

Microfluidic shear assays to distinguish between bacterial adhesion and attachment strength on stiffness-tunable silicone substrates

Supplementary Information

Supporting calculations for pressure within microfluidic channels

Pressure within the microchannel can be obtained by invoking the Bernoulli's equation with head loss, in which p_1 and v_1 represent the pressure and velocity at the inlet of the microchannel while p_2 and v_2 represent the pressure and velocity at the outlet. ρ , g , f , L , and D_H represent fluid density, gravitational acceleration, friction factor, channel length, and hydrodynamic diameter, respectively:

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + f \frac{L}{D_H} \frac{v^2}{2g}$$

For a wide rectangular channel, the hydrodynamic diameter can be approximated by the following standard equation, in which a and b are the sides of the channel:

$$D_H = \frac{2ab}{a + b}$$

Thus, the microchannel in this study, which has width of 600 μm and height of 100 μm , has a hydrodynamic diameter of 1.71×10^{-4} m. Friction factor in laminar flow (as is the case in this study) can be obtained from the following equation, where Re is the Reynolds number and μ is the dynamic viscosity of the fluid:

$$f = \frac{64}{Re} = \frac{64\mu}{\rho v D_H}$$

Since the channel dimensions do not change and the microchannel outlet is open to the atmosphere, $v_1 = v_2 = v$ and $p_1 - p_2 = p_{gauge}$. The Bernoulli equation can then be rearranged to the form:

$$p_{gauge} = \rho g f \frac{L}{D_H} \frac{v^2}{2g} = \frac{32\mu L v}{D_H^2}$$

In this study, the highest flowrate through the microchannel was 0.1 mL/min, which can be converted to a velocity of $v = 0.028$ m/s. Thus, p_{gauge} was found to be 1084 Pa for the highest flowrates tested of 0.1 mL/min. This gauge pressure matches well with experimental results reported in literature for similar flowrates and channel geometries¹⁻².

Our simulations found deformation of the side walls of the microchannel to be several orders of magnitude smaller than any vertical deformation so side deformations are not reported. The total vertical deformation at the centre of the microchannel is shown in Figure 3C in response to various gauge pressures in the microchannel. For instance, pressure of 1084 Pa (corresponding to the high shear flowrate of 0.1 mL/min, at the fluid channel entrance) causes a total vertical deformation of ~ 8 μm when the stiffness-tunable layer of PDMS was soft, and ~ 1.5 μm when the stiffness-tunable PDMS was stiff. In comparison, the medium shear flowrate of 0.05 mL/min produces 541 Pa, which would vertically deform the microchannel by ~ 4 μm and ~ 0.7 μm , respectively for a stiff PDMS and soft PDMS stiffness-tunable layer.

Supplementary References

1. Hardy, B. S.; Uechi, K.; Zhen, J.; Pirouz Kavehpour, H., The deformation of flexible PDMS microchannels under a pressure driven flow. *Lab on a Chip* **2009**, 9 (7), 935-938.
2. Gervais, T.; El-Ali, J.; Günther, A.; Jensen, K. F., Flow-induced deformation of shallow microfluidic channels. *Lab on a Chip* **2006**, 6 (4), 500-507.