Electronic Supplementary Material (ESI) for Integrative Biology
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SUPPORTING MATERIAL

Mathematical derivation of dissipative friction coefficients

Dissipated power (P) released by ruptures of integrin receptor-ligand bonds is expressed as

$$P = -\frac{dE}{dt} = -\boldsymbol{F}_{D,i}^{c} \cdot v_i^c = C_c \boldsymbol{v}_i^c \cdot \boldsymbol{v}_i^c = C_c \left|\boldsymbol{v}_i^c\right|^2 \quad . \tag{A-7}$$

Consider that there were m ruptures over time $t_1 \le t \le t_2$. The energy released at the i-th rupture that occurred at time t_i is given by:

$$\Delta E_i = \frac{1}{2} k_{LR} \left(L_b(t_i) - \lambda \right)^2 . \tag{A-8}$$

The total energy released by the m ruptures is given by

$$\Delta E = \sum_{i=1}^{m} \Delta E_i = \frac{1}{2} k_{LR} \sum_{i=1}^{m} \left(L_b(t_i) - \lambda \right)^2 . \tag{A-9}$$

Assuming that the velocity is constant over time $t_1 \le t \le t_2$, we relate this energy release to the frictional dissipation coefficient:

$$\begin{aligned} C_c \left|\boldsymbol{v}_i^c\right|^2 (t_2 - t_1) &= \Delta E \\ C_c &= \frac{\Delta E}{\left|\boldsymbol{v}_i^c\right|^2 (t_2 - t_1)} \end{aligned} \tag{A-10}$$

Supporting Figure Legends

Figure S1. Meshes of lumen models of diameters of A) 8.8 µm and B) 20 µm; all meshes have equilateral triangular element with a side length of 0.75 µm.

Figure S2. A) Simulated trajectories of cell migrations along seven rectangular conduits with the identical height of 3µm, and different widths of 6 µm, 10 µm, 15 µm, 20 µm, 30 µm, 50 µm and 70 µm. Cells are initially spherical. Ligand surface density is varied continuously from 1.25×10^3 molecules/μm^2 to 1.55×10^3 molecules/μm^2 over a longitudinal conduit length of 100 µm. The black lines indicate trajectories of nuclei for the first three hours, B) comparison of average cell migration speeds: the simulation model vs. experiment data by Irimia and Toner (S20). Average speed and standard error of mean (N=5) are shown for the seven different channels, and C). linear regression (R^2 =0.719) of simulated migration speed vs. experimental migration speed.

Figure S3. Steps of individual cell's migratory direction at the 3 µm tall channel with the width of 30 µm at times of A) 60 min, B) 90 min, and C) 114 min.

Figure S4. Three different plug shaped cell migrations in narrowed lumens, whose diameters are A) 12 µm, B) 8.8 µm, and C) 6 µm; black arrows indicate the directions of cell migrations, and blue arrows represent tangential forces of stress fibers on the surface of lumens.

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Supporting Figures

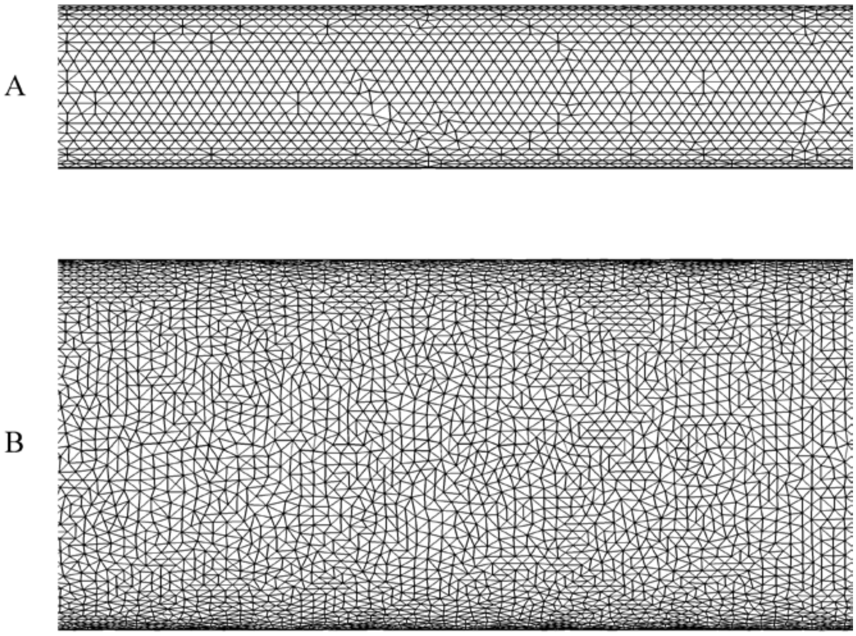

Figure S1

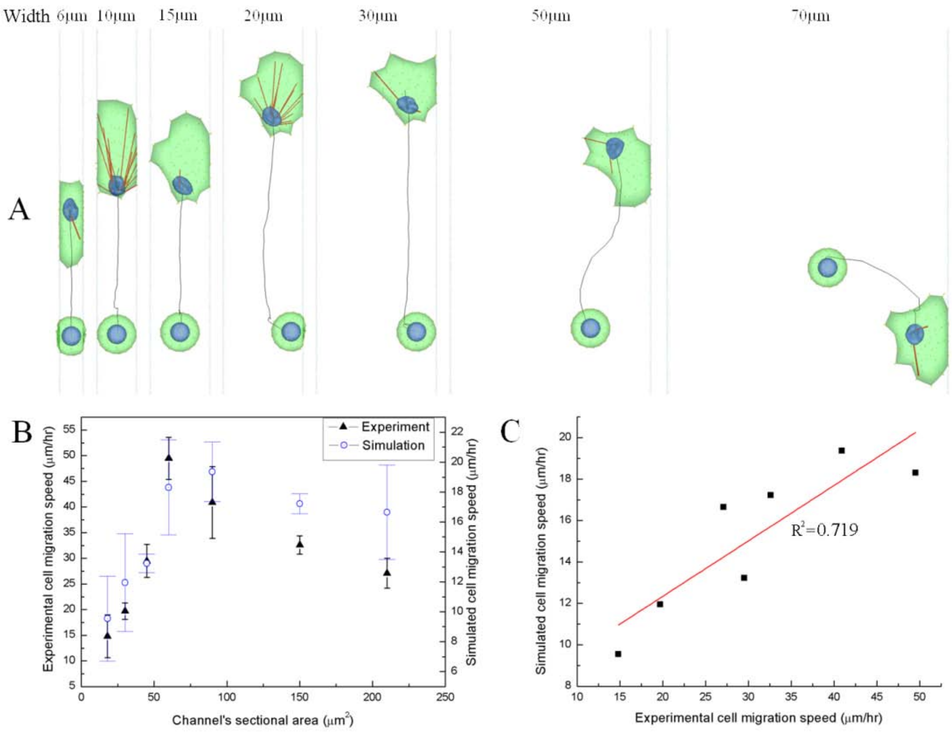

Figure S2

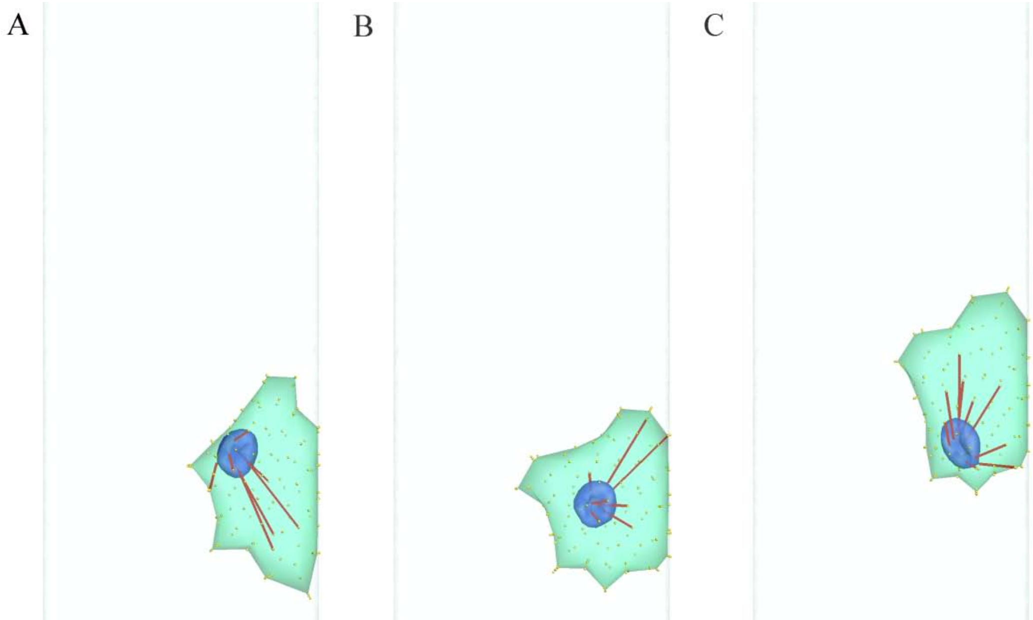

Figure S3

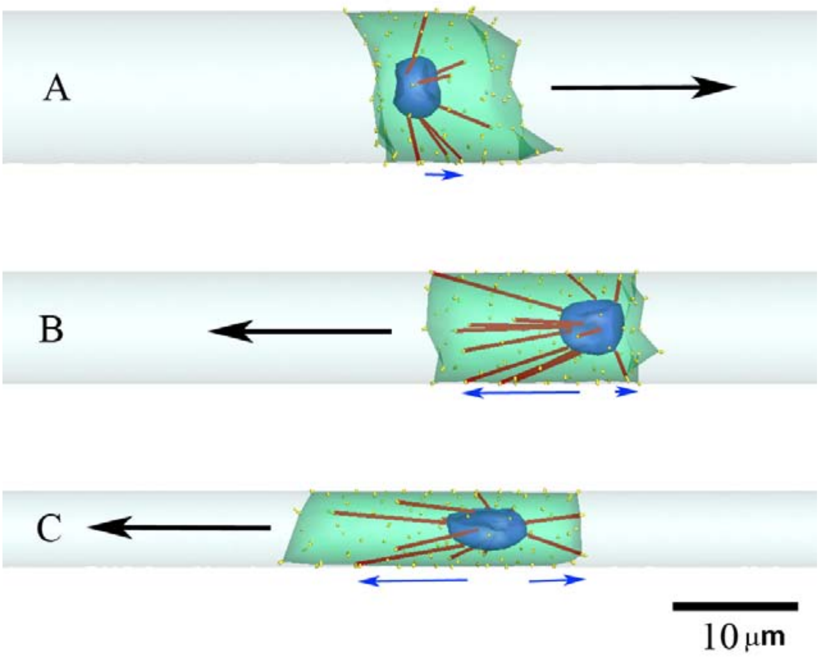

Figure S4