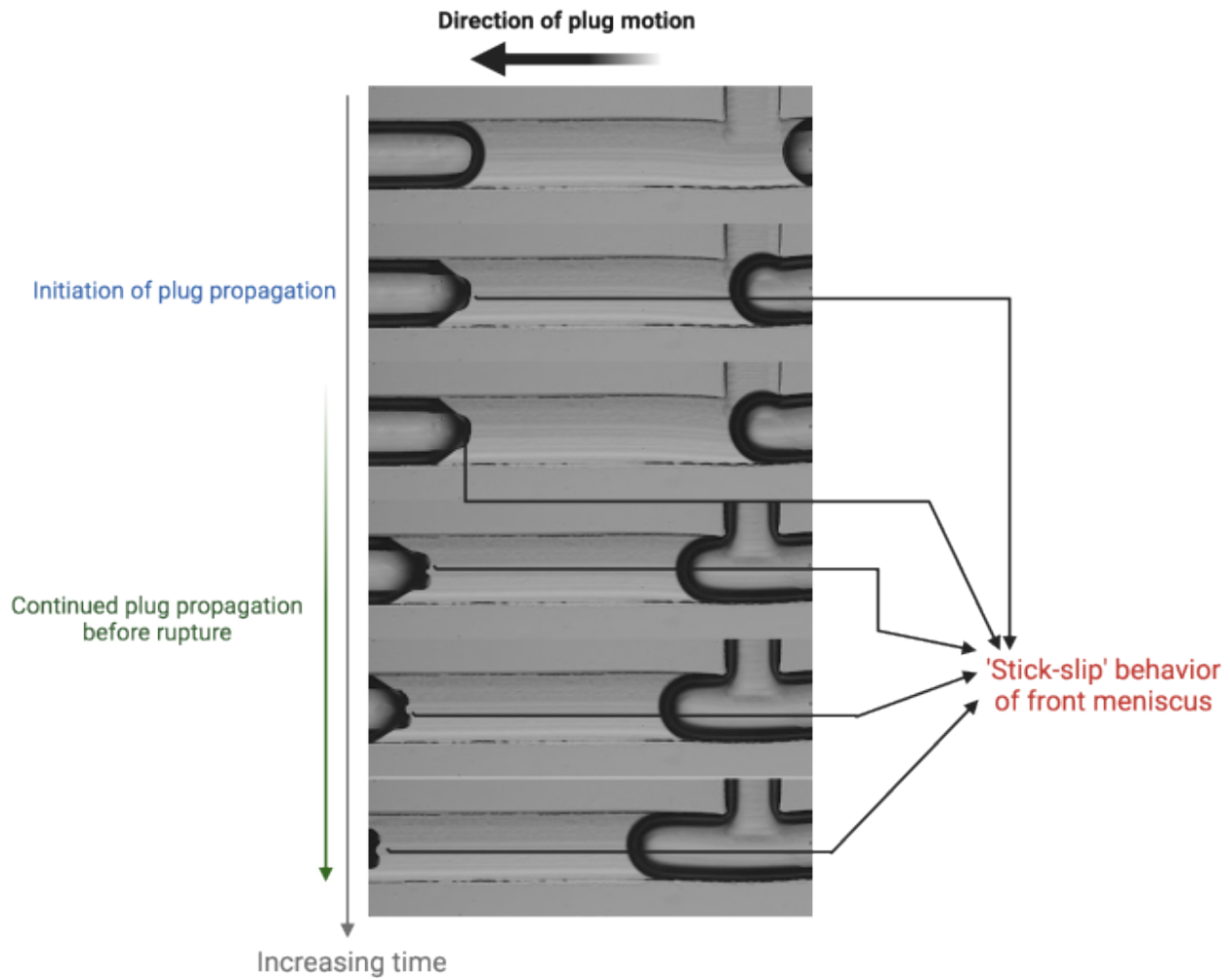


Supplemental Figure 1. Liquid plug characterization and viscosity effects **A)** Calibration curve of air flow rate vs. measured pressure drop confirms functionality of the pressure transducer. **B)** Typical pressure vs. time profile for a single liquid plug **C)** The distribution of times between plug initiation for 297 plugs generated sequentially under identical conditions. **D)** The distribution of peak pressure differentials for 297 plugs generated under identical conditions.



Supplemental Figure 2. Liquid plug stick-slip phenomenon. These image captures taken from Supplemental Video 1 demonstrate the visualization of stick-slip dynamics during the initiation of plug motion. The front meniscus experiences stick-slip motion as labeled by red font.

$$\varepsilon_r = \frac{h_r}{a} = \frac{1.34Ca_r^{2/3}}{1+1.34 \times 2.5Ca_r^{2/3}}, \quad R_r = \frac{\mu}{\pi a^3(1-\varepsilon_r)^2} \left(\frac{2 \times 1.79 \times 2^{2/3} Ca_r^{-1/3}}{1+1.41Ca_r^{1/3}} + 1.1 \right)$$

**Supplemental
Eq. 1**

$$R_f = \frac{\mu}{\pi a^3(1-\varepsilon_f)^2} \left(-2 \times 3^{2/3} f Ca_f^{-1/3} \right), \quad f = \sum_{k=0}^5 C_k (\log_{10} \alpha)^k + \frac{1.02\varepsilon_f^{0.348} \alpha^{-0.594}}{1+0.0778\alpha^{-0.594}}$$

**Supplemental
Eq. 2**

where $Ca_f = \mu U_f / \sigma$, U_f is the velocity of the front bubble, $\varepsilon_f = h_f / a$,
 $\alpha = \varepsilon_f / (3Ca_f)^{2/3}$, $C_0 = -0.149$, $C_1 = 2.04$, $C_2 = 0.570$, $C_3 = 0.233$,
 $C_4 = 0.064$, and $C_5 = 0.00689$.

$$R_c = \frac{\mu L_p}{2\pi a^4} \left[16 + 77.9725 \left(\frac{L_p}{a} + 0.5546 \right)^{-1.7670} \right]$$

**Supplemental
Eq. 3**