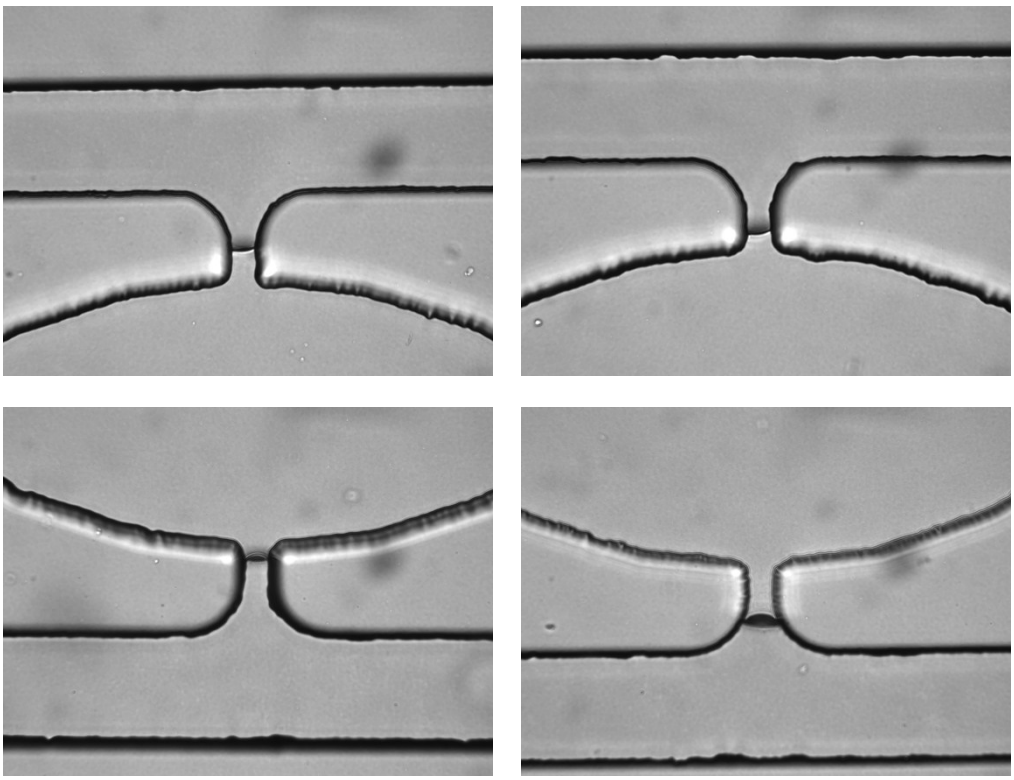

Fig. S2. Gel loading with previous communication pore design. Although it can prevent gel bursting to certain extents, it is difficult to pin the gel at specific location.

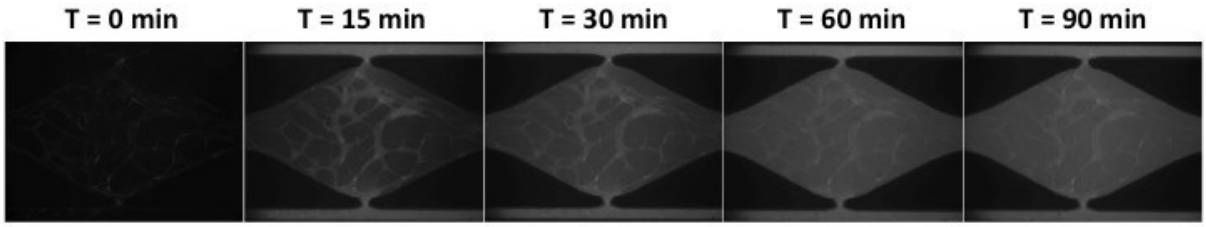

Fig. S3 Experimental result on 4 kDa dextran perfusion into the 3D microvascular network, and its transportation rate across vascular wall into the interstitial space was faster than that of 70 kDa dextran due to the small molecular weight.

Supplementary movie 1: Perfusion of 15 μm fluorescent microparticles inside vessel lumens, which confirms the perfusability of the lumenized microvascular network.

Supplementary movie 2: Perfusion of 70 kDa FITC-dextran for 15 minutes, which confirms physiologic tightness of the EC junctions and completeness of the interconnections between artery/vein and the capillary network without non-physiological leakage.