

Description of Additional Supplementary Files

File Name: Supplementary Data 1

Description: Collected data to quantify the resistance force by optical tweezers.

File Name: Supplementary Data 2

Description: Collected data of cell movement area expansion rate with different Matrigel stiffness.

File Name: Supplementary Movie 1

Description: Cellular behavior at FN boundary.

File Name: Supplementary Movie 2

Description: Collective cell behavior at FN boundary.

File Name: Supplementary Movie 3

Description: Collective cell behavior at ex-boundary of PDMS membrane without FN pattern.

File Name: Supplementary Movie 4

Description: NHBE cell migration without Matrigel cover. (Circular pattern)

File Name: Supplementary Movie 5

Description: NHBE cell migration with Matrigel cover. (Circular pattern)

File Name: Supplementary Movie 6

Description: NHBE cell migration with Matrigel cover. (Various geometric patterns)

File Name: Supplementary Movie 7

Description: MDCK cell migration without and with Matrigel cover.

File Name: Supplementary Movie 8

Description: 3D imaging of Actin and nucleus for visualizing 3D cell organizations

File Name: Supplementary Movie 9

Description: Individual NHBE cellular behaviour without Matrigel cover.

File Name: Supplementary Movie 10

Description: Individual NHBE cellular behaviour with Matrigel cover.

File Name: Supplementary Movie 11

Description: Simulation result without resistance force from ECM.

File Name: Supplementary Movie 12

Description: Simulation result with resistance force from ECM.

File Name: Supplementary Movie 13

Description: Directing collective cell migration by artificial modification of ECM with magnetic microbeads.

File Name: Supplementary Movie 14

Description: Simulation result without artificial modification in ECM.

File Name: Supplementary Movie 15

Description: Simulation result with artificial modification in ECM.

File Name: Supplementary Movie 16

Description: 3D NHBE branching morphogenesis in the Matrigel localized 2 different stiffness.

File Name: Supplementary Movie 17

Description: Time-lapse and z-stack imaging of 3D NHBE branching with DQ collagen in Matrigel